ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT PROPOSAL

APA-R-82-002

HARZA-EBASCO
JOINT VENTURE

AUGUST 16, 1982

VOLUME 1
TECHNICAL PROPOSAL
BINDER 2

HARZA-EBASCO
Susitna Joint Venture
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HARZA-EBASCO

C(B) ORGANIZATION

Harza and Ebasco have formed a Joint Venture to accomodate the technical complexity and magnitude of the Susitna Project. The combined organization has established a team of professional personnel with extensive experience in hydroelectric project engineering, project control, and environmental studies to provide the services necessary to complete all activities on this project. The strength provided by our combined resources lies in the significant reserve of professional personnel available to support project functions, respond quickly to changing project manpower requirements, and supply the necessary specialists.

Joint Venture Management

The Joint Venture will be managed by the Joint Venture Management Committee, comprising one principal and one alternative representative from each company. As indicated on Exhibit B-1, the Management Committee will report directly to the President of each company thereby assuring the highest level access to the combined Joint Venture resources. The operation of the Management Committee is explained in detail in the Joint Venture Agreement provided in Section A,"General,"of the proposal.

Dwight Glasscock, Vice President and member of the Harza Board of Directors, will act as Chairman of the Management Committee. Carl Whitehead, Senior Vice President of Ebasco will serve with Mr. Glasscock on the committee. These two individuals, as company officers, have the leadership experience necessary to manage the diverse skills associated with our combined organizations. Exhibits B-1a through B-1c, at the end of exhibits, provide more detail on the corporate structures supporting the Joint Venture and identify the important position each member of the Management Committee fills in his respective organization.

The Management Committee will meet at least quarterly with the Project Manager in either Bellevue or Anchorage to ensure that the proper resources are committed to the project. Additional meetings will be held as required to address support project activities.

As stated above, Mr. Glasscock and Mr. Whitehead will report directly to the President and Chief Executive Officer of their resepctive firms. This most senior level reporting responsibility will ensure access at the level in each firm where resources can be directed to meet specific project objectives with dispatch. Mr. Richard D. Harza and William Wallace III,

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Overall Project Management

The primary Project Management functions of the Joint Venture identified on Exhibit B-2 have been located in the Project office in Anchorage. This offers significant advantages to both the Power Authority and the Joint Venture as far as management of project activities is concerned. First, the proximity of the key Project Management staff to the Power Authority's Management staff will provide for direct access and rapid exchange of information concerning project status, and facilitate resolution of any concerns or problems. Second, by placing the Project Management staff in the location where critical project activities such as licensing, environmental studies, geotechnical investigations, development of design concepts and construction will occur, the Joint Venture can provide direct control of the Project. The key Project Management personnel and their responsibilities are described below.

The overall management responsibilities and major decision making authority is vested in the Project Manager. Dr. R.S. LaRusso will report to the Power Authority on all aspects of the Project and will be responsible for directing the activities of all project personnel. To implement the overall management plan and provide the specific direction needed to accomplish project goals, the Project Manager will provide his direction to the managers of three major functions: engineering, project control, and regulatory and environmental affairs. The functions and responsibilities of these managers is described below.

Engineering Operations

The Engineering Operations Manager, A. Zagars, will be responsible for the direction and management of all project engineering activities. As indicated on Exhibit B-3, four major areas will report to the Engineering Operations Manager and he will control their operations during the simultaneous efforts related to studies, investigations and design concepts, and during the detailed design phase of the Project. The four major areas are:

- Bellevue Office Engineering which is responsible for execution of work packages defined in the Anchorage office, including the production of detailed design specifications and construction drawings to support project construction.

- Project Studies and Design, located in Anchorage which will, through coordination of design studies and geotechnical analyses, provide the conceptual layout and design work packages to the Bellevue Office.

- The Geotechnical Exploration Program, which will provide the data resulting from subsurface investigation programs and geotechnical features of the project. (See Exhibit B-7).

- Non-technical Project Features Management, located in Anchorage which will provide the basic performance specifications and review associated with the nontechnical facilities for issuance of contracts to design subcontractors.

Project Control

The Project Control Manager, M. Soniker, will be responsible for the implementation of the overall project control systems designed primarily to control the costs of technical and support services, as well as capital cost of the project. As Exhibit B-4 indicates, the Project Control Manager will have one major group in Bellevue and several individuals in Anchorage reporting directly to him. The Bellevue organization, which reports to the Lead Cost/Schedule Control Engineer, is responsible for:

- Control of the schedule associated with performance of the technical and support services necessary to provide the project detailed design and the associated construction contract packages.

- Control of the services costs of the project including expenses associated with project operations and provision of specific monetary cost reports on the project.

- Development of project capital cost estimates including estimates of total project cost, and engineer's estimates for equipment and construction contracts.

The individuals in Anchorage who report to the Project Control Manager will have similar types of responsibilities in the cost schedule area, although their activities will be directed toward the non-technical subcontractors and the field study and investigation programs. In addition, the following functions will also report directly to the Project Control Manager.

- Contract Administration of the non-technical and field investigation subcontractors.

- Project Accounting, responsible for accumulation of field costs and for administration of personnel in Anchorage.

- Project Coordination, responsible for accumulating information for inclusion in monthly reports and control of procedures, technical documents, and drawings.

Environmental and Regulatory Programs

The Environmental and Regulatory Programs Manager, Dr. G. Lawley, will provide technical direction and guidance to those Joint Venture personnel and subcontractors who are performing licensing support activities, environmental studies and designs and analysis of field data. He will be responsible for all activities which require coordination with natural resources management agencies, the FERC and the Power Authority. Reporting directly to the Environmental and Regulatory Programs Manager, as indicated on Exhibit B-5, are the following:

- The FERC License Support group, which is responsible for identification of licensing requirements, development of a program for response to these licensing requirements, and interface with the Power Authority and appropriate regulatory bodies.

- The Environmental Studies and Designs group will review, monitor and design (as necessary) field programs which are being conducted in support of defining project environmental impacts.

- The Bellevue Support Activities group, which consists of technical specialists who will be available to support the environmental work effort on an as needed basis. These individuals can, if required, support analysis, review the work of project subcontractors and prepare technical reports to agencies.

Transition Program

The Joint Venture recognizes that a considerable amount of time and effort has been expended to date by existing Power

Authority consultants to prepare a preliminary design of the Susitna Project. This information, including field studies, environmental and technical investigations, feasibility analyses and preliminary plant conceptual drawings has provided the basis for developing our proposal for completion of project technical activities. The Joint Venture proposes to use this information as a starting point, and then effect a smooth transition from the existing consultant to our own forces.

To accomplish this transition, the Joint Venture will benefit from a Transition Team comprised of three individuals who have gained considerable experience in Alaska (J.L. Ehasz, R.L. Meagher, and S.O. Simmons). The Transition Team will function as staff-level advisors to the Project Manager, providing guidance and direction in the initial work efforts. These three individuals will impart their background knowledge of the Susitna project and Power Authority requirements to the Project Team as they develop the complete project work plan.

It is expected that the total transition period for the project will be approximately one year. During this time, the objectives of the Project Team will be to establish the basis for completion of project design. After completion of this task, the Transition Team will be dissolved and the personnel who comprised the Team will be assigned to their normal project functions on the Internal Review Board. Throughout the completion of the detailed design, which includes preparation of engineering specifications and construction drawings, the design will be reviewed by the Internal Review Board members to ensure compliance with the established design concepts.

Position Descriptions

The Joint Venture has developed position descriptions for key personnel on the organization chart. Position descriptions have been organized as follows:

- Project Management
- Engineering Operations
- Project Control
- Environmental & Regulatory Programs

Project Management

Project Manager (Anchorage)

The Project Manager will be responsible for administration of the contract between the Joint Venture and the Power Authority. He will be the formal link between the Power Authority and all elements of the project organization.

He will oversee and hold the responsibility for final authorizations concerning all operations of the Susitna Hydroelectric Project team. He will be directly responsible for formal issue of all project documents, for executing subcontracts in support of the Anchorage and Bellevue offices. He will develop employment conditions, with the Management Committee, for personnel assignments and he will be responsible for final approval of personnel assignments.

Upon receipt by the Project Manager of programs for investigations, studies and design efforts from the Engineering Operations Manager, the Environmental Program Manager, and the Project Control Operations Manager, the Project Manager will be responsible for final authorization and budget allocation.

The Project Manager will initiate, schedule and chair meetings between his staff and the Power Authority, the Internal Review Board, and the External Review Panel. He will make presentations as necessary to the Power Authority's Board of Directors and, when requested, to public information forums.

The Project Manager will report to the Joint Venture Management Committee concerning the status of the Project.

Public Participation Program Manager (Anchorage)

The Public Participation Program Manager will be responsible for communicating information about the Project's engineering, environmental, and cost elements to the Alaska Power Authority Public Participation Office. The Program Manager will be available at public meetings, meetings with Citizen Advisory committees and working groups to assist the Power Authority in the collection and distribution of information. He will report to the Project Manager and have direct access to the managers of Engineering Operations, Project Control, and Environmental and Regulatory Programs to provide convenient exchange of information between the Project Team and interested individuals and groups.

Engineering Operations

Engineering Operations Manager (Anchorage)

The Engineering Operations Manager will direct the engineering studies required to further develop, confirm and refine the layout of project features of the Susitna Hydroelectric Project, and subsequently, the detailed design of these features. He will also be responsible for the engineering associated with the development of the non-technical facilities.

Working with his staff, he will establish schedules for the work and organize procedures for execution of all technical work items, including detailed procedures for information transfer, master filing, checking, review, and approval. He will be responsible for project design and drafting standards, and other project technical documents.

He will schedule engineering personnel assignments, or approve the assignment of personnel by others, to all key engineering positions on the project. He will review and evaluate performance of engineering personnel and recommend salary adjustment at appropriate intervals established for the project.

The Engineering Operations Manager will initially review all products of engineering studies, investigations, and designs.

He will present reports to the Power Authority staff, the External review Panel, and the Internal Review Board, as well as to the Project Manager, to whom he will report.

Office Engineering Manager (Bellevue)

The Bellevue Office Engineering Manager will direct the production of all of the Susitna work assigned to the Bellevue Office by the Engineering Operations Manager in Anchorage. He reports to the Engineering Operations Manager in Anchorage. Assigned to the Bellevue office team to support the Bellevue Office Engineering Manager are the seven Lead Engineers shown on Exhibit B-6.

The Bellevue Office Engineering Manager and his Lead Engineers will participate with the Engineering Operations Manager and his staff, under the direction of the Project Manager, in Anchorage in the development of the detailed Work Plan, the Review of Previous Studies and the development of the Project Conceptual Design. Upon completion of their work in Anchorage, the Bellevue Office Engineering Manager and his team of Lead Engineers will return to Bellevue to complete staffing the office and proceed with the production of detailed designs and contract documents.

After Bellevue is authorized by the Engineering Operations Manager to proceed with a specific work task, the Bellevue Office Engineering Manager is responsible to complete the work on schedule and within the manhour and dollar budgets established during development of the detailed work plan. He is also responsible for coordination through the Anchorage Office with the site field office with respect to timely acquistion of field results for efficient production of the work. He also has responsibility for quality control of the design work as well as scheduling and gathering all data necessary for the Internal Review Board participation. In order to maintain efficiency and cost effectiveness, he must schedule the participation of specialists from the Harza-Chicago and Ebasco-New York. He also must coordinate with the Harza and Ebasco home offices when discrete subtasks such as Finite Element or Hydraulic Transient analyses are assigned to the home offices by the Engineering Operations Manager in Anchorage.

He is responsible for monthly progress reporting for work under his jurisdiction. He will also participate, when requested by the Project Manager, in meetings with the Power Authority's External Review Panel, FERC, public agencies and if necessary Public Information Meetings.

Lead Geologist (Bellevue)

The Lead Geologist will be responsible for the review and evaluation of geological data resulting from the field exploration program and will cooperate with geotechnical and other design staff in the application of this data to pertinent aspects of the project design. He will supervise geological activities within the design group, which will include participation in geotechnical design studies as well as preparation of geological documentation and geologically oriented portions of the contract documents. The Lead Geologist also will be responsible for interfacing with the Manager of the Geotechnical Exploration Program, with various consultants and with the Joint Venture Internal Review Board. He will collaborate with the Geotechnical Exploration Program Manager on scheduling the field operations to ensure that completion of field tasks and transmittal of field data meet the design and contract document production schedules. In addition, the Lead Geologist will provide liaison with and support of the environmental studies related to geology and soils.

Lead Geotechnical Engineer (Bellevue)

The Lead Geotechnical Engineer will be responsible for the review and evaluation of all geotechnical data resulting from the field exploration program and will coordinate the work of the geotechnical staff with the geologists in applying geotechnical parameters to the project design. He and his staff will carry out analyses and studies of soil mechanics, rock mechanics and foundation conditions bearing on the design of the embankment dam and other earth structures and on foundation design and foundation treatment for all project structures both above ground and underground. He will have primary responsibility for preparation of design memoranda, contract drawings and specifications for the dam and its foundation treatment and instrumentation, for structure drainage systems and will collaborate with civil and structural engineers in preparation of contract documents for other project structures. The Lead Geotechnical Engineer will interface with the Geotechnical Exploration Program Manager, with various consultants, and with the Joint Venture External Review Board.

Lead Civil/Structural Engineer (Bellevue)

The Lead Civil/Structural Engineer will be responsible for the technical content and quality control of his staff's work. He and his staff will carry out studies, analyses and design of all above ground and underground concrete and structural steel structures, based on equipment arrangement needs of the mechanical and electrical disciplines and parameters resulting from hydraulics studies. He will have primary responsibility for preparation of preliminary civil design criteria, design memoranda, layouts, contract/construction drawings, and certain sections of the specifications for all civil/structural components of the Project, utilizing the the Joint Venture's design aids and drafting standards plus industry codes and standards. In addition, under his supervision the powerhouse outline "base" drawings will be developed, which will be used by electrical and mechanical disciplines for showing their equipment.

Lead Hydraulic Engineer (Bellevue)

The lead hydraulic engineer will direct the hydraulic design studies for the project. He will assign the work to hydraulic engineers in accordance with the project schedule. He will also serve as the coordinator between the hydraulic design work and other disciplines in the organization.

The Lead Hydraulic Engineer will serve as the technical representative for coordinating and advising the hydraulic laboratory work. As such he will prepare the model program, inspect the model testing and handle the day-to-day communications with the hydraulic laboratory.

Additionally, the Lead Hydraulic Engineer will serve as required during External Review Panel meetings to present the results of hydraulic design studies and to answer questions regarding the hydraulic aspects of the Project.

Lead Mechanical Engineer (Bellevue)

The Lead Mechanical Engineer will be responsible for the selection of the generating unit turbine and governing system, for selection and design of gates and trashracks, for selection of cranes and hoists, and for design of project general mechanical service and safety systems. He and his staff will make the studies and analyses necessary to confirm or revise the preliminary designs made at the feasibility level. They will interface closely with the other disciplines (civil, hydraulics, electrical) and the Joint Venture Internal Review Board in preparing the preliminary design layouts and arrangements for each of the project features and will select and formalize in design memoranda the criteria to be use in final equipment selection and system design. He will direct the mechanical design staff and ensure its coordination with the other involved disciplines, in preparation of specifications, contract/construction drawings and quality control memoranda utilizing Joint Venture design criteria, drafting standards, and industry standards. He will provide mechanical input to the evaluation of bids received and make recommendations of award.

The Lead Mechanical Engineer will be responsible for the review of manufacturers' design data and drawings, and will also be responsible for the inspection of major mechanical/equipment at manufacturing facilities and assistance to field forces in project start-up. Operation and maintenance manuals will be prepared under his direction.

Lead Electrical Engineer (Bellevue)

The Lead Electrical Engineer will be responsible for selection of all major project electrical equipment (except transmission system) and the design of the grounding, generation and generation control and protection, and station service electrical systems for the various project features. He will administer and supervise a staff who will confirm, or revise, the feasibility level electrical design, and perform the studies necessary to establish a preliminary electrical layout and define the criteria and parameters to be followed in the final electrical design. Electrical design memoranda formalizing these critiera will be prepared under his direction.

He will direct the preparation of the final designs, specifications, contract/construction drawings and construction/installation quality control memoranda. He will coordinate the interfacing of his section's work with that of the other disciplines and the Internal Review Board. He will also coordinate his staff's work with the specialist Joint Venture electronics staff where they interface on computer control and microwave systems. He will prepare technical analyses of electrical equipment bids and provide input to the electrical sections of construction bids documents.

He will supervise the review of manufacturers' submittals and in-plant acceptance inspections and tests. He will assist the Power Authority and the Construction Manager's staff in field inspection and testing and project start-up. Operation and maintenance manuals will be prepared under his direction.

Lead Support Services Engineer (Bellevue)

The Lead Support Services Engineer will be responsible for the Joint Venture's services in the preparation and issue of contract documents for construction control packages. He will coordinate with the design disciplines who will draft the technical specifications required for the documents. He will be responsible for coordinating construction input to the construction and equipment procurement bid packages by the Construction Manager and the Power Authority staff. Also, working jointly with the Construction Manager and the Power Authority, he will conduct the bidding process and he will coordinate the Joint Venture's analysis of bids and recommendations for award.

The Lead Support Services Engineer's staff will include specialists in construction planning and scheduling. He will supervise construction and constructibility input to the design process and the preparation of bidding documents and bid analysis. He will also provide internal constructibility review of the designs, specifications and drawings prepared by the design disciplines. He will provide assistance to the field during construction as requested by the Anchorage office or Resident Engineer.

Project Studies and Design Manager (Anchorage)

The Project Studies and Design Manager will support the Engineering Operations Manager and in his absence will act on his behalf. He will participate in the preparation of the Detailed Project Work Plan.

He will have direct involvement in the development of investigation memoranda, the Project Conceptual Design and the preparation of the Project Conceptual Design Report. He will aid the Engineering Operations Manager in the assignment of discrete work packages to Bellevue offices and the Harza and Ebasco home offices. He will coordinate the transmittal of field investigation results to these offices, as well as responses from these office to field questions. He will be responsible for the technical aspects of the conceptual design of the non-technical features of the Project as well as the review of the design subcontractor prepared contract documents designs, drawings and specifications.

Geotechnical Exploration Program Manager (Anchorage)

The Geotechnical Exploration Program Manager will be in overall charge of both the field exploration activity and geotechnical activity in the Anchorage office. He will plan, organize, direct, schedule and review the work carried out by the Joint Venture team of geologists and geotechnical engineers and the several field subcontractors. He also will be responsible for assimilation and preparation of the field and laboratory data for transmittal to the Bellevue Design office. He will assure timely interaction with the design group in the Bellevue office. The Geotechnical Exploration Program Manager and his senior staff will review proposed layouts and preliminary designs and will apprise the Bellevue design group of recommended layout adjustments or design modifications stemming from the investigation findings. In addition, will be responsible for the adequacy of all support functions for the field operations by maintaining close liaison with subcontractors responsible for camp operation, permitting and logistical support.

Non-Technical Project Features Manager (Anchorage)

This Manager will be responsible for management of the non-technical design subcontractors and the logistic support for field investigations. He will be responsible for developing the scope of services for each design subcontract, issuing proposals, negotiating the technical aspects of the non-technical design work, seeing that the work is given adequate review to assure its quality, and monitoring progess of the design work. He will also coordinate with the Power Authority and the Construction Manager and coordinate design subcontractors when necessary. The organization of this area is shown on Exhibit B-8.

The Manager will direct the logistic support activities for field investigations to ensure that the subcontractors that provide coamp facilities, transport, and equipment are functioning in a manner that permits an efficient field investigation program.

Project Control

Project Control Manager (Anchorage)

The Project Control Manager will have overall responsibility for the control of costs of technical and support services, control of schedules and preparation of capital cost estimates. The Project Control Manager will manage and supervise implementation of the EPICS program, the non-technical administative control of Subcontractors, the administration and accounting in the Anchorage office, liaison with the Construction Manager regarding cost/schedule control, preparation of project status reports, and logistics and communications between Bellevue, Anchorage and the site. The Project procurement activities will also be under his administrative control so that accounting, statusing and cost/schedule impacts will be automatically channeled to the Project Controls group. He will be responsible for optimizing the communications and data links between Anchorage, Bellevue and the site to gain maximum efficiency and economy.

Lead Cost/Schedule Control Engineer (Bellevue)

The Lead Cost/Schedule Control Engineer in Bellevue, who reports to the Project Control Manager in Anchorage, is responsible for the control of services costs, capital cost and schedules for the activities performed in the Bellevue office. Reporting to the Lead Cost/Schedule Engineer are the Project Estimator, Service Cost Engineers and additional Cost/Schedule Control Engineers who will develop and maintain cost and schedule baselines for the Project in order to perform these control functions.

Lead Contract Administrator (Anchorage)

The Contract Administrator is responsible for administration of the local engineering subcontracts and the numerous subcontractors involved in the geotechnical exploration and environmental investigations. Technical supervision in most cases will be the function of the appropriate Joint Venture geotechnical or environmental staffs, or Frank Moolin and Associates. The Contract Administrator ensures that the proper bidding procedures are implemented and that any changes in original contracts are properly analyzed and processed.

The Contractor Administrator will also have the function of ensuring maximum participation in the hiring of Alaskan subcontractors and the implementation of the Power Authority - Cook Inlet Native Village and Cook Inlet Region Agreement as contained in the RFP Attachment VIII.

Lead Cost/Schedule Engineer (Anchorage)

The Cost/Schedule Engineer is responsible for establishing the initial baselines associated with the local non-technical engineering subcontracts and the contractors supporting the field geotechnical and environmental investigations. He will update and monitor progress on these in accordance with the requirements of the cost/schedule control program. In addition, he will provide support to the Project Estimator and Project Management personnel in the control of costs and schedules of the Project. He will obtain local cost data and other data that are needed for estimating local costs. Transport limitations that must be known such as harbor facilities, rail and road limitations for weight and size of equipment will also be obtained.

Accountant (Anchorage)

The Accountant will process invoices and handle local payrolls and miscellaneous materials expenses for field and office activities. In addition, he will provide the personnel functions associated with the non-professional staff of the field office.

Project Coordinator (Anchorage)

The Coordinator has the function of ensuring that all parties update their cost/schedule reports, as scheduled, monitoring progress, establishing distribution schedules, acting as liaison between the engineers, the procurement group, and the Bellevue Project Control group.

Environmental and Regulatory Programs

Environmental and Regulatory Programs Manager (Anchorage)

The Environmental and Regulatory Programs Manager will be responsible for implementing the work plan outlined in Section D(c), "Environmental Studies". He will be the Project Management Team's key individual in the execution of environmental and regulatory programs which are central to the issue of project licensing. He will be the principal point of contact between the Joint Venture and the Power Authority's environmental staff on technical issues and will provide assistance as needed to the Public Participation Support Program, engineering studies and project control functions.

The Environmental and Regulatory Programs Manager will be responsible for preparing periodic progress reports on the status of environmental program activities. He will also have overall responsibility for all technical environmental documents developed by the Joint Venture and its subcontractors.

From an administrative standpoint, the Regulatory Enviromental and Regulatory Programs Manager will be responsible for managing the costs and maintaining the schedule of the environmental program. Supported by the Joint Venture project control staff, he will be responsible for planning and executing the environmental program. He will provide input to the project management information system (see Section D(1)) in accordance with project procedures for budget and schedule planning, monitoring, and reporting.

Agency Liaison (Anchorage)

The Joint Venture has established the position of Agency Liaison in Anchorage during the FERC licensing period. The position will be a staff position, reporting to the Regulatory and Environmental Programs Manager, providing continuing technical and adminstrative liaison between the Joint Venture and the state and fede-al agencies involved with the Susitna Project. This will be an especially important function in early 1983, when a change is made in the consultant, the transition is made from feasibility to design activities, and the FERC License Application is submitted.

FERC Licensing Coordinator (Anchorage)

The position of FERC Licensing Coordinator has been established to coordinate the day-to-day activities necessary to ensure proper response during the FERC licensing process. In this role, he will provide technical and administrative coordination for engineering and environmental input to FERC requests for additional information, special studies, meeting participation, documentation, and a variety of other tasks as required. This position, full-time in Anchorage, will require heavy involvement with the participating agencies and with Power Authority staff.

Permits Coordinator (Anchorage)

The proposed program for acquisition of permits other than the FERC License is described in Section D(e-f) of this proposal. The position of Permits Coordinator, however, is proposed as integral to the overall Environmental and Regulatory Program. The Permits Coordinator will lead the preparation of all federal, state and local permit applications necessary for both design activities as well as overall approval of project components, monitor compliance with permit requirements, and provide input as necessary to the FERC licensing process.

Technical Programs (Anchorage)

Three lead technical specialists will be assigned to the Anchorage Joint Venture office for the duration of the licensing period, in the following positions:

- Lead Aquatic Ecologist
- Lead Terrestrial Ecologist
- Lead Resources Planner

These resident positions are necessary to ensure that continuous oversight and management guidance is available in the disciplines most critical to the licensing process. In addition, these individuals will work closely with the environmental subcontractors in their respective disciplines.

The responsibilities and qualifications of the lead technical specialists are as follows:

The Lead Aquatic Ecologist will:

- Supervise and coordinate resident and anadromous fisheries monitoring programs
- Assess alternative project design impacts on resident and anadromous fisheries
- Direct continued fisheries mitigation plan development
- Coordinate fisheries programs with Alaska state and federal agencies and fisheries interests
- Act as a liaison on fisheries subconsultant activities

The Lead Terrestrial Ecologist will:

- Supervise and coordinate wildlife monitoring programs
- Continue development of wildlife mitigation measures and planning
- Coordinate wildlife programs with Alaska, state and federal wildlife management agencies
- Assess alternative project design impacts on area wildlife
- Act as a liaison with terrestrial resources subconsultant activities

The Lead Resources Planner will oversee all technical activities, including the following:

- Supervise and coordinate land use studies
- Coordinate sampling activities during the socioeconomic impact monitoring program

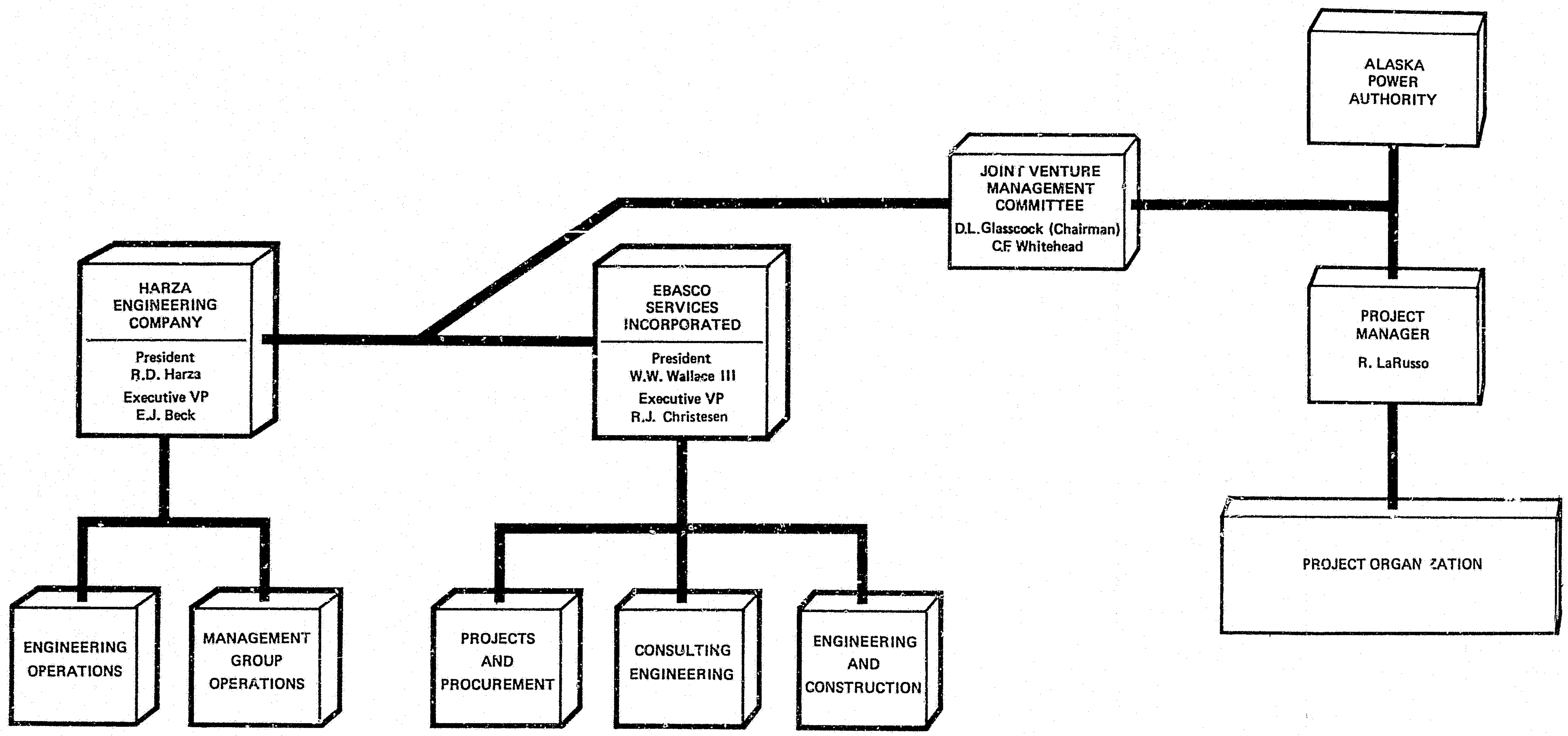
- Support the public participation program
- Coordinate archeological and cultural investigations
- Evaluate recreation development objectives
- Coordinate studies of project work force impacts

Manpower Loading

The initial effort to organize the design program and project organization will require early assignment of project management and project control personnel. The initial engineering staffing will be needed to review previous studies and to develop the design concept, Environmental and FERC licensing support staff will be needed to familiarize themselves with the on-going data collection program and to review the license application so they can effectively take over those programs. Preliminary arrangements for these early assignments will be made during the contract negotiation period.

Exhibits B-9 and B-10 show the staffing requirements in Alaska and in Bellevue. We have not shown the manpower loading for home office support because it is relatively small (about 15 percent) and it will not substantially impact the home office workload. The combination of the two exhibits show that the work force builds to a peak of about 100 personnel in Alaska and Bellevue by mid 1984. Home office support and design subcontractor forces will probably add about 100 more personnel at that time.

The peak loading in Alaska in 1983 and 1984 are for the summer field investigations. The peak loading in the Bellevue design office during 1984 is caused by design activities related to the dam and diversion facilities and the second peak in 1985-86 is related to the period when most of the equipment design and contract documents are being prepared. The manpower loading corresponds to the work task schedules that are shown in Section D(b).

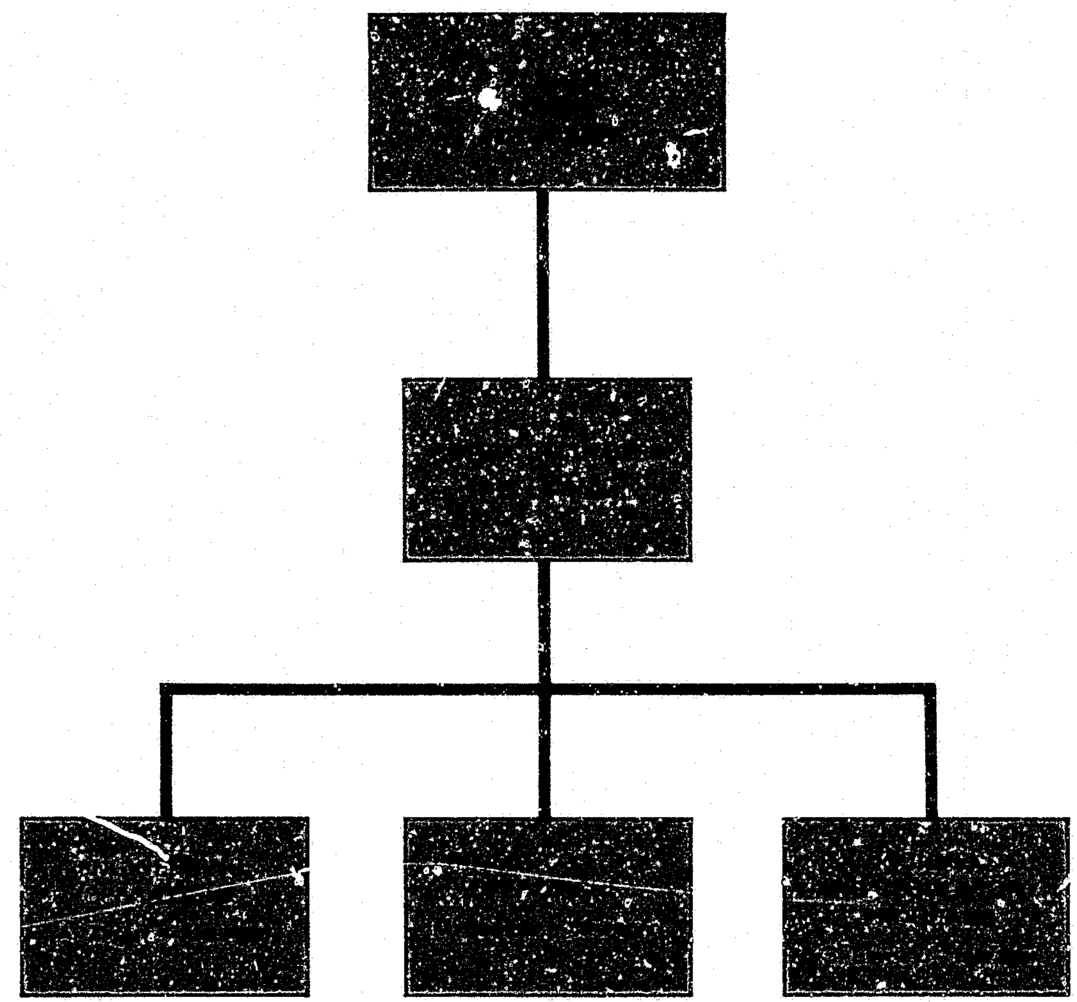


SUSITNA HYDROELECTRIC PROJECT

CORPORATE ORGANIZATION

HARZA-EBASCO

EXHIBIT B - 2

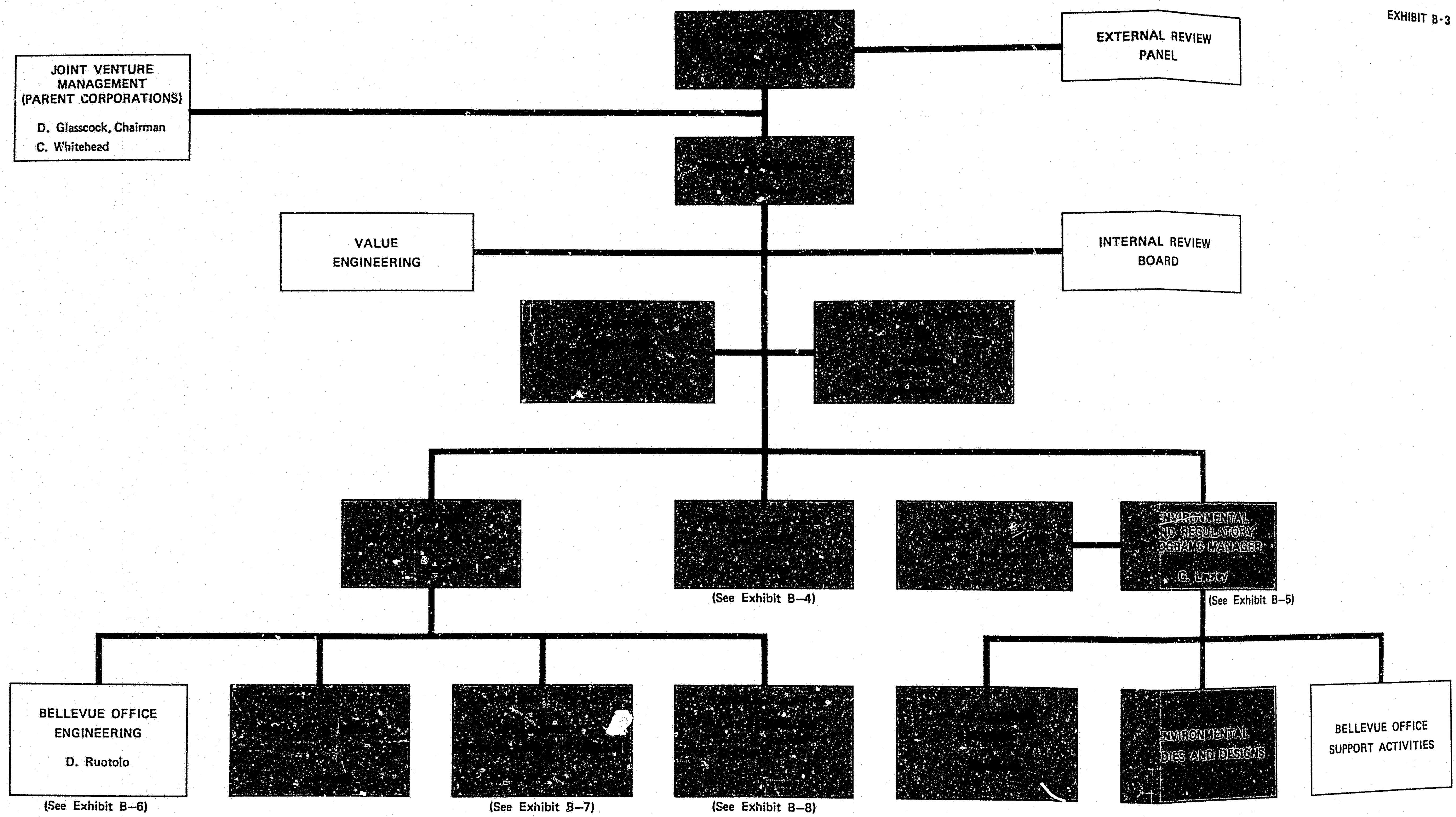


SUSITNA HYDROELECTRIC PROJECT

PROJECT MANAGEMENT TEAM

HARZA-EBASCO

EXHIBIT B-3



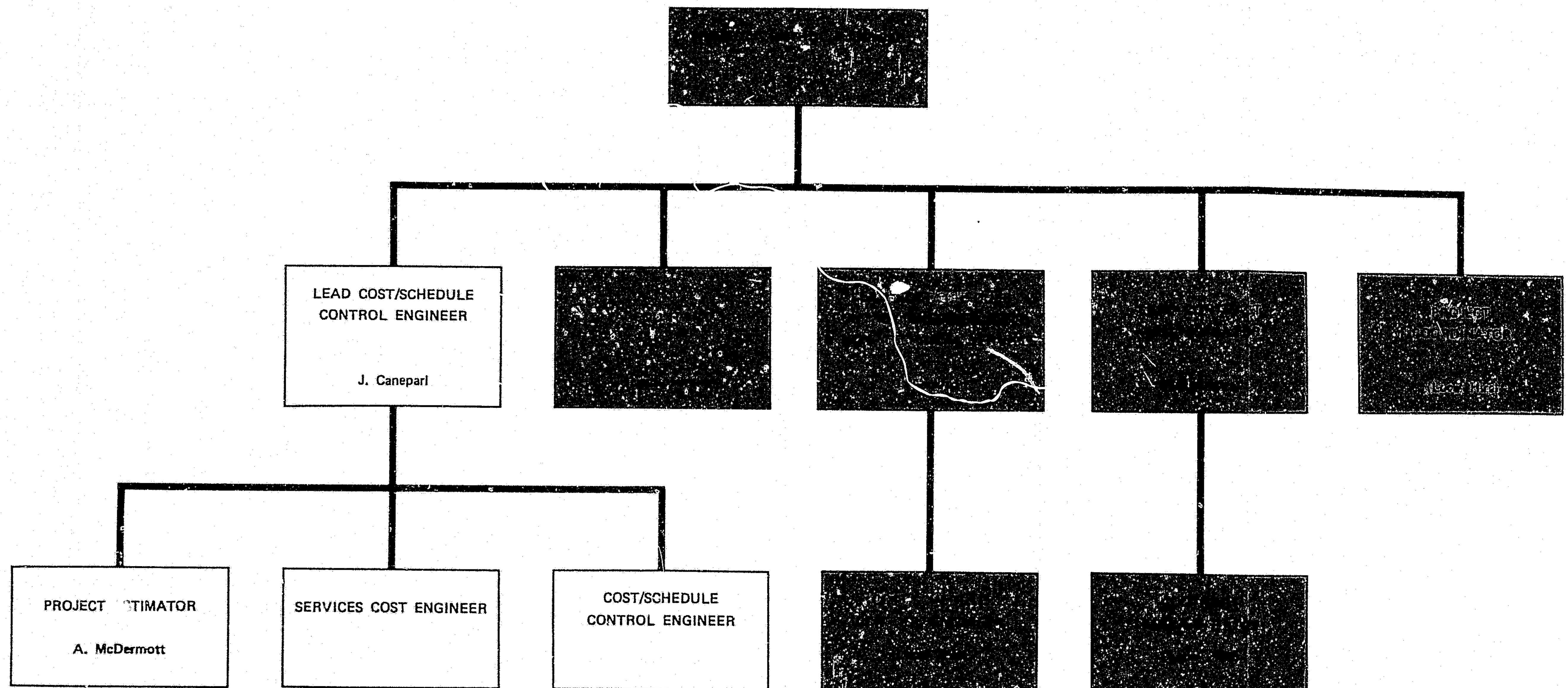
Anchorage based operations

HARZA-EBASCO

SUSITNA HYDROELECTRIC PROJECT

MANAGEMENT AND SUPPORT ORGANIZATION

EXHIBIT B-4



Anchorage based operations

SUSITNA HYDROELECTRIC PROJECT

PROJECT CONTROL ORGANIZATION

HARZA-EBASCO

EXHIBIT B - 5

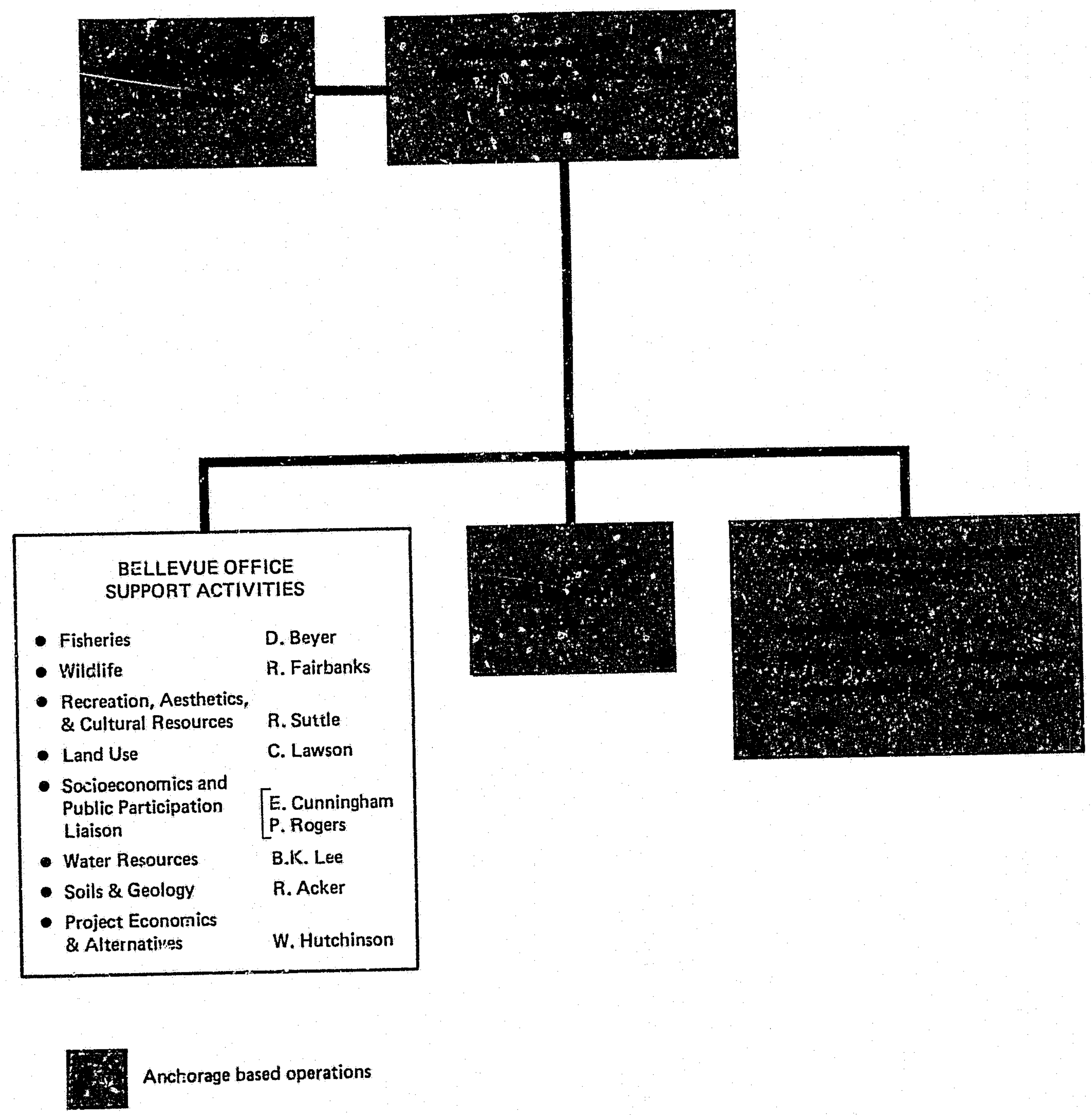


EXHIBIT B - 6

SUSITNA HYDROELECTRIC PROJECT

ENVIRONMENTAL AND REGULATORY PROGRAM MANAGEMENT ORGANIZATION

HARZA-EBASCO

EXHIBIT B-6

BELLEVUE OFFICE ENGINEERING
D. Ruotolo

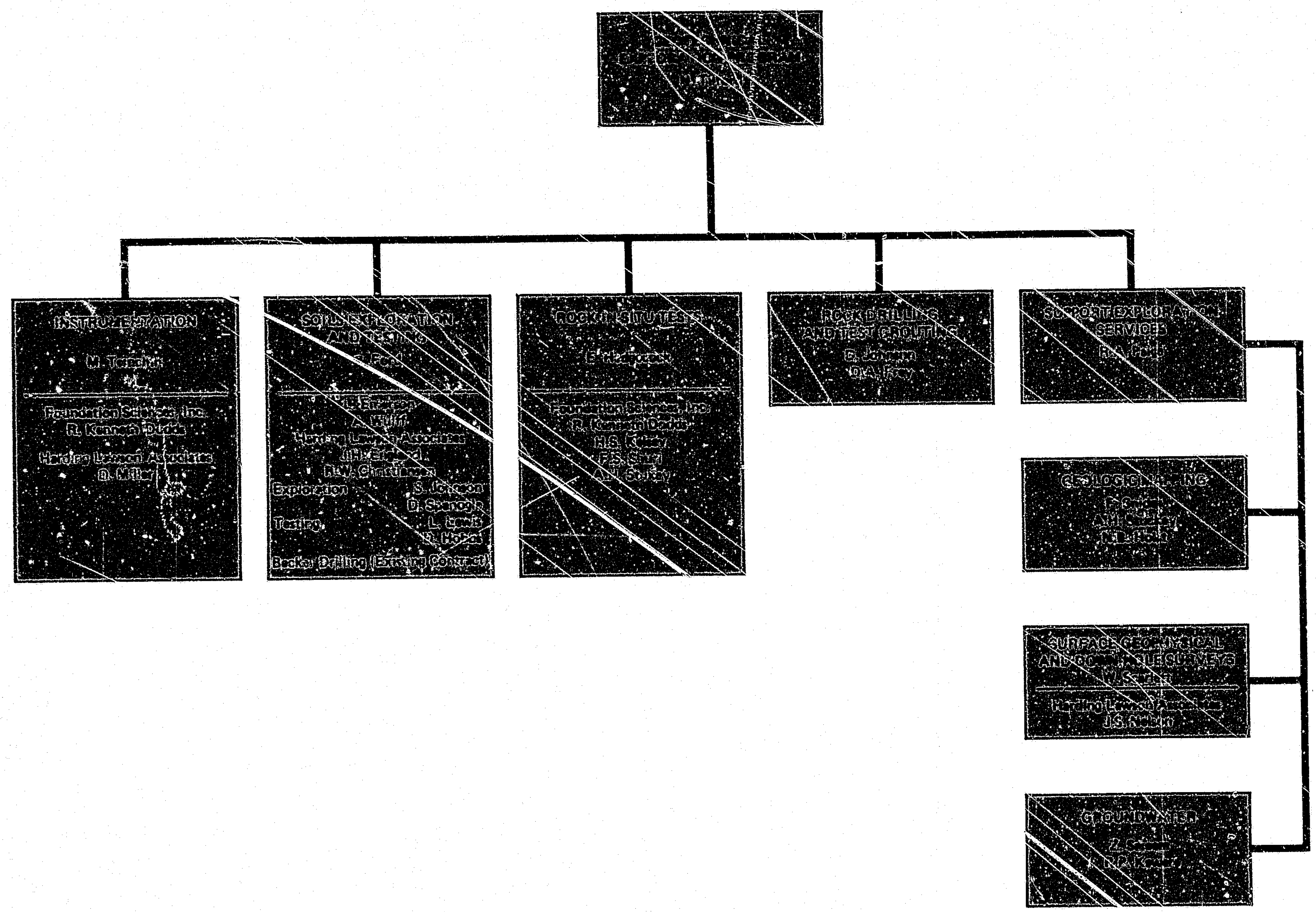
- **LEAD GEOLOGIST** — R.C. Acker
  - Senior Geologist — R.P. Kewer
- **LEAD GEOTECHNICAL ENGINEER** — C.D. Craddock
  - Senior Geotechnical Engineer — K.L. Wong
  - Senior Rock Mechanics Engineer — H.H. McPherson
  - Senior Engineer (Dam Design) — M. Pavone
  - Senior Engineer (Dam Design) — K. Liu
  - Engineer (Geotechnical) — A. Custin
- **LEAD CIVIL/STRUCTURAL ENGINEER** — J. Straubergs
  - Senior Engineer (Design/Analysis) — G.C. Antonopoulis
  - Senior Engineer (Structural Steel) — M. Akagi
  - Principal Engineer (Analysis/Design) — S. Goyal
  - Principal Engineer (Analysis/Design) — G. Ellis
- **LEAD HYDRAULICS ENGINEER** — H.W. Coleman
  - Senior Engineer (Hydraulics) — E. Gemperline
- **LEAD MECHANICAL ENGINEER** — R.S. Burkhart
  - Gates & Hoists Specialist — U. Vitols
  - Hydraulic Machinery — D.K. Smith
- **LEAD ELECTRICAL ENGINEER** — J.J. Quinn
  - Senoir Engineer — D. Undevia
  - Senior Engineer — G. Scheel
  - Systems Engineer — E.C. Foszcz
  - Power Systems Engineer — J. Szablya
- **LEAD SUPPORT SERVICES ENGINEER** — R. Vine
  - Specifications Specialist — R.B. Styles

SUSITNA HYDROELECTRIC PROJECT

BELLEVUE OFFICE ENGINEERING ORGANIZATION

HARZA-EBASCO

EXHIBIT B - 7

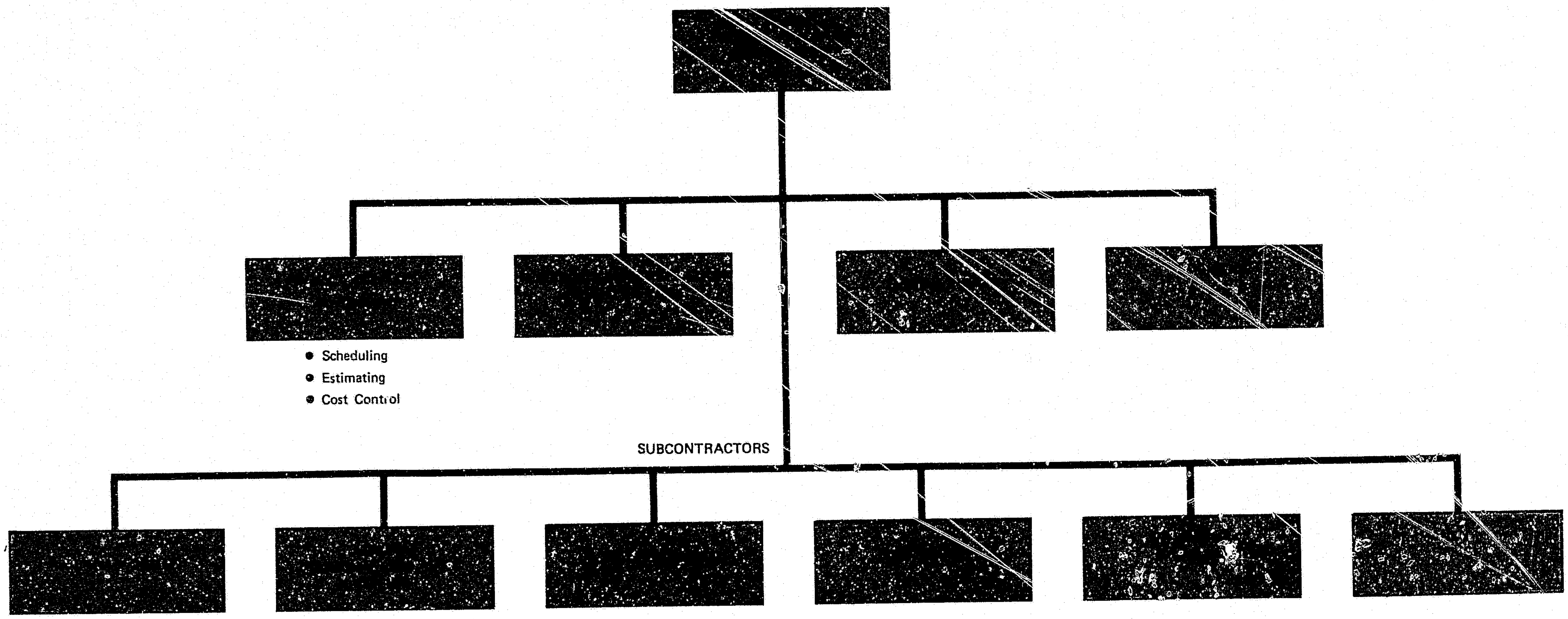


SUSITNA HYDROELECTRIC PROJECT

GEOTECHNICAL EXPLORATION PROGRAM ANCHORAGE

HARZA-EBASCO

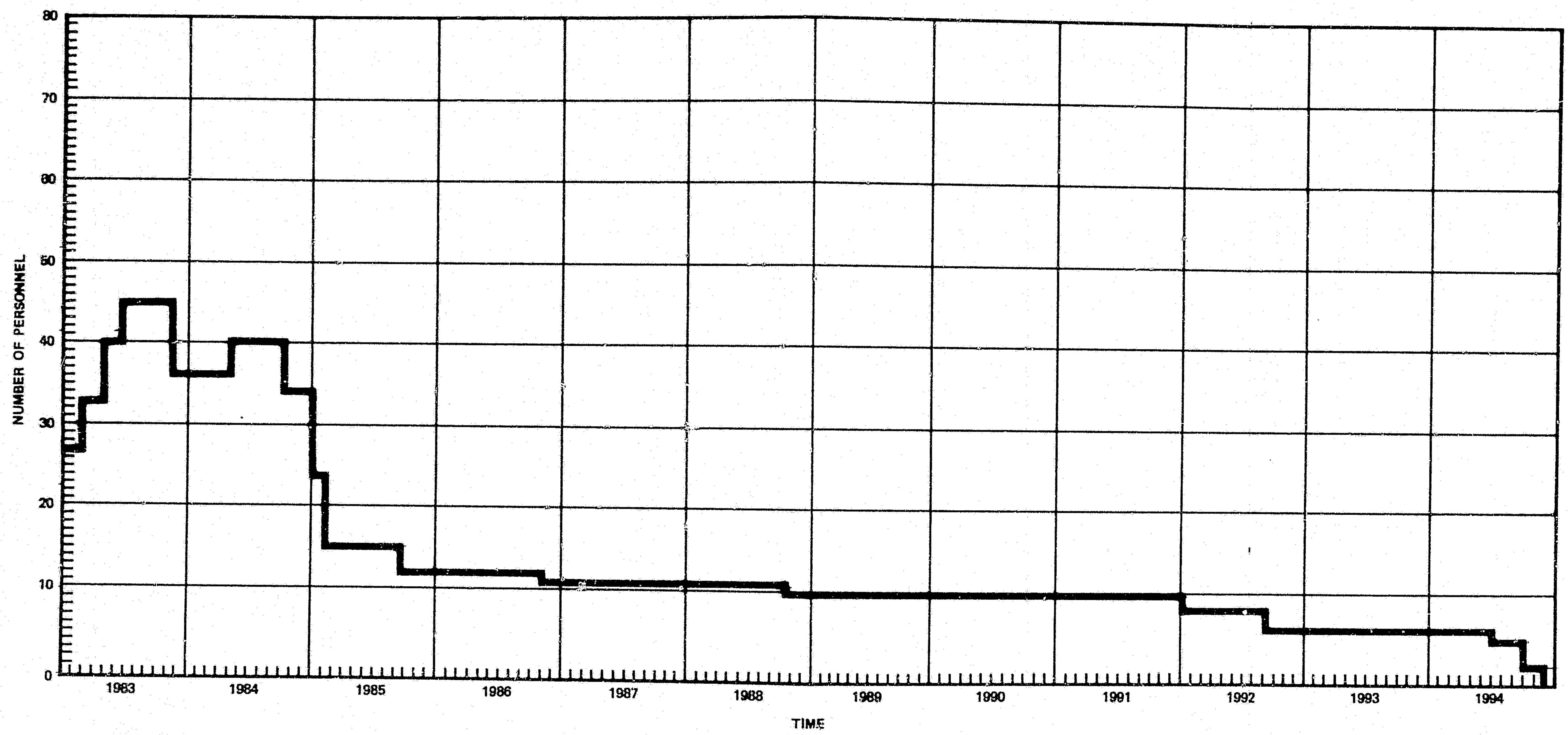
EXHIBIT B-8



SUSITNA HYDROELECTRIC PROJECT

DESIGN OF NON-TECHNICAL FACILITIES
MANAGEMENT ORGANIZATION

HARZA-EBASCO

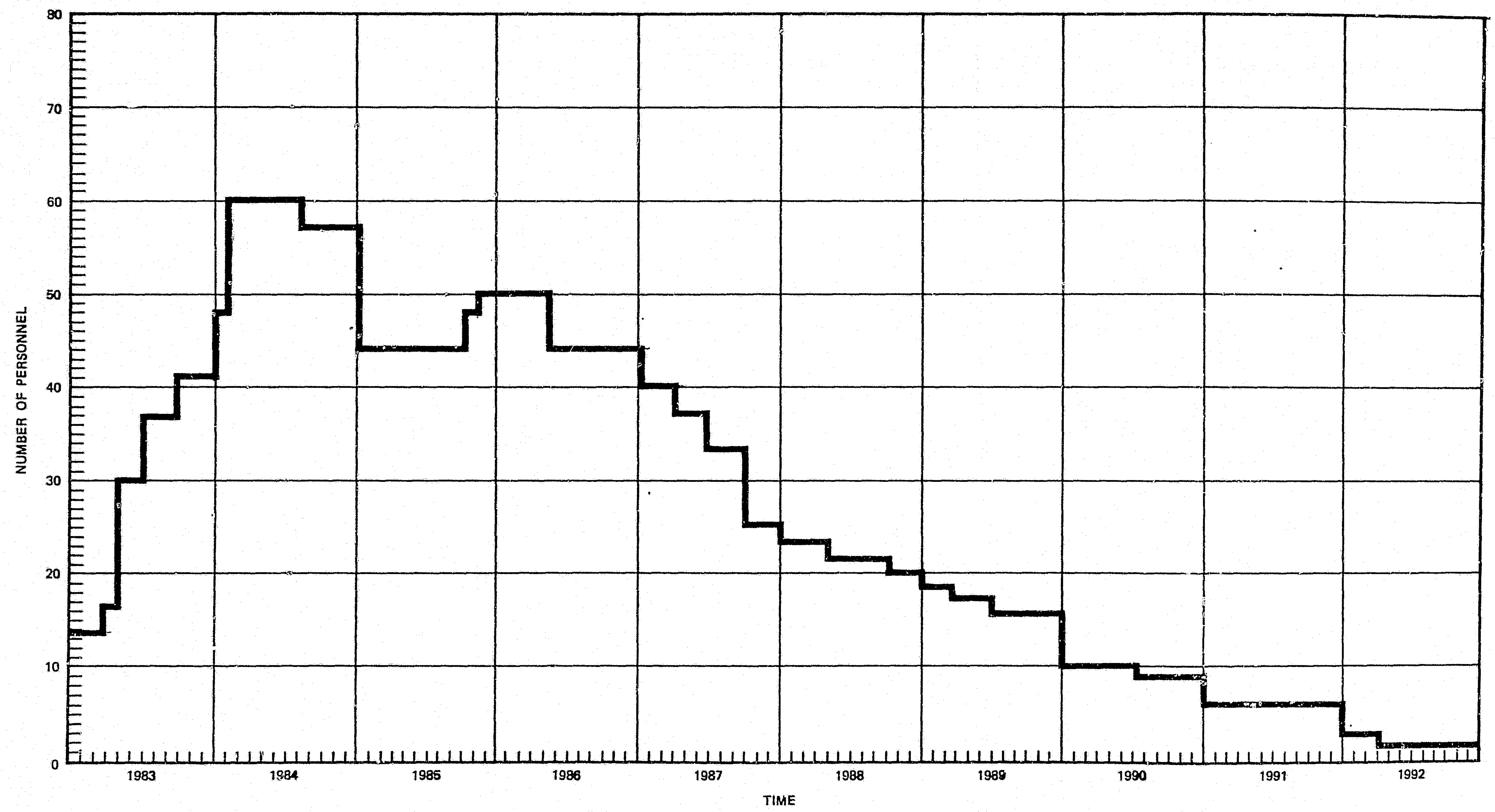


HARZA-EBASCO

SUSITNA HYDROELECTRIC PROJECT

MAN LOADING BY MONTH ANCHORAGE OFFICE & FIELD INVESTIGATIONS

EXHIBIT 3 - 10



SUSITNA HYDROELECTRIC PROJECT

MAN LOADING BY MONTH
BELLEVUE OFFICE

HARZA-EBASCO

ENGINEERING OPERATIONS

EXHIBIT B -1a

CHIEF ENGINEER
J. A. Veltrop

DEPUTY CHIEF ENGINEER
W. T. Bristow

SENIOR PROFESSIONAL STAFF
Chief Staff Engineer
A.E.Allen

Principal Civil Engineer	A. Zagars
Principal Civil Irrigation Engineer	M.A. Olson
Principal Electrical Engineer	Y. Fukuda
Principal Geologist	E.E. Komie
Principal Hydraulic Engineer	D.S. Louie
Principal Hydrologist	B.H. Wang
Principal Mechanical Engineer	T.Zowski
Principal Planning Engineer	K.E. Sorensen
Principal Power Development Engineer	A.E. Allen
Principal Geotechnical Engineer	J.A. Scoville

A. C. Hauswald
Assistant to the Chief Engineer

H. K. Pratt
Assistant to the Chief Engineer

E. T. Moore
Senior Hydroelectric Engineer

WATER AND ENERGY PLANNING AND DESIGN DEPARTMENT
H. H. Chen

Energy Resources Planning	V. Tammekivi
Water Resource Planning	M. P. Saunders
Hydroelectric Planning	L. D. Nichol
Hydraulic Analysis & Design	F. G. DeFazio
Small Hydro Design & Fish Facilities	K. R. Leonardson

LAND RESOURCES AND ENVIRONMENTAL SCIENCES DEPARTMENT
J.C. Jones

Environmental Sciences	J. T. Thrall
Hydrology	R. E. Aten
Land Reclamation & Irrigation	D. B. Palmer
Special Projects	J. T. Passage

GEOTECHNICAL DEPARTMENT
D. E. Kleiner

Geology	R. C. Acker
Soil Mechanics & Foundation I	R. G. Oechsel
Soil Mechanics & Foundation II	D.E. Kleiner (Acting Head)

HYDROELECTRIC DEPARTMENT - CIVIL
R. J. Banys

Architecture	J. J. Schalk
Hydroelectric I	P. Naris
Hydroelectric II	R. D. Witte
Hydroelectric VI	R.E. Gewargis

HYDROELECTRIC PUMPED-STORAGE DEPARTMENT - CIVIL
M. Bruzas

Hydroelectric III	V. J. Zipparro
Hydroelectric IV	B. A. McKiernan
Pumped-Storage	A. Duros
Wastewater Structures	E.E. Gruninger

STRUCTURAL DEPARTMENT
R. P. Wengler

Structural Analysis and Design	C.H. Yeh
Structural Design I	H. Sedath
Structural Design II	J. M. Hahn
Computer Services	K.J. Reca

ELECTRICAL DEPARTMENT I
J.T. Nikolas
Assistant Head J. C. Aberer

Hydro Generation & Substations I	J. C. Aberer
Industrial Projects	E. W. Nance
System Studies	P. J. Donalek
Transmission & Distribution	A.V. Sapelkin

ELECTRICAL DEPARTMENT II
L. Eilau

Computer Control & Communications	R.L. Kuntzendorf
Hydro Generation & Substations II	L. Eilau
Pumped-Storage	H. M. Henriksen

MECHANICAL DEPARTMENT
W. E. Larson
Assistant Head G. H. Post

Gates, Cranes and Hoists	U. Vitols
General Mechanical I	R. S. Burkhart
General Mechanical II	C. Esser
Hydraulic Machinery	R. W. Fazalare
Thermal Systems	G. H. Post

ENVIRONMENTAL ENGINEERING DEPARTMENT
A. L. Lagvankar

Water and Waste Management	H. C. Molzahn
Treatment Plants	T. W. Hurdle
Industrial Processes	K.V. Mayenkar

CONSTRUCTION MANAGEMENT DEPARTMENT
D.J. Duck
Assistant Head R.D. Hilliard

Contracts and Construction Services	S.E.G.Hjertberg
Contract Documents and Procurement	A. L. Schafer
Scheduling & Estimating	L.F. Levy
Field Contracts & Administration	D.J. Duck

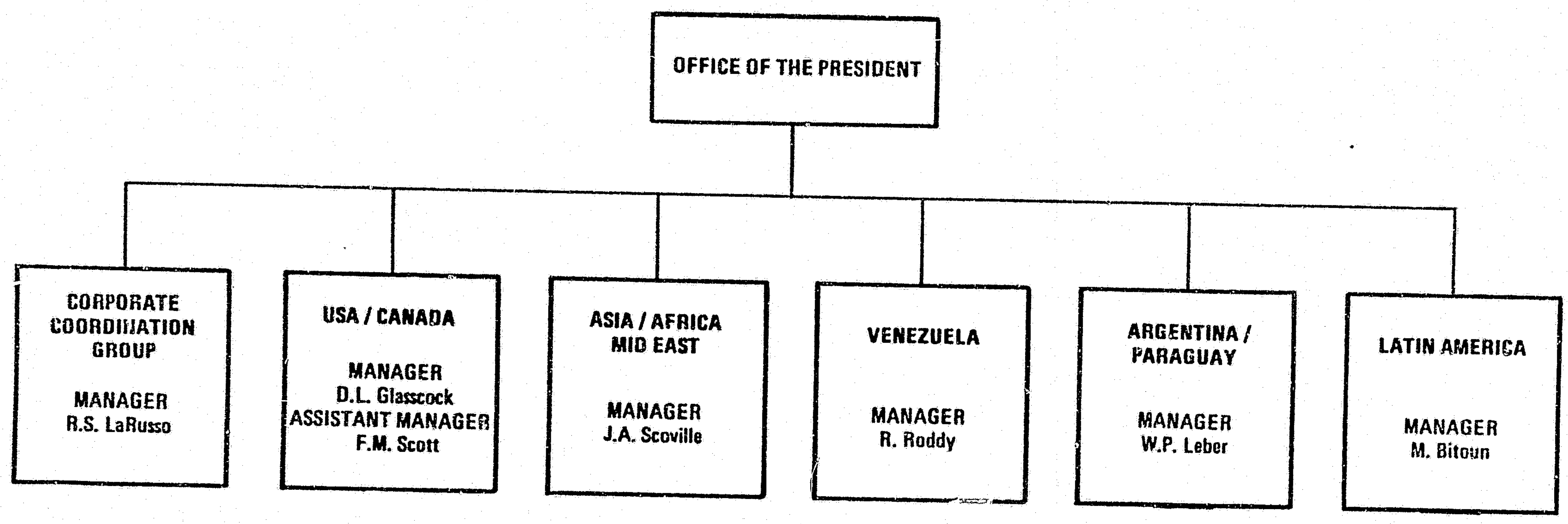
OTHER EXPERIENCE

PROJECT EXPERIENCE

EXHIBIT B - 1b

MANAGEMENT GROUP OPERATIONS

PROJECT MANAGEMENT AND BUSINESS DEVELOPMENT ACTIVITIES



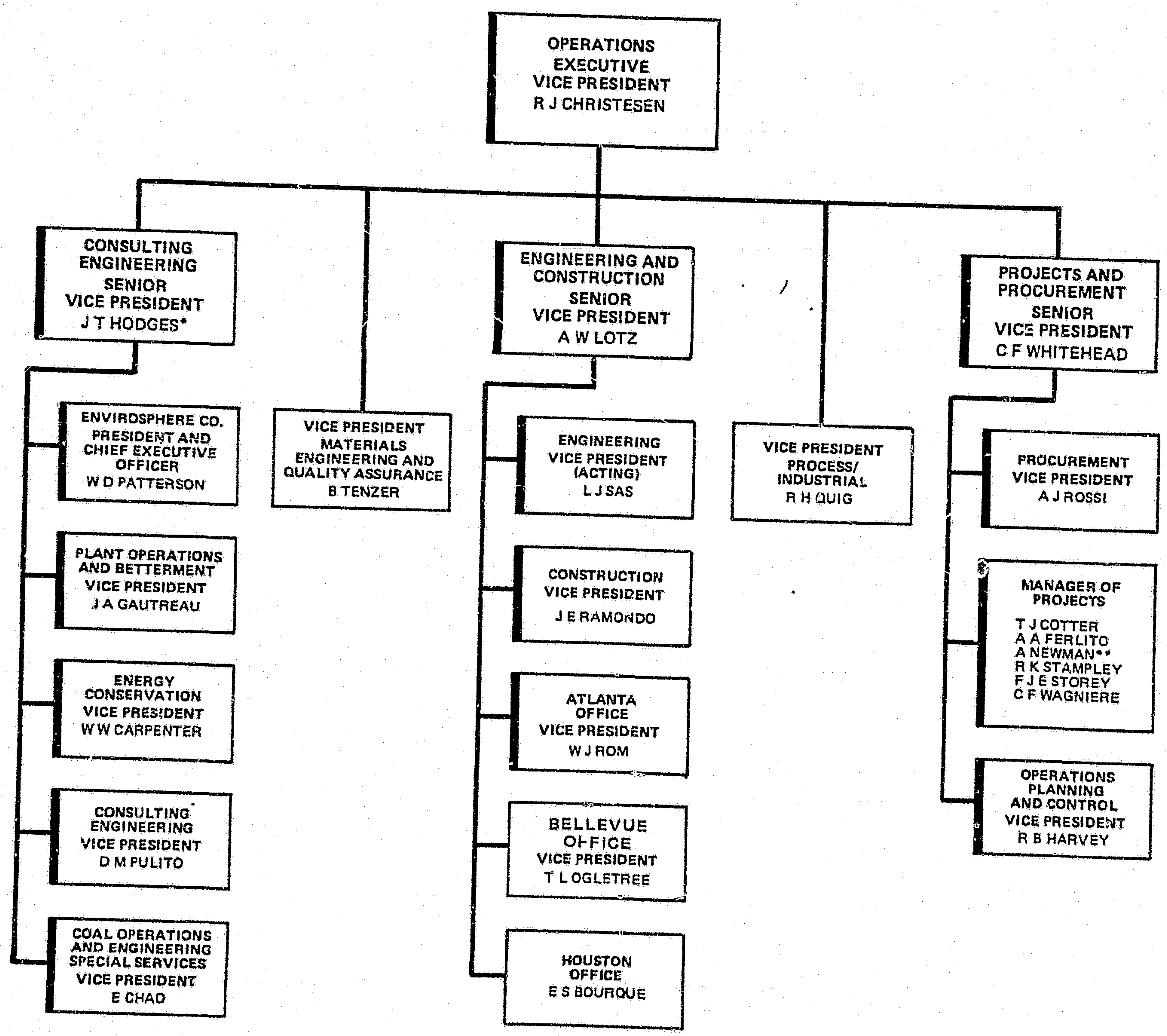
OTHER EXPERIENCE

PROJECT EXPERIENCE

000154

EXHIBIT B - 1c

Ebasco Services Incorporated
COMPANY ORGANIZATION - OPERATIONS



*CHAIRMAN OF THE BOARD OF ENVIROSPHERE COMPANY
**DIRECTOR OF COAL PROJECTS

PROJECT EXPERIENCE

OTHER EXPERIENCE

HARZA-EBASCO

PROJECT EXPERIENCE

OTHER EXPERIENCE

HARZA-EBASCO

C(C) EXPERIENCE

The Harza-Ebasco Joint Venture has extensive experience in all aspects of the design and licensing of hydroelectric projects and the design and construction of underground facilities for hydroelectric and other projects. Specific discussions are provided for the following five recent major projects undertaken by Harza or Ebasco:

1. Guri Hydroelectric Project, Venezuela
2. Chicago Tunnel and Reservoir Plan, Illinois
3. Bath County Pumped-Storage Project, Virginia
4. Keban Gorge Hydroelectric Project, Turkey
5. Ludington Pumped-Storage Project, Michigan

The project descriptions follow the format stipulated in the RFP for the Susitna Project except that the distinction between Project Description (Section a) and Services Provided (Section b) has been made more distinct. We have used Section (a) exclusively for the project description. Section (b) has been used to describe the exact services performed by the Joint Venture participants including specific involvement in project planning and completion of electrical power system studies.

1. GURI HYDROELECTRIC PROJECT

a. Project Description

The Guri Project, on the lower Caroni River, Venezuela, is being constructed in stages, with an ultimate generating capacity of 10,300-MW from 20 units scheduled for completion in 1986. The initial phase, completed in 1969, consists of a 100-m high concrete gravity dam with rockfill wing embankments, a 30,000-m^3/s spillway, a 9600-m^3/s safety fuse plug, and a three unit, 580-MW powerhouse. The second stage, completed in 1977, consists of an extension of the initial powerhouse and penstocks 4 through 10, bringing the total power rating to about 2,000 MW. This entailed the construction of a $3,000,000, record size cellular cofferdam between unit 3 and the spillway. The final stage, begun in 1978, involves raising the existing reservoir by 52 m, and building an additional ten-unit powerhouse. Staged construction, which was planned in the original design, allowed a smooth construction sequence in the raising process.

The dam, when raised to its final elevation, will be 162 m high and form a reservoir at elevation 270 m with a capacity of

135,000 million m^3 and a surface area of 4250 km^2. It will be comparable with the largest reservoirs in the world.

The Caroni River drains 89,200-km^2 of the Guayana Shield Region in eastern Venezuela. The Lower Caroni River has an average annual flow of almost 5,000-m^3/s. At the Guri site, 90-km from the Orinoco River, sufficient storage is available to control almost completely the variable flow of the river. The Guri site controls some 97 percent of the flow of the Lower Caroni. About 73 percent of the runoff occurs in the wet season, from May through October, while the remaining six-month season has only 27 percent. Storage at Guri augments the critical dry season flow. The initial project regulates streamflow on a seasonal basis and brings the regulated flow to more than five times the minimum flow. Analysis of the potential floods on the Caroni River has indicated a probable maximum inflow of 48,000-m^3/s.

Guri concrete structures are found on granitic gneiss of the Guayana Shield Area, a stable Precambrian rock mass. This very hard rock is being crushed for coarse and fine aggregate as there is a lack of natural aggregate and sand deposits. The final stage involves the placement of 6,711,000-m^3 of concrete and 95,242,000-m^3 of fill. The final stage work which is now about 35 percent complete will bring the capacity to 3,000-MW by 1983 and then progressively to 10,300-MW by 1986.

b. Services Provided

Harza's involvemnet with Guri began in 1959 and is continuing throughout all phases of the project. The following items highlight the specific services provided by Harza:

- Review of earlier studies made by others and determination of the hydroelectric potential of the Caroni River.

- Feasibility studies, including power market studies, and preparation of a report establishing the general concept and economic feasibility of the project.

- An environmental assessment of the final stage project.

- Preparation and analysis of bidding documents for the general construction, procurement and installation of equipment; and analyses of bids.

- Final design and preparation of detailed construction drawings.

- Review of equipment designs as prepared by manufacturers.
- Engineering supervision of construction which included provision of a Resident Engineer and key resident staff.
- Shop inspection and supervision of testing of equipment during manufacture and fabrication.
- Supervision of final acceptance tests of the project.

During the period of May 1980 through June 1982, Harza served as construction manager for the Guri Project, furnishing personnel to direct the construction work and purchasing equipment required to keep the construction on track while the client was negotiating a change of construction contractors. Harza services during this period included field supervision of construction activities, such as concrete batching, mixing, placing and finishing.

c. Dates of Design Work

Table C-1
DATES OF GURI DESIGN

Stage	Engineering Design Started	Engineering Design Completed	Project Construction Scheduled (Initial)	Project Construction Completion (Actual)
Initial	1961	1970	1968	1970 1/
Second	1970	1977	1977	1977
Final	1973	1988 2/	1986	1982 2/

1/ Construction began in 1963; original schedule was delayed by 18 month work stoppage in mid-1968 by construction contractor.

2/ Construction began 1973; original schedule was delayed by two year work stoppage in 1976 by construction contractor. Four new contracts were negotiated in 1980. Refer to Engineering News-Record (29 July 1982) for further details on the construction history of Guri.

d. Project Location and Ownership

The Guri Hydroelectric Project is located on the Lower Caroni River, in the State of Bolivar, Venezuela. The Caroni is the most downstream right bank tributary of the Orinoco River.

The project is owned by the Corporation Venezolana de Guayana - Electrificacion del Caroni (CVG-EDELCA). The Alaska Power Authority may contact the following individuals for information about Harza's performance on the project.

1. Dr. Rodolfo Telleria V.
   Past General Manager CVG-EDLECA (Up to 1978)
   Present address:

   Plaza Centroal Torre B
   10th Floor Office A
   Caracas, Venezuela

   Telephone Caracas 283-51-79
   283-63-64

   Telex 28107

2. Dr. Efrain Carrera S.
   Vice President and General Manager (1978 to date)

   Present address:

   C.V.G. Electrificacion del Caroni, C.A.
   Direccion Obras de Guri

   Apartado No. 62413
   Caracas, Venezuela
   Telephone Caracas 910-479

   Telex EDELCACS 21650

e. Cost of Design Services[1/]

Stage	Design Work Cost ($ Millions)	Related Construction Cost ($ Millions)
Initial	4.4	130[2/]
Second	2.5	8[illegible][3/]
Final	140[4/]	4460[5/]

1/ Services performed by Harza

2/ The total project cost including change orders and claims paid to construction contractor exceeded initial budget by $15 million.

3/ Initial total cost was estimated at $78 million. The cost overrun was due principally to the single bid $42 million received for construction and installation which was $11 million over the engineers original cost estimate of $31 million.

4/ This figure includes an estimated $60 million to be billed for engineering services between now and project completion in 1988.

5/ In 1978 a contract for $3,750 million was signed for civil work and equipment installation. In 1980, it became necessary to cancel this contract. In 1980 four new substitute contracts were negotiated and raised the original costs by $710 million.

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f. Type of Contract

The services provided by Harza have been billed on the basis of cost plus percentage fee.

g. FERC Licensing

FERC licensing was not required for this overseas project.

h. Cost Control and Scheduling

Project scheduling in 1961 was based on projected load growth in the EDELCA system through 1985. Harza provided EDELCA with estimates of cost for the planning and design of the Stage I dam, based on man-hour estimates by the design description division heads for the tasks to be performed by their work forces.

Prior to 1976 when a computer based budget and cost control monitoring program was initiated, the division heads recorded the man-hours spent on a weekly basis, as the work was performed, comparing the aggregate hours spent with the status of the work and the total man-hour budget. A similar record was kept by the project manager in order to enable him to spot potential overspending by individual divisions, or on a given task as a whole. Although the system involved considerable input, the cost to the project was more than offset by the value of keeping the work on track.

In 1976 the monitoring of man-hour budgets for this as well as other Harza projects became the responsibility of an enlarged Budget and Cost Control Section, which previously had monitored only billings. Man-hour budget and expenditures henceforth were analyzed by computer, with the project manager being provided a biweekly printout of man-hours expended by each section. Used in conjunction with the Work Planning and Review form, which projects future time expenditures for each task or subtask, the management of man-hour budgets by computer has proven highly effective.

2. CHICAGO TUNNEL AND RESERVOIR PLAN

(major underground project)

a. Project Description

The Chicago Tunnel and Reservoir Plan (TARP is the largest urban flood and pollution control project ever constructed. It will serve the 375-square-mile metropolitan Chicago area which currently depends on an overburdened combined storm and sanitary sewer system. Principal features of the project include:

- 131 miles of 9- to 36- ft diameter tunnels 180 to 300 ft below ground,
- 252 vertical drop shafts to divert wet-weather flows into the tunnels from 640 existing combined sewer overflow outlets,
- Three quarried reservoirs of 83,000, 40,000 and 27,000 acre-ft storage capacity,
- Two underground pumping stations of 710 and 150 mgd capacity to lift the collected wet-weather flows to existing sewage treatment plants or to storage reservoirs.

Coupled with other drainage improvements, the TARP system will practically eliminate combined sewer overflows to the area's waterways and the associated releases of contaminated water to Lake Michigan.

b. Services Provided

Harza has been continuously involved since 1965 in the planning, investigations, design, and construction phases of TARP and earlier versions of the plan. The City of Chicago and the Metropolitan Sanitary District of Greater Chicago were the principal public agencies sponsoring the project. Six consulting engineering firms have handled parts of the work. Harza's specific assignments during the early planning and investigation phases are outlined below:

Chicago Deep Tunnel Plan

1965 - Prefeasibility Studies

1967 - Feasibility Studies

1967 - Planning, supervision and monitoring of subsurface exploration program
(24 boreholes with laboratory testing and geophysical logs plus 280 miles of seismic geologic profiles)

Lawrence Avenue Sewer (one of three Pilot Projects)

1966 - Appraisal Study

1966 - Construction Drawings and Specifications

1968 - Services During Construction

Harza Services During Planning. In late 1970 the Metropolitan Sanitary District of Greater Chicago (MSDGC) and the City of Chicago joined with officials of Cook County and the State of Illinois to reactivate the Flood Control Coordinating Committee which had coordinated earlier studies. The revitalized committee appointed a Technical Advisory Committee to direct specific engineering for the development and examination of alternative plans. Engineers from many public agencies and consulting firms participated in a wide array of studies. Harza's specific assignments during this phase of planning were:

Northside Tunnel Plan

1971 - Subsurface Exploration Program
(70,000 ft of borehole, 48 observation wells, hydrologic studies)

1971 - Alternative Tunnel Systems Studies

Chicagoland Flood and Pollution Abatement Plan

1971 - Benefits/Costs of Pumped Storage

Chicago Underflow Plan

1973 - Preliminary Design of Storage Reservoirs

Utilizing the studies by Harza and other consultants, the Flood Control Coordinating Committee had by 1972 evaluated the cost effectiveness of a series of 57 alternative system plans.

The selected alternative was the one which had been designated as the Tunnel and Reservoir Plan or TARP.

Through this planning phase Harza studies and evaluations had covered such topics as aquifer protection, hydraulic optimization of systems, establishment of geotechnical planning parameters and design criteria, pumped-storage power generation, economic analyses, environmental assessment, and financing analysis. Disciplines involved within the sequence of Harza assignments included urban hydrology, hydraulics, sanitary engineering, geology, geotechnical engineering, hydrogeology, and engineering economics, in addition to the traditional fields of civil, structural, electrical, mechanical and construction engineering.

Harza Services During Design: The 1972 report of the Technical Advisory Committee had identified the TARP as a $1.2 billion project(1972 prices). This estimate was based on a 10-year construction schedule starting in 1972 with 6 percent annual cost escalation.

In May 1973 Harza received the assignment from the MSDGC to confirm and refine the conclusions of the 1972 report of the Technical Advisory Committee. The principal concerns were the optimization of the number and location of quarry reservoirs and the diameters of the resulting tunnels. Harza's report in October 1973 recommended specific sites, locations, and sizes for the reservoirs, the pumping station, and the tunnels. Harza also estimated costs and recommended construction of the system in two phases for economic, geologic, and construction reasons.

Phase I, which is primarily for water pollution control, eventually received 75% construction grants from USEPA. Phase II, which is primarily for urban flood control, remains under study by the Corps of Engineers to determine the appropriate federal role in urban drainage. Phase II has become the focus of a national debate on this issue.

The recommended plan included three major tunnel and reservoir systems:

- Mainstream and Lower Des Plaines area
- Calumet area
- Upper Des Plaines area

In October 1973 Harza began developing preliminary designs for the Mainstream Tunnels. This scheme provided for construction of an initial 40.5-mile tunnel along the Mainstream route that extends far enough to intercept all overflow points along the waterways. This Phase I system will reduce polluting overflows by 85 percent. Phase II was planned by Harza with sufficient flexibility that quarried reservoirs and additional tunnels could increase storage and conveyance capacity to any desired level of flood and pollution protection.

Based on geotechnical factors, the size of anticipated construction contracts, and the scheduling of construction, Harza recommended that the Phase I Mainstream Tunnels be constructed under eight contracts.

The MSDGC began final design of the upstream Addison to Wilmette contract segment with their own staff. Harza prepared the engineer's estimate of construction costs and provided other technical support for this design effort.

Harza was assigned final design of the remaining seven Mainstream contract segments in three contracts awarded in 1974 and 1975. A summary of the major underground structural project features designed by Harza is given in Table C-3. In addition, Harza designed many connecting structures, and the mechanical, electrical, and control systems for the pumping stations and other control features.

Table C-3

SUMMARY OF UNDERGROUND STRUCTURAL

FEATURES OF TARP DESIGNED BY HARZA

CHAMBERS (in limestone and shale)
2 Pumping stations each 105-ft H X 63-ft W x 213-ft L

TUNNELS (limestone and shale)

Diameter,ft	Length,ft	Lining
33	44,804	concrete
30	92,420	partial concrete
20	18,237	unlined
13	6,648	concrete

SHAFTS (limestone and shale)

Purpose	Number	Diameter,ft	Total Depth,ft
Construction	7	25	1,710
Access	6	3.5	1,537
Vent	12	6 to 8	3,203
Drop Inlet	99	4 to 17	25,107

Construction Contracts Awards: Harza assisted in presentations to funding agencies during 1975. The TARP project was endorsed by the Illinois and U.S. EPA's in mid-1975. Construction grants from these agencies allowed the project to move ahead.

The Addison to Wilmette segment of the Mainstream Tunnel designed by MSDGC was the first segment bid in October 1975. The low bid was 4 percent below the Engineers Estimate which had been prepared by Harza.

Construction contracts for five Mainstream System segments designed by Harza were bid between September 1977 and January 1978. The five bids totaled $480 million. This total was 2.0% over Harza's initial estimate and 6.2% below Harza's final estimate. More details on the bidding of these five contracts and that for the Mainstream Pumping Station are given in Table C-4.

Harza Services During Construction: Since 1978, Harza has provided office and resident engineering services on five of the Mainstream tunnel construction contracts which totalled $480 million. Completion is expected in 1983, about one year ahead of schedule, and substantially under budget.

In October 1979 Harza was awarded a contract to provide services during construction of the Mainstream Pumping Station, a $261 million project. In addition to providing office and resident engineering services, Harza is preparing manuals for maintenance and operation of the pumping station.

c. Dates of Design Work

Information regarding specific dates for TARP is included in sections b. and e. of this project description.

d. Project Location

The project is located in the Greater Chicago urban area. The Power Authority may contact the following individuals at the Metropolitan Sanitary District of Greater Chicago, 100 East Erie St., Chicago, IL. 60611.

Mr. Frank E. Dalton
Deputy Chief Engineer
(312) 751-7856

Mr. Joseph H. Irons
Supervising Civil Engineer
(312) 751-5588

Table C-4

SIGNIFICANT DATA
PROPOSED CONTRACTS

CHICAGO TUNNEL AND RESERVOIR PLAN MAINSTREAM TUNNEL SYSTEM

Location	Construction (Phase)	Length, Feet	Preliminary Est. Cost 1/ Millions of Dollars	Engineers Estimate Millions of Dollars	Date of Engineers Estimate	Low Bid Millions of Dollars
59th-Central	(1)	18,804	46.6	85.6	8/77	86.5
Central-Damen	(1)	26,000	65.7	116.2	8/77	99.0
Damen-Roosevelt	(1)	17,316 2/	61.6	114.4	9/77	107.8
Roosevelt-Ogden	(1)	13,778 3/	38.9	99.9	10/77	102.0
Ogden-Addison	(1)	22,614	51.3	94.2	12/77	85.2
Mainstream Pumping Station	(1)	47,733	100.0	249.0 4/	7/79	261.6

Notes: 1/ Estimated Costs are construction contract costs only. Not included are costs for project related services such as administrative, legal, engineering, etc. Costs are based on: labor rates from ENR, July 3, 1975; equipment costs from Construction Equipment Cost Reference Guide updated to July, 1975; tunnel and raise boring machine costs from Manufacturers recommendations; material cost for the Chicago area as listed in ENR July, 1975; and include an escalation factor of 6% per year applied over an assumed 5 year construction duration period starting July 1975. Connecting structure contracts and costs are not included.

2/ An additional 8,089 feet of 30 foot diameter tunnel is required for South Fork of the South Branch of the Chicago River. Cost for this work is included in the above.

3/ An additional 6,681 feet of 15 foot diameter tunnel is required for the Chicago River branch to Lake Michigan. Cost for this work is included in the above.

4/ The Pumping Station Contract as awarded included the 73rd Street to 59th Street branch tunnel but was not included in the preliminary estimate.

e. Cost of Design Services

Details of design and construction service contracts between MSDGC and Harza are presented in the following summary and in Table C-4.

Contract No:	A53103 Supervision of Subsurface Exploration Program and Design of Tunnels (2 segments - Damen to 59th St.)
Total Funding:	$1,328,000 (Cost reimbursable with ceiling)
Subcontracting:	$33,000
Period of Performance:	Dec. 73 to Oct. 76
Record of Performance:	Harza met the schedule which was set in response to the flow of funds from USEPA within the original ceiling price.
Contract No:	A62705 - Design of Mainstream Tunnels (3 segments - Addison to Damen) $782,150 (cost plus fixed fee with ceiling)
Subcontracting:	$105,900
Period of Performance:	July 75 to Sept.77
Record of Performance:	Harza met the schedules set periodically as USEPA released funds for the project.
Contract No:	A64529 - Design of North Branch Tunnel
Total Funding:	$1,149,240 (cost plus fixed fee with ceiling)
Subcontracting:	$251,100
Period of Performance:	Dec. 75 to June 79

Contract No: A64485 - Design of Mainstream Pumping Station

Total Funding: $2,750,000 (cost plus fixed fee with ceiling)

Subcontracting: $230,600

Period of Performance: Dec. 75 to Sept. 79

Contract No: A76421 - Services During Construction of Mainstream Tunnel

Total Funding: $17,000,000 (cost reimbursable with ceiling)

Subcontracting: $3,819,000

Period of Performance: Jan. 78 to Jan. 84

Record of Performance: Construction of the tunnels is currently ahead of schedule and under bid estimates.

Contract No. A87267 - Services During Construction of Mainstream Tunnel Pumping Station

Total Funding: $5,765,200 (cost reimbursable with ceiling)

Subcontracting: $824,000

Period of Performance: Oct. 79 to Nov. 84

Record of Performance: Construction of the pumping station is on schedule and budget.

f. Type of Contract

The Harza-MSDGC contracts are either cost plus fixed fee with ceiling or cost reimbursable with ceiling, as noted in the preceding summary.

g. FERC Licensing

This project did not involve FERC licensing.

h. Cost Control and Scheduling

Typical of Harza consulting services, project work was initially scheduled by outlining project work tasks in detail, establishing a critical path of task priority and laying out in calendar sequence the timing and duration of each task. This initial schedule has been frequently revised by the client in response to changing situations of the project, financing and work scope.

Cost control is provided by establishing a man-hour budget, assigning technical groups and personnel and identifying production elements for each work task. Each technical group involved in a task is assigned a budget linked to specific items of the work task they will produce. In this way the budget is controlled in relation to work items produced. Budgets are reviewed every two weeks with lead engineers in charge of particular work tasks. Computer printouts quickly indicate variances from the man-hour budget and production schedules so remedial actions can be implemented before any serious problems develop.

3. BATH COUNTY PUMPED-STORAGE PROJECT

a. Project Description

When completed in 1986, the Bath County Pumped-Storage Project will be largest project of its kind in the world. It will have an installed capacity of 2,100 MW and reservoirs large enough for 11 hours of continuous full load power generation. In addition to being the largest pumped-storage project in the world, the Bath County Project will have the distinction of having the highest dam in the United States east of the Mississippi River. From core trench foundation to crest level, the upper reservoir dam will be 475 feet high and will create a 36,500-acre-foot reservoir with 22,500 acre-feet available for power generation.

The project consists of two dam and reservoir complexes with interconnecting tunnels and a powerhouse. The lower reservoir will be formed by a dam on Back Creek, while the upper reservoir will be formed in the hills above it, on Little Back Creek. The lower reservoir dam will be 135 feet high with a total storage capacity of 30,500 acre-feet and its impoundment will be approximately 1,000 feet below the level of the upper reservoir. In order to maintain and improve the natural stream flow characteristics of Back Creek, 3,200 acre-feet of reservoir storage will be reserved for minimum releases during periods of low flow, and 2,500 acre-feet will be reserved for flood control storage.

Both dams were designed for zoned earth and rockfill construction. Spoil from excavation for the tunnels, powerhouse, and intake will provide much of the shell material needed for constructing the dams.

Static and dynamic analyses of both the upper reservoir and lower reservoir dams have been made using the latest available finite element methods. The type of computer analyses used are essentially the same as those used in the design of the LaHonda Dam of the Uribante-Doradas Project.

Water conduits, surge tanks, drainage, and construction access tunnels constitute a significant part of the construction effort at the project. More than one million cubic yards of rock have been excavated from these underground structures, with most being used as fill for the dams.

Three 28.5-foot power tunnels will start at the intakes on the east side of the upper reservoir. They will run at a two percent slope for an average distance of 3,600 feet and then drop vertically for approximately 990 feet. At the lower level they will return to the 2 percent slope for an average distance of 3,415 feet. Approximately 1,000 feet from the powerhouse, the three conduits will bifurcate into six 18-foot penstocks.

Shaft-type surge tanks 350 feet high and 44 feet in diameter are being provided for each power tunnel to dampen flow surges resulting from sudden load rejection or acceptance by the generating units. For aesthetic and structural reasons, the surge tanks are located underground.

Ground stability and the control of seepage and groundwater have been major concerns in the design of the Bath County Project. Because the steep-sided slopes of the upper reservoir will be subjected to daily drawdowns of up to 105 feet, the overburden is being removed from portions of the drawdown zone to prevent slides. This overburden is being used to construct the upper dam. Drainage tunnels with drain holes encircle the surge tanks to prevent possible seepage from saturating the hillside rock and causing blowouts. Two additional drainage tunnels are located approximately 150 feet above the penstocks to collect groundwater and any seepage from the power conduits. These tunnels will effectively limit the external groundwater pressure on the penstocks to the head differential of 150 feet.

The Bath County powerhouse is located on the west side of the lower reservoir, about one mile upstream from the lower dam. The Francis-type pump-turbines have guaranteed pumping capacities, at the normal maximum head of 1,270 feet, of 3,000 ft^3/sec per unit and at the normal minimum head of 1,100 feet, 4,100 ft^3/sec. Operating heads will range from 1,280 to 1,103 feet. The maximum total pumping load will be 2,400 MW at 21,000 cfs.

b. Services Provided

Summary of Services: Harza services include geological site studies, FPC licensing and engineering design services for civil, mechanical and electrical facilities for all of the Bath County Project except switchyard, transmission lines, public roads and bridges. A number of specialized services also were provided.

Geotechnical Studies: Harza planned and supervised an extensive exploration and testing program, with about 60,000 linear feet of core drilling, for both geologic exploration and location of construction materials. An exploratory adit some 900 feet long was excavated. Tests were carried out inside the adit to obtain tunneling and penstock design data, including tunnel convergence and deformation measurements, plate bearing tests, rock bolt pull-out tests, and long-term studies of the stability of the exposed rock. Harza prepared the specifications for these studies and administered the drilling contracts.

Subsurface exploration drilling to determine foundation characteristics and geologic conditions of project features consisted of 146 holes with the cumulative total of 49,502 feet. Exploration of riprap and aggregate source areas consisted of 100 holes with a total of 11,356 feet. In addition, holes were drilled for the diversion channel, bridge sites, road relocation, and horizontal drain and seepage investigation.

Exploratory Adit: The adit was excavated under Harza's supervision to evaluate tunneling conditions and to measure in-situ properties of the rock mass in order to establish criteria for the final design and the construction of the underground works. Field studies included the geologic mapping of the tunnel walls, core holes, a shotcrete test section, rock bolt test section, and a comprehensive program of in-situ rock testing.

The test program conducted by Harza to determine the in-situ properties of the rock mass included:

1. Tunnel convergence measurements.

2. Multiple position borehole extensometers.

3. Borehole overcoring tests.

4. Plate bearing tests.

5. Rock bolt pull-out tests.

A total of 993 feet of adit was excavated under Harza's supervision by Gates and Fox, of Loomis, California, under subcontract to Daniel Construction Company, Greenville, South Carolina.

Geophysical Investigation: Geophysical surveys were implemented by Harza in order to maximize the information available from the core holes. Downhole geophysical logs were obtained to assist in the determination of stratigraphic correlations and to provide measurements of in-situ rock properties, such as shear and pressure wave velocity, shear, bulk, Young's Modulus, porosity, density, and Poisson's Ratio. A total of 27 holes were surveyed by the Birdwell Division of Seismograph Service Corporation under the direction of Harza, from which temperature, caliper, gamma ray, neutron, density, and velocity logs were obtained.

Seismic refraction surveys were carried out by Weston Geophysical Engineers, Incorporated, to provide data concerning the depth and nature of the various soil and rock horizons in the upper reservoir area. Harza analyzed the geophysical logs to establish stratigraphic correlations within the Chemung Formation in the upper reservoir area and to confirm the correlations determined from examination of the drill cores.

Construction Materials Investigations: A thorough investigation has been made by Harza technical personnel of the available earth and rock materials occurring in the project area. In these investigations, geologists have assisted soils engineers in their search for suitable materials, particularly in the search for suitable rock material for riprap and aggregate. Rock samples from potential source areas were examined both petrographically and by X-Ray diffraction techniques to determine the rock mineral constituents.

Environmental Studies: Detailed environmental studies were carried out prior to preparation of the FPC License Application, as well as in response to questions raised during the licensing process. The baseline studies in preparation of the environmental report (Exhibit W of the FPC License Application) were done by VEPCO, assisted by several special consultants. Some of the more important studies carried out by Harza were:

- Temperature and water quality studies of the upper and lower reservoirs

- Sediment control planning for Back Creek and Little Back Creek

- Visual impact analyses for the upper reservoir access road

- Riffle-pool analyses of Back Creek

- Planning and designing of recreation facilities

- Design of a permanent wastewater treatment plant that serves the construction force and will serve the general public and the operating personnel after completion of the project.

Harza also provided written testimony for the FPC proceeding of the license application. Several Harza technical personnel functioned as witnesses for the proceedings.

Project Planning and Power System Studies. The project planning tasks carried out by Harza were the initial layouts of the project site after the site was selected by VEPCO. Harza also did the initial sizing and resizing of the project facilities. Harza carried out the power system studies needed for the economic evaluation of integrating the Bath County facilities into the overall VEPCO power system.

c. Dates of Design Work

Harza began engineering design of the Bath County Project in 1972 with startup planned for 1979. Although initial plans called for four units and 1,500 MW of power, subsequent design studies led to plans for six units and 2,100 MW. In 1974, the owner decided to delay the project and ordered all work stopped except for licensing assistance activities. Work resumed in 1976 in anticipation of receiving a license, which was finally received in 1977. Startup was scheduled for the first three units in 1982 and for the second three units in 1983. In 1977 the planned startup was again delayed one year by VEPCO to 1983 and 1984. In 1978, VEPCO advanced startup to 1982.

In May 1980, VEPCO again delayed the work for two years and rescheduled startup for three units in 1985 and 1986, respectively. An overall schedule of project activities is presented below.

1970-72. Site feasibility studies, drilling, geology, soils, environment and recreation

1972-73. Major design phase.

1973. FPC License Application submitted.

1974-76. Client temporarily halts engineering design services.

1977. FPC license approved.

1977. Site construction activity begins.

1978. Project construction begins.

1980-82. Client temporarily halts construction.

1985. Online service of first three units begins; completion of recreation facilities.

1986. Completion of total project.

d. Project Location and Owner

The project is located in Bath County, north-central Virginia. Its owner is the Virginia Electric and Power Company, P.O. Box 564, Richmond, Virginia 23204. Persons to be contacted regarding the quality of Harza's services are:

Mr. James M. Hagood, Jr.

Director of Hydroelectric Engineering

(804) 771-6103

and: Mr. S. C. Brown

Vice President

(804) 771-3274

e. Cost of Design Services

Construction design work was conducted from 1977 to present with only a minor amount prior to 1977. Total billings for design related work to July 1, 1982 were $16,554,393. Total billings, not including exploratory work, were $25,778,408. This total includes licensing activity, Services During Construction, Resident Engineering, and Special Assignments not related to design.

Billings for design work, 1975 to July 83	$16,554,393
Billings for Services During Construction	6,068,047
Billings for Resident Staff	3,011,864
Billings for special services	144,104
Total 1975 to July 1, 1982	$25,778,408

An initial estimate of engineering costs was made in 1977 prior to the client's most recent delay in the work. The cost estimate was revised in 1980 to reflect the impact of delays. The latest cost estimate for engineering including Construction Management Services is $43,244,00. We are presently approximately $500,000 under this estimate.

The first cost estimate for the six-unit plant (December 1972), with startup planned for 1979 was $469 million. The most recent (February 1981) cost estimate, including all delays and cost escalations and with the 1985-86 startup, is $1,651 million.

f. Type of Contract

Services have been billed on the basis of cost plus percentage fee.

g. FERC Licensing

Harza assisted the project owner in the preparation of the FPC license application which was submitted in 1973. In particular Harza prepared all of the following Exhibits in addition to assisting the client in the preparation of other exhibits and in responding to questions from FPC regarding the application:

J. General Map of Project Area

K. Detail Map of Project Area

L. General Design Drawings of Principal Structures

M. General Description of Equipment and Appurtenances

R. Proposed Recreation Plan

h. Cost Control and Scheduling

The scheduling of the Bath County Pumped-Storage Project has been revised frequently by the client in response to agency actions and load demands. The project presently is on schedule for the desired 1985-86 startup.

Cost control is accomplished by means of annual budgets in which each task to be done is scoped and budgeted. Each technical group contributing to the task is assigned budget for their part of the work. The budget is controlled by review every two weeks of computer generated summaries of time used and work produed. Variances are reviewed with lead engineers in charge of the particular task and remedial actions are implemented in budget and schedule objectives as required.

4. KEBAN HYDROELECTRIC DEVELOPMENT

a. Project Description

This hydroelectric project is located within the Keban Gorge on the Euphrates River, approximately 30 miles northwest of city of Elazig, Turkey,

The major project features are: The Keban Dam consisting of both a zoned earth and rockfill dam and concrete gravity dam. The earth and rockfill dam has a maximum height of 690 feet and volume of 21 million cubic yards. The concrete gravity dam has a maximum height of 295 feet and volume of 1.3 million cubic yards. The total crest length of Keban Dam is 3,606 feet. The concrete gravity portion includes the intake, spillway, and transition sections. The intake structure provides a separate inlet for each unit with gates suspended by the intake hoists. The spillway is a gated structure with a capacity of 477,000 cfs. There are 8 separate penstocks, 17 feet in diameter. The Keban reservoir is about 163 miles long, has a surface area of approximately 158,000 acres, and has a storage volume of about 24,330,000 acre-feet. The drainage area for the project is approximately 25,000 square miles.

The fully enclosed powerhouse has eight vertical shaft Francis turbines nominally rated at 155 MW at a head of 475 feet. Total installed capacity is 1,240 MW generating 6×10^9 kWh average annual energy. Initially the power plant went into commercial operation with four 155-MW units. Four additional units were installed in 1981.

The Keban Project represented a major challenge in foundation engineering to provide protection against serious geologic hazards. The foundation rock consists largely of subhorizontal massives of limestone and marble, with some impervious schist, which are generally moderately hard and sound. Extensive solution by groundwater created numerous caverns of various dimensions in the limestone. Additionally, major faulting and displacement had occurred in the project area. To successfully cope with the underground cavity system, comprehensive subsurface treatment was required to ensure the watertightness of the foundation and the integrity of the main dam and its appurtenant structures.

The main dam is a zoned rockfill embankment, 690 feet high and 2,215 feet in length, having a central impervious core, filters and transition zones and a compacted rockfill shell. This portion of the dam has a total volume in excess of 21,000,000 cubic yards. The dam is 36 feet wide at the crest and is curved slightly in the upstream direction to ensure compression of the core when the dam deflects under the applied load. Both upstream and downstream slopes are 1.85 horizontal to 1.0 vertical. The upstream cofferdam is incorporated into the upstream shell. Principal features of the embankment design are described below.

The core and the upstream and downstream fine and coarse filter zones were carried to sound rock throughout the entire foundation. The central impervious core is designed with both the downstream and the upstream faces having slopes of 6 vertical to 1 horizontal. The core has a minimum width of 26 feet increasing uniformly to a maximum width of about 197 feet at its base. A continuous grout curtain is provided below the core and into the abutments. Fine and coarse filter zones having uniform widths of 13 feet each are provided upstream and downstream of the core. In addition, a fine rock zone having a minimum uniform width of 10 feet is provided between the coarse filter and rockfill shell zones. The shell zones consist of compacted rockfill obtained by quarrying the limestone at the site and have 50 feet wide zones on the upstream and downstream faces, reserved for oversized rock.

The regional geology is quite complex with the oldest rock at the site being schists and marble, covered by limestone. All are strongly faulted. Although a wide range of rock competence was encountered, underground work for two 50-foot diameter diversion tunnels involving over 380,000 cubic yards of excavation and extensive rock treatment was successfully completed under the supervision of an Ebasco team of geologists and engineering personnel. Rock judged to be competent was left unlined and only the tunnel invert was paved. Other sections were sufficiently competent to remain exposed temporarily but required concrete lining. In faults and broken rock, rock bolts were installed followed by structural steel bents. The steel supports were carried to the spring line wherever the side wall rock was competent. Where the sides were broken it was necessary to carry the bents down to the invert level. Concrete lining was required over substantial sections of the tunnel.

The foundation rock is largely made up of limestone and marble, with several beds of schists also present. Initial site exploration disclosed that the limestone, normally a very competent rock had been subject to solution activity and that design of a reliable grout curtain would be required. To successfully cope with this natural underground cavity system, mainly from the point of view of establishing a watertight cutoff but also in some cases to ensure sound structural support, very extensive undergound treatment was necessary. Whenever economically feasible, every effort was made to avoid adjustments in the location of surface structures by the application of in-depth treatment of the fault zones. For a typical example, studies were carried out to determine the effect of a fault zone, up to 100 feet in width, which closely paralleled a concrete gravity section and which was located immediately downstream of this structure. Finite element models were prepared for several sections of the gravity dam and of the rock foundation for a width of 450 feet and depth of 300 feet into the foundation. the finite element models were analyzed for water, gravity and earth pressure loads to determine foundation and structure stress distributions and deformations. The treatment solution adopted in the foundation of this gravity section consisted of constructing a series of underground foundation struts normal to the axis of the dam and downstream of the monoliths to transfer applied loads safely to the foundation.

The most substantial difficulty was that of providing a watertight grout curtain. A maze of faults and accompanying solution caverns and readily erodible fault fill-in materials, such as clays, calcite and gravels within the cavernous and faulted foundations took more than 390,000 cubic yards of concrete grout. Most of the grouting was done from an intricate network of adits--more than 39,000 linear feet driven to depths 40 feet below the Euphrates River gorge bottom. In size, most adits ranged from 8 x 8 feet up to 15 x 16 feet. The deeper adits demanded grouting ahead of the face from higher level adits before shooting, to prevent groundwater inflow during advances. Recesses excavated into the downstream side of the adits allowed downhole exploratory drilling without disturbing the mainline work.

Foundation exploration and grout curtain work moved in step. As an example, approximately 100,000 feet of rotary exploratory holes were drilled from the lowest adit, some of the holes extending 650 feet below the adit or almost 1,400 feet below the top of the dam. More than 980 feet of 2 to 3 inch diameter holes were drilled from the foundation adits to construct the grout curtain. Where the foundation conditions were too poor for a grout curtain to provide reliable cutoff a diaphragm wall was constructed. This type of concrete cutoff wall, after being developed at Keban, has subsequently been used to treat similar foundation problems on several other major projects.

b. Services Provided

The services provided by Ebasco throughout the development of the project included feasibility studies, detailed power system and transmission studies, conceptual design, detailed design and engineering, procurement, financial services, construction management and project start-up.

c. Dates of Design Work

Start: 1965

Completed: 1974

d. Project location and Ownership

The project is located within the Keban Gorge on the Euphates River northwest of Elazig, Turkey.
Owner's Name: Develet Su Isleri - State Water Works
Government of Turkey

For Contact: Refic Akarum, Chief of Dams Ankara, Turkey
Bakenlikar, Ankara, Turkey
Telephone: 90-41-18-1100

e. Total Project Cost: $458,000,000

Ebasco Cost Involvement: $ 22,000,000

f. Type of Contract: Cost plus fixed-fee.

g. FERC Licensing

FERC licensing was not required for this overseas project.

h. Cost Control and Scheduling

Project cost control and scheduling activities were accomplished utilizing a manual system. This system developed equipment schedules indicating when purchase orders were to be placed as well as detailed estimates of quantities and cost which were used to develop bar charts showing construction activities. This manual system has been replaced by a computer aided system as described for the Ludington Pumped Storage Project.

5. LUDINGTON PUMPED STORAGE PROJECT

a. Project Description

The Ludington Pumped Storage Project is the largest facility of its type in the world. It is located on the Michigan Lower Peninsula on the east shore of Lake Michigan, which is the lower reservoir for the plant. It was awarded ASCE's "Outstanding Civil Engineering Achievement Award" in 1973. The Project consists of an 82,000 acre-foot upper reservoir, an intake structure, buried steel penstocks, a six-unit powerhouse with a total capacity of 1,872 MW, lakefront protection and a 345-kV switchyard.

The 2.2-mile long by 1 mile wide upper reservoir with a gross capacity of 82,000 acre-feet is contained within a six-mile-long embankment constructed of over 37 million cubic yards of fill averaging 103 feet in height. Inside slopes of the embankment are faced with 535,000 tons of hydraulic asphalt concrete and the bottom of the reservoir is lined with a clay blanket on a pervious base 800 feet above bedrock.

The six unit intake structure was designed with the help of extensive model studies to minimize the effect of 20 feet per second discharge velocities exiting from the penstocks in the pumping mode and to avoid energy reducing vortices in the generating mode. The six steel penstocks vary in diameter from 28.5 feet to 24 feet and have a total weight of 17,000 tons. For esthetic reasons the penstocks were buried to permit an uninterrupted view of the bluff above Lake Michigan.

The powerhouse is a semi-outdoor type 600 feet long by 120 feet wide and extends 85 feet below lake level. This structure which is supported on a dense clay, required over 220,000 cubic yards of concrete and 10,000 tons of reinforcing steel. The six pump-turbines and generator-motor units are the largest ever constructed in both power and physical size. They are each rated at 312 MW, 450,000 hp, an inlet diameter of 24 feet, runner diameter of 27.5 feet and a generator-motor diameter of 69 feet. A 350-ton station gantry crane services the units.

Lakefront protection consists of two jetties extending 1,600 feet into the lake and a breakwater 1,850 feet long, 2,700 feet from and parallel to the shore. Extensive model testing was utilized to determine location, shape and height of jetties and breakwater to insure protection of the powerhouse against high waves and to prevent scour as the units discharge up to 80,000 cfs.

b. Services Provided

Ebasco performed the preliminary feasibility studies, licensing, design engineering, procurement, and construction management of the entire Project and actual construction of selected portions of the project as discussed below.

Scheduling. The Ludington Project was constructed on an extremely tight schedule. Close coordination of design and construction was required to effect completion of the dike and powerhouse in a relatively short construction period of three years and four months. An early result of this planning effort was the decision to design and build a two-stage powerhouse which permitted early completion of exterior walls and slabs. Erection of the turbines and generators as well as placement of the second stage concrete could then be accomplished under a temporary roof without delays due to weather.

Selective winter operations were also planned in order to meet schedule objectives, and mitigate the deterimental effects of the weather in Northern Lower Michigan. Excavation and delivery to the site of 2.5 million cu. yds. of clay permitted placement to proceed in the spring when thawing road conditions caused severe restrictions on axle loadings. Similarly adequate quantities of aggregates were stockpiled during the fall, before deliveries by bulk lake carriers were halted by ice, to permit placement of 50,000 cu. yds. of concrete during the worst of the winters of 1970-71 and 1971-72. The 180 cu. yds. per hour batch plant was winterized and provisions made to heat the aggregate stockpiles and mix water by the concrete supplier. Exterior forms were insulated, and protective enclosures heated by steam were installed at the powerhouse to maintain optimum curing temperatures during cold weather. A concrete laboratory at the site handled field sampling and other tests needed to insure tight quality control. Fly ash was employed to improve workability and reduce cement quantities.

Test Fill Program. Extensive soils testing preceded and continued throughout the construction period focusing mainly on the construction of the embankment and lining to develop the "method type" specifications employed and to ensure that the earthwork contractor fulfilled the specifications for the embankment and reservoir. The heterogeneity of the soils made it impractical to rely on a performance specification. Therefore, an extensive test program that was undertaken to develop reliable method specifications determined the most suitable compaction equipment required for each of the four zones, the thickness of each layer, the number of passes, speed of machine and the optimum mositure content.

Numerous Consultants and Subcontractors. Because of the pioneering approach to the design and construction of the project, many consultants and laboratories were employed to assist in analyzing soil conditions, developing rigid specifications for dike fill, the asphalt dike liner and the clay reservoir lining. Twelve consulting engineers and about 25 subcontractors were involved in these testing and laboratory programs. Actual construction was performed by about 60 subcontractors except that Ebasco placed all the concrete and installed the mechancial equipment and piping systems with its own forces.

Foreign Procurement, Vendor Quality Assurance (VQA) and Expediting. Much of the equipment installed on this project was provided from foreign sources for either economic reasons or because it was not manufactured in the U.S.A. The turbines and generators were furnished by Hitachi. Resident inspectors were stationed in Japan during the fabrication and factory assembly of these huge machines, maintaining close surveillance of the entire manufacturing and quality control procedures. The ten main power transformers were furnished by ASEA in Sweden and the generator-side air blast breakers were fabricated by Brown Boveri in Switzerland. Although not in full time residence at each factory, Ebasco's specialized electrical VQA inspectors stationed in Europe made frequent visits and witnessed all required tests before the equipment was released for shipment. Ebasco's Traffic and Expediting Department also made major contributions in assuring the safe and on-schedule delivery of those pieces of equipment that often were on the critical path to trial operation of each unit.

c. Dates of Design Work

Design and preparation of FPC License Application started in 1967. Drawings and specifications were completed in 1971. Construction was completed in 1973.

d. Project Location and Owner

The project is located on the east shore of Lake Michigan about four miles south of the town of Ludington, Michigan and 47 miles north of Muskegon. It is owned jointly by Consumers Power Co. and the Detroit Edison Co. For additional information, the Alaska Power Authority may contact:

Mr. C. R. Bilby, Vice President
Consumers Power Company
212 West Michigan Avenue
Jackson, Michigan 49201
(517) 788-0550 x1515

e. Cost of Design Services

Engineering and design services were performed at a cost of approximately $16,000,000. Initial estimated cost and actual cost of the project:

1967	FPC Estimate	$176,000,000
1970	NY Estimate	220,300,000
1973	Final Cost	239,084,000

f. Type of Contract

Cost plus fixed fee.

g. FERC Licensing

Ebasco prepared all drawings and technical exhibits for the FPC application, provided expert witnesses at the public hearings and analyzed all FPC stipulations. We were successful in persuading FPC not to require a concrete spillway for the Upper Reservoir, although we did provide a small fuse plug spillway in a natural drainage channel.

h. Cost Control and Scheduling

At the time that engineering and design activities were being performed for the Ludington Project, Ebasco did not utilize an earned value type of cost and schedule control system such as they currently employ. The Ludington Project did, however, use a computer-based cost control system which relied on a Project Cost Engineer and Project Planners to support the management of technical services functions.

At the start of the project, a three-page detailed bar chart schedule was developed as a baseline master schedule. From this, a CPM was established for engineering, construction and startup services, all of which were provided by Ebasco. The CPM was computerized to facilitate its regular update. Using the CPM, specific dates for task start and finish were identified to the lead engineers in each discipline. The lead engineers, then developed manpower projections on a discipline basis, to complete the total project, making a correlation between task requirements in manpower terms and schedule dates. This information was fed into a computerized manpower control system. Each month, a printout was sent to the Project Cost

OTHER EXPERIENCE

Engineer and each Lead Discipline Engineer (LDE) which provied-ed, for each discipline:

- Actual workdays expended for the month
- Forecast for the month
- Variance for the month
- Accumulative workdays expended on the project
- Forecast for the next year on a monthly basis
- Forecast for subsequent years to complete the project
- Total budget for the project (discipline)
- Variation between actual expenditures plus forecast work-days to complete and approved budget

The LDE and Cost Control Engineer would, each month, work together to assess the reasons for project variations and update the cost report. The cost control data was included as part of the monthly report.

In addition to the cost update, the LDE would work with the Project Planner to identify actual start/finish dates relative to CPM requirements. His input would be assessed and any problems or potential problems caused by delays were identified. Corrective action plans were then developed to assure that schedule dates were met.

Capital cost was controlled through the development of monthly cost reports and quarterly updates which compared the latest cost projections with the most recent estimate of capital cost. This was also the first hydroelectric project which accumulated and maintained accounting records and cost report information on a jobsite computer. Detailed backup for the cost reports included monthly printouts of each class of concrete with unit prices and manhours for the individual components (e.g. forms, reinforcement, embedments, etc). The system proved to be of great value in maintaining close control of the concrete operation. Table C-5 tabulates trial operation and commerical operation dates which were scheduled in 1968, demonstrating the success Ebasco had in controlling progress.

Table C-5

LUDINGTON PUMPED STORAGE

CONSUMERS POWER COMPANY & THE DETROIT EDISON COMPANY

Completion Schedule

	Trail Operation		Commerical Operation	
Unit #	Schedule	Actual	Schedule	Actual
1	11-01-72	11-18-72	01-03-73	01-17-73
2	02-01-73	02-23-73	03-01-73	03-15-73
3	04-01-73	04-12-73	05-08-73	04-28-73
4	06-01-73	05-29-73	06-25-73	06-11-73
5	08-01-73	07-27-73	10-01-73	08-06-73
6	10-01-73	09-18-73	11-30-73	09-28-73

OTHER EXPERIENCE

HARZA-EBASCO

C (i) EXPERIENCE IN COLD REGIONS

Susitna design concepts must be developed which are appropriate to the subarctic conditions at the site. For example, foundation treatment of the left abutment of the Watana Dam must consider the presence of permafrost. The thawing of the permafrost by the reservoir during project operation will affect seepage through the abutments and possibly foundation deformation. The severe weather conditions and the discontinuous permafrost in borrow areas are factors which will affect the scheduling of dam construction and the specific use of materials in the dam. The glaciation that occurred during recent geologic history has left relict river channels on both banks backfilled with tills and outwash.

Prior to project construction, the ongoing site investigations must be planned and conducted with full knowledge of the site climatic conditions.

The Joint Venture, its subcontractors and consultants have extensive experience in working in subarctic climates and at sites subject to glacial effects.

Harza Experience

Harza has been working in a subarctic environment continuously for the past 25 years. This work has been primarily in Iceland where Harza has successfully executed three projects:

- Burfell Hydroelectric Development
- Thorisvatn Lake Diversion
- Hrauneyjafoss Hydroelectric Development

The activity in Iceland has provided full knowledge of the engineering and construction problems resulting from severe weather conditions.

Burfell Hydroelectric Development

Harza's work began in Iceland in 1957 with planning, engineering and economic studies that supported subsequent decisions to proceed with the Burfell Project. Extensive field investigations, carried out from 1959 through 1965, included topographic mapping, overburden soundings, diamond core borings, permeability testing, ground water measurements, locating and testing sources of natural construction materials, geologic mapping, hydrographic surveys, hydraulic measurements, route reconnaissance for roads and transmission lines, driving an exploratory tunnel, ice investigations, and meteorological observations.

The Thjorsa River is a glacial river and carries a considerable amount of bed load in the form of basalt sand, lightweight volcanic cinders and pumice. Unqiue ice problems are also present in the river and had to be contended within the design of the intake for this run-of-river project and its spillway.

The major ice problem is represented by sludge ice. Frazil ice is formed on the broad, shallow, frequently braided but swiftly flowing reaches of the river upstream of the site and particularly in an upstream tributary. The flow can be as much as 1500 cfs or more of loosely packed ice. Additionally, ice bridges form upstream. They are formed by a combination of floating sludge ice, anchor ice and cake ice. These partial dams create backwater and resulting head until the pressure produces a rupture and consequent floods downstream which are called "step bursts" which could reach a peak of 20,000 cfs.

The solution adopted, after extensive hydraulic models studies in the River and Harbour Research Laboratory at the Technical University of Norway at Trondheim, was designed to reduce, insofar as feasible, the effects on ice and bed load on power generation. Reservoir storage at Burfell to solve the ice and bed load problems was ruled out by economic reasons. The layout briefly consists of a diversion dam with a spillway consisting of four fishbelly flop gates and a section of uncontrolled spillway with flashboards to pass normal flows as well as "step bursts".

A diversion inlet structure to the right of the spillway was designed to pass the flow containing the bed load as well as the ice skimmed from near the surface of the water on downstream while permitting the mid-depth water to pass into the power canal to the units. This structure requires sluicing water or "waste water" to transport the ice and bed load downstream. The quantity of sluice water varies with the time of year. It was also necessary to include a gate control tower on the diversion inlet structure to permit gate operation in advance of "step bursts". The gate control tower is only manned during the winter, when "step bursts" occur. A warning system located upstream alerts the operator to the "step burst" flow.

It was acticipated at the time of design that a reservoir would be constructed upstream of Burfell at the confluence of the Tungnaa River. This upstream reservoir is now under construction; it will eliminate the ice problems at Burfell and reduce the bed load transport.

A paper presented before the American Society of Civil Engineers 19th Hydraulic Division Conference in Iowa City, Iowa August 18-20, 1971 titled "Ice Passing Facilities at Burfell Project" and authored by C. K. Willey is included in this section. It describes in detail this solution for the bed load and ice problems.

Harza provided complete engineering and design services, prepared contract documents for construction and for procurement of all equipment, and provided a resident staff of engineers and technicians during construction. Project construction began in 1966, and was essentially complete in 1969 when first commercial operation of the units commenced.

Thorisrvatn Lake Diversion

During the early 1970's Harza, in association with Icelandic partners, provided complete exploration, engineering, design and construction surveillance services for the Thorisvatn Lake Diversion. The diversion of Thorisvatn included construction of two dams, canals leading both to and from the lake and control structures. The successful completion of the lake diversion project has provided a substantial increase to the energy output at Burfell.

Hrauneyjafoss Hydroelectric Project

Feasibility and planning studies for the Hrauneyjafoss Hydroelectric Project began during the early 1970's. Detailed mapping, exploration of foundation and borrow sources, pump out tests, hydraulic modelling, and route studies for access roads and transmission lines were conducted. The potential for leakage from the reservoir through highly permeable scoriaceous basalt and through mixed ash, sand and gravel interbeds between the basalt flows was studied extensively. Foundation treatment consisted of deep core trench excavation, dental concrete, and extensive grouting.

Construction at Hrauneyjafoss began in 1977 and was essentially complete in 1981, when reservoir filling and first commercial operation of units began. Evaluation and analysis of the data from piezometers, observation wells and weirs has shown that the foundation treatment for the dam and dikes was successful.

Other Experience

At the Mossyrock Hydroelectric Project in Washington, as at Watana, the action of glaciers forced the shift of the river from channel to channel, leaving behind a series of till and outwash filled bedrock valleys. At Mossyrock, as will be the case at Watana, the selection of the relict channel treatment demanded careful analysis of the stratigraphy of the several till and outwash layers and of the potential for seepage, piping and instability of the till slopes exposed to the reservoir. Seismic refraction surveys, in-situ permeability tests, groundwater observations, and sampling and testing of the various strata were required to provide input to the hydrogeologic analysis of the relict channel and to the seepage and stability studies. The results of the field and office studies led to the selection of a drainage curtain as the most appropriate relict channel treatment. The curtain consisted of six-inch-diameter wells, spaced 20 feet on centers, constructed through the till and outwash. The wells were connected to a drainage adit so that seepage flows attracted to the system were carried downstream by gravity. The performance of the drainage system was monitored by a network of observation wells, which provided the data needed to evaluate the hydrogeologic regime both before and after reservoir filling. The treatment was completely successful.

In addition, Harza has been selected by APA to execute three of its projects. These involve the engineering and design of the Black Bear Lake Hydroelectric Project, the feasibility study of the Chester Lake Hydroelectric Project, and the assessment of energy alternatives for the Bethel region. These activities add to our growing experience in cold weather regions.

Ebasco Experience

Ebasco has performed engineering, design and construction services on power stations in cold regions for the past 20 years. This work has been primarily in the northern states of Michigan, Minnesota and Montana. Three projects are noteworthy, where extremely cold weather conditions were a significant factor in the design and construction.

The Ludington Pumped Storage Project in Michigan and the Clay Boswell Steam Electric Station in Northern Minnesota are exposed to extremely cold winter conditions. Ebasco's engineers and constructors had to schedule the large earth moving operations with regard to cold weather precautions. The earth structures were protected by loose sacrificial lifts and berms which were removed prior to the next season's work. Another significant consideration was cold weather concreting, which involved special design mix precautions as well as special placing and curing techniques. Heating and thawing of frozen ground prior to placing foundations was common in order to maintain construction schedules in temperatures of 15° to 25°F below zero.

The Noxon Rapids Hydroelectric Project in Montana was designed and constructed by Ebasco and involved construction of large concrete gravity dam structures in extremely cold winter conditions. A particularly noteworthy aspect of this project was the existence of a relict river channel buried in the glacial formations upstream of the dam. This relict channel, very similar to that at Watana, was instrumented and treated.

Ebasco also has designed and analyzed various large mine tailings dams and water recovery systems for a taconite facility in northern Minnesota. On occasion the temperature at these locations drops below -40°F and these facilities have in-corporated functional design and construction methods to take care of low temperatures.

In Alaska, Ebasco has performed geotechnical design and foundation engineering with respect to the installation of a gold mining and processing facility at the old Independence Mine near the Susitna Project Site. This work was performed for ENSEARCH Exploration Company which is the owner and operator of the facility.

With respect to studies and cold region engineering required for arctic and subarctic conditions, Ebasco has performed two significant works:

The first is a thorough review of the James Bay Project in Northern Canada, This study involved site visits by Ebasco engineers and review of the feasibility of treating the numerous channels, dams, dikes and powerhouses as well as the preferred sequential development of the vast project.
In this review Ebasco recommended to the James Bay Corporation, the preferred method and sequence of development for the Project with recognition of the Arctic conditions and their effect on the construction and on the economics of the work. The present development, now under construction, is the scheme recommended by Ebasco.

The other project is the recently performed independent cost review of the Susitna Project performed for the Power Authority. This study and cost evaluation also involved site visits by Ebasco's engineers and discussions of the design, engineering and construction methods necessary to sucessfully engineer and construct the Project under the conditions found at the Watana and Devil Canyon sites.

Harding Lawson Experience

Harding Lawson Associates (HLA) has provided geotechnical engineering services throughout the State of Alaska for over 12 years. Their services include investigation of soil and permafrost conditions, using both drilling and geophysical techniques, installation and interpretation of instruments for observing temperature, ground water, settlement and deflection, and inspection and monitoring of foundation and embankment construction. The following project list indicates the range and scope of work provided.

Rock Island Development Project

The work was performed in the summer of 1981 and the winter of 1981-82, for the Exxon Company, U.S.A. HLA provided geotechnical criteria for the conceptual design of this first oil and gas development in the Arctic Ocean. Their services included both onshore and offshore soils investigations using Rolligon and barge mounted drilling equipment and onshore and marine geophysical techniques. Of special interest was the marginally bonded saline permafrost soils encountered offshore. An extensive laboratory testing program was performed including conventional unfrozen soil tests and frozen thaw-strain, strength, and thermal conductivity testing. Analysis was performed for pile design in both onshore and offshore permafrost, fill material sources, strength and deformation characteristics of both frozen and unfrozen embankments, thermal properties of the soils, pipeline protection from sea ice and thaw settlement studies. Engineering services amounted to $3,000,000.

Seal Island Exploration Site

This project was performed in the winter of 1981-82 for the Shell Oil Company. The 60-foot high island was constructed in 40 feet of water and involved about 600,000 cubic yards of fill. During the placement of the fill, HLA monitored fill quality and ice content and resulting fill density. Following completion of the fill placement, we instrumented the island with slope indicators, thermistor strings, and borehole extensometers to monitor lateral deflections, temperatures and settlement. HLA's billings were $200,000.

Barrow Utilidor System

This work for Frank Moolin & Associates began in 1978 and is continuing. The object of HLA's work has been to provide soil and permafrost engineering services for the design and construction of a buried, walk through, city-wide, warm utilidor system. We investigated the soil and permafrost conditions, which consist of high ice content permafrost containing considerable brine zones. Analysis included evaluation of backfill materials, thermal analysis for design of insulation systems, and pile design for both cold and marginal permafrost zones.

Harrison Bay Regional Study

The objective of this study, performed in the winter of 1981 - 82 for five petroleum companies, was to develop geotechnical data for the cost evaluation of oil and gas leasing. Using on-ice drilling and cone penetration equipment, HLA investigated the offshore soil and permafrost conditions to identify material sources and foundation conditions for the construction of petroleum exploration facilities. The remote field investigation required the development of an on-ice camp, Roll-A-Gon, helicopter and fixed wing support equipment.

EBA Engineering Consultants Ltd Experience

EBA's staff have a broad background in operating on Canada's frontiers, in both a physical and a technical sense. This is based on more than a decade of Arctic onshore experience and more than five years of offshore experience.

They have extensive experience in the geothermal analysis, the design of structures on temperature-sensitive soils, the development of subsurface investigation techniques in arctic and marine environments, and the development of advanced laboratory facilities and data monitoring systems. These procedures have evolved in large part through the firm's participation in major natural resource development projects and the design of arctic offshore structures.

EBA has provided geotechnical consulting services for a variety of terrestrial arctic projects. The projects have included site investigations and engineering analyses for major proposed pipelines, compressor stations, tailings dams, municipal projects, and communications towers. Locations span the arctic region from Point Barrow, Alaska to Frobisher Bay, Baffin Island. EBA has been responsible for planning and executing field programs to collect geotechnical data and following through with engineering design for these projects.

EBA's involvement in northern projects since 1969 has resulted in the development of some innovative solutions for problems unique to permafrost regions. These innovations include the following:

- Modification of the CRREL ice coring auger for sampling frozen soils.
- Adaption of a high frequency vibratory drill for use in extensive sampling programs in permafrost soils.

- Development of reliable instrumentation for monitoring ground temperatures.

- Development of a computerized data bank for storage and retrieval of borehole and laboratory data.

EBA has been instrumental in the development of a two-dimensional, finite element computer program to model heat transfer processes associated with the aggradation or degradation of permafrost. This analytical tool has found extensive application in assessing the behavior of heated structures found on frozen soil, such as:

- Foundation designs incorporating heat pipes or ventilation systems

- Instrumentation and analysis of a gas pipeline test facility

- Thermal analysis of road and railway fills

- Evaluation of the settlement and frost heave potential of pipelines in permafrost, and a buried oil production system at Norman Wells, N.W.T.

EBA will analyze the effects of construction, the reservoir and project operation on the permafrost in the dam abutments and foundations. In addition, because of their experience and capability in the instrumentation, sampling and testing of frozen soils, their assistance will be required for the detection of permafrost in borrow areas, the evaluation of the effects of permafrost in materials utilization, and the study of methods to thaw ground ice prior to grouting.

Frank Moolin & Associates Experience

Design experience of Frank Moolin & Associates, Inc.,(FMAA) encompasses various projects located in the arctic and subarctic regions of the State of Alaska. These projects total approximately $350,000,000 in value. Projects range from those designed for construction on continuous permafrost at Alaska's northern most city of Barrow, located on the Arctic Ocean, to those designed for construction on discontinuous permafrost at other locations, or on no permafrost at the southern city of Valdez, located on Prince William Sound.

FMAA's arctic and subarctic design experience covers three major areas: 1) Design only projects, 2) Design and project/construction management projects, and 3) project/con-struction management projects that include design review responsibility.

Design Only Projects

Alascom Earth Station, Prudhoe Bay. FMAA provided complete design services for this satellite communications complex. The design involved civil/site design, foundation design for a 13-meter satellite antenna structure, and a 150-ft. high communications tower, as well as the complete architectural, structural, mechanical, and electrical design for the communications operations building. A pile type foundation was used and special consideration was given to thermal balance because of heat generated by electronic equipment.

B. J. Hughes Multi-Use-Facility, Prudhoe Bay. FMAA provided complete design services for a 40,000 sq. ft. multi-purpose facility. The facility houses a dry-mix concrete bulk plant, a heavy equipment maintenance shop, a wash rack, specialized drilling equipment, offices, parts storage and break rooms. Because of extremely heavy load conditions, a unique geotechnical (foundation) design was required to be integrated with structural and thermal design considerations. The outcome was a design that included a freeze back system for the foundation. The project utilized a fast-track design approach to allow the client to construct the facility in a minimum of time.

Design and Project/Construction Management

Barrow Utilities System, Barrow. The largest project that FMAA is currently working on is design and project/construction management for the Barrow Utilities System. The project consists of designing a complete water and sewer system for population use of over 5,000, and performing project/construct-ion management services from inception to completion of the project scheduled for 1985.

Unique design concepts were utilized to ensure safe, reliable construction of the system in continuous permafrost. The system consists of a man-sized, below-ground wood utilidor, connecting service utiliducts, lift stations, a water distribution plant, and elevated and buried arctic pipelines. This project is state-of-the-art: a system of this type has never before been constructed in continuous permafrost. It requires detailed geotechnical and thermal design analysis and testing to ensure that thermal balance is maintained in the utilidor and other facilities in an energy efficient manner to obtain optimum operation of the system and to prevent degradation of the permafrost. Other design factors considered were the use of local labor for construction and the need for high reliablility and maintainability because of the harsh arctic environment and remote location.

FMAA also is providing all project/construction management service for the project including field engineering, quality control, inspection, project control (cost and scheduling), contract administration, logistics support, site construction management and home office design support.

Design Review and Project/Construction Management.

Container Terminal and Floating Dock, Valdez. FMAA is provided complete project/construction management services for this facility, including design review. FMAA serves as an extension of the Engineering Department of the City of Valdez. The facility consists of a 21-acre dredged and haul filled marshalling yard, 1500-ft causeway and 1500-ft trestle on piles, 700- by 100-ft concrete floating dock, dock mooring and anchoring system, and two 200- by 32-ft steel span dock access ramps. The floating dock is the largest prefabricated concrete floating dock in the world. FMAA reviewed all structural, geotechnical (civil) and electrical designs for this project, as well as materials, constructibility, contract and specifications compliance.

Municipality of Anchorage Capital Improvement Projects, Anchorage. FMAA is providing comprehensive project management services for multiple capital improvement projects within the Municipality of Anchorage, including design review. Major projects include a new headquarters library, a significant expansion of the existing historical and fine arts museum, and olympic size swimming pool, and other projects. FMAA's services include architectural, geotechnical, civil and structural design review as well as review for constructibility and value engineering.

Their knowledge and skills will be used during site investigations for logistic support, for permitting and for management scheduling and cost accounting of the several site investigation contracts. In addition, management services by Frank Moolin and Associates will be required for the design subcontracts for the non-technical facilities.

Special Consultants

The Joint Venture will draw upon the experience and expertise of various consultants for additional support in cold regions engineering and design:

- Dr. R. B. Peck - outstanding experience in the design and construction of major dams in cold regions. Dr. Peck's experience on Churchhill Falls, James Bay and the Susitna feasibility studies is well known.

R. W. (Tink) Martin - expertise in constructibility analyses, materials usage, cost estimating and scheduling. Tink Martin was responsible for the scheduling and performance of all civil related construction activities in Section II of the Trans-Alaska Pipeline and, more recently, was responsible for the management and direction of all construction projects for Alaska International Constructors. His expertise will be used in relating scheduling, materials usage and constructability.

Dr. W. G. Nelson - expertise in Arctic engineering and design. Prof. Nelson's background includes consulting services to government and industry and the teaching of Arctic Engineering at the University of Alaska.

E. F. Lobacz - extensive experience in cold regions engineering and construction. As past Chief, Civil Engineering Research Branch, Cold Regions Research and Engineering Laboratory (CRREL), Corps of Engineers, Mr. Lobacz developed a broad background in foundations, dams, pavements, and materials in cold regions. He is familiar with current civil engineering design and construction practices in cold regions throughout North American, Europe and Asia. His expertise will be used for review of design of the non technical facilities.

C (j) FERC Licensing Experience

A list of projects for which the Joint Venture has provided FERC licensing services during the last 15 years is provided in Table C(j)-1. A substantial discussion of FERC licensing experience during the last five years was provided in the Statement of Qualifications submitted to the Alaska Power on June 3, 1982. That discussion describes, in detail, the complexities of the licensing process for the following projects;

Kootenai River Hydroelectric Project (#2752)
Davis Pumped-Storage Project (#2709)

Table C(j)-1

FERC LICENSING EXPERIENCE

Project	Location	MW Capacity
Harza		
Black Bear Lake	Alaska	6
Jim Falls Hydro Redevelopment	Wisconsin	45
Boundary Addition	Washington	392
Sullivan Creek	Washington	16
Raystown	Pennsylvania	20
Brumley Gap	Virginia	3000
Mayfield 4th Unit	Washington	40
Bath County Pumped-Storage	Virginia	2100
Cornell Hydro Plant Redevelopment	Wisconsin	30
Kootenai River	Montana	144
Mount Hope Pumped-Storage	New Jersey	1000
Stony Creek Pumped-Storage	Pennsylvania	1710

Table C (j)-1 (cont'd)
FERC LICENSING EXPERIENCE

Project	Location	MW Capacity
Montezuma Pumped-Storage	Arizona	250-500
Seneca Pumped-Storage	Pennsylvania	380
Havasu Pumped-Storage	Arizona	500
Raystown	Pennsylvania	2
Mossyrock	Washington	300
Markland	Ohio River, Indiana	65
Ebasco		
Sandy Creek	Washington	6
Grant Lake	Alaska	7
Nooksack Falls	Washington	14
White Salmon River	Washington	125
Davis Pumped-Storage Project	Virginia	2100
Ludington Pumped-Storage Project	Michigan	1895

C(k) Previous Joint Venture Experience

The Joint Venture firms have not worked together in a previous relationship as a Joint Venture but have recently had the experience of performing mutually complementary tasks on the presently under construction Bath County Pumped-Storage Project (See Above for description of the project). Ebasco Services incorporated was retained by Allegheny Power Systems to conduct a complete evaluation and appraisal of the Bath County Pumped-Storage Project. The purpose of the evaluation and appraisal ws to establish cost of the project so that Allegheny Power Systems could establish cost of the project so that Allegheny Power Systems could determine whether or not a purchase of approximately half of the project's installed capacity would be worthwhile. Work tasks included a technical evaluation of project, an appraisal oif the value of construction completed at the time and an estimate of cost to complete the project.

Mr. J. Ehasz, the Chief Civil and Geotechnical Engineer, had overall responsibility for the work being done for Allegheny Power Systems. In this capacity, he and other Ebasco staff members had contact with the Harza Project Manager, Mr. Arvids Zagars and other Harza staff members while reviewing designs, construction progress, and quality of work. Two technical meetings were held with personnel in the analysis of the work done on the project. Upon their review, the client decidded to commit to a purchase of about 40 percent of the project capacity.

Ebasco's evaluation of Harza's design work on the one side, and Harza's opinion of Ebasco's performance during the services for APS on the other side, were mutually complimentary. Also, both companies have been aware of each others past achievements in the hydroelectric field, and thus the mutual contact in connection with the construction of the Bath County Project strengthened the desire to pursue the design of the Watana Project with joint efforts combining the expertise of both companies gained in the past.

The following individuals maybe contacted regarding performance on this assignment:

John H. Bail
Director of Power Engineering
Allegheny Power Service Corporation
800 Cabin Hill Drive
Greensburg, Pennsylvania 15601
(412) 837-3000

Mr. James Hagood
Director of Hydroelectric Engineering
Virginia Electric and Power Company
Richmond, Virginia
(804) 771-6103

PROJECT STAFF

It is also noteworthy that staff members which are currently employed by Ebasco (S. O. Simmons, R. G. Anderson) played significant roles in the licensing activities surrounding environmental issues on the Bath County Project while employed at Harza. Mr. Simmons was responsible for the development of a recreation development plan which was satisfactory to the U.S. Forest Service and other state agencies. He successfully defended the proposed plan in FPC licensing which eventually led to the issuance of a project license.

Mr. Simmons developed the analyses of recreation use while at Harza for the Kootenai Hydroelectric Project. That material was used for the development of Exhibit R for the License Application. Hearings are currently in progress where much of the material Mr. Simmons was responsible for is under construction.

Mr. Roger Anderson played a substantial role in the licensing activities for the Bath County Project where visual impact mitigation was considered an important element of the licensing process. His analyses were used to route project access roads so that the visual impact of these features were of minor environmental consequence. Mr. Anderson also developed the visual impact analyses for the Kootenai River Hydroelectric Project while at Harza. His analyses were used in the development of Exhibit B of the License Application.

Mr. Norm Tilford, who will lead the geotechnical programs, was also a member of the Harza's engineering staff and is a professional colleague and peer of a number of staff members who were his associates while on the Harza staff. Mr. Tilford and members of his staff on this assignment, including Dr. Z. A. Saleem, another past Harza employee, are familiar with the processes and procedures of both organizations which will help in assuring the proper integration of field staff in the support of the project.

AMERICAN SOCIETY OF CIVIL ENGINEERS

19TH HYDRAULIC DIVISION CONFERENCE

Iowa City, Iowa - August 18-20, 1971

ICE PASSING FACILITIES AT BURFELL PROJECT

by

C. K. WILLEY
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ICE PASSING FACILITIES AT
BURFELL PROJECT

By C. K. Willey,[1] F. ASCE

INTRODUCTION

Iceland is an island republic located just south of the Arctic Circle within the North Atlantic as shown on Figure 1. Its area of about 40,000 square miles is inhabited by 203,000 people, dominately descendants of the Norse Vikings, with the admixture of some Celtic blood, who settled the country beginning in 874 A.D. These permanent settlers replaced the original ones, Irish monks, who had arrived about 50 years earlier. Settlement and agricultural development was rapid with the approximately 25% productive land, all located along the coast lines, being utilized fully within the next century by a population reaching about 75,000. That population level remained essentially static until gradual increases started with the 20th century.

This century has seen in Iceland, as in so much of in the rest of the world, the changing of a basically agricultural society into one marked by urbanization and its resulting need for industrialization. Ocean fisheries, still the dominant foreign exchange earner for Iceland, have stabilized; so has agriculture. Mineral wealth in a volcanic country such as Iceland is of minor significance. But Iceland does have relatively abundant, largely undeveloped, potential energy resources in

1/ Vice President, Harza Engineering Company, Chicago, Illinois.

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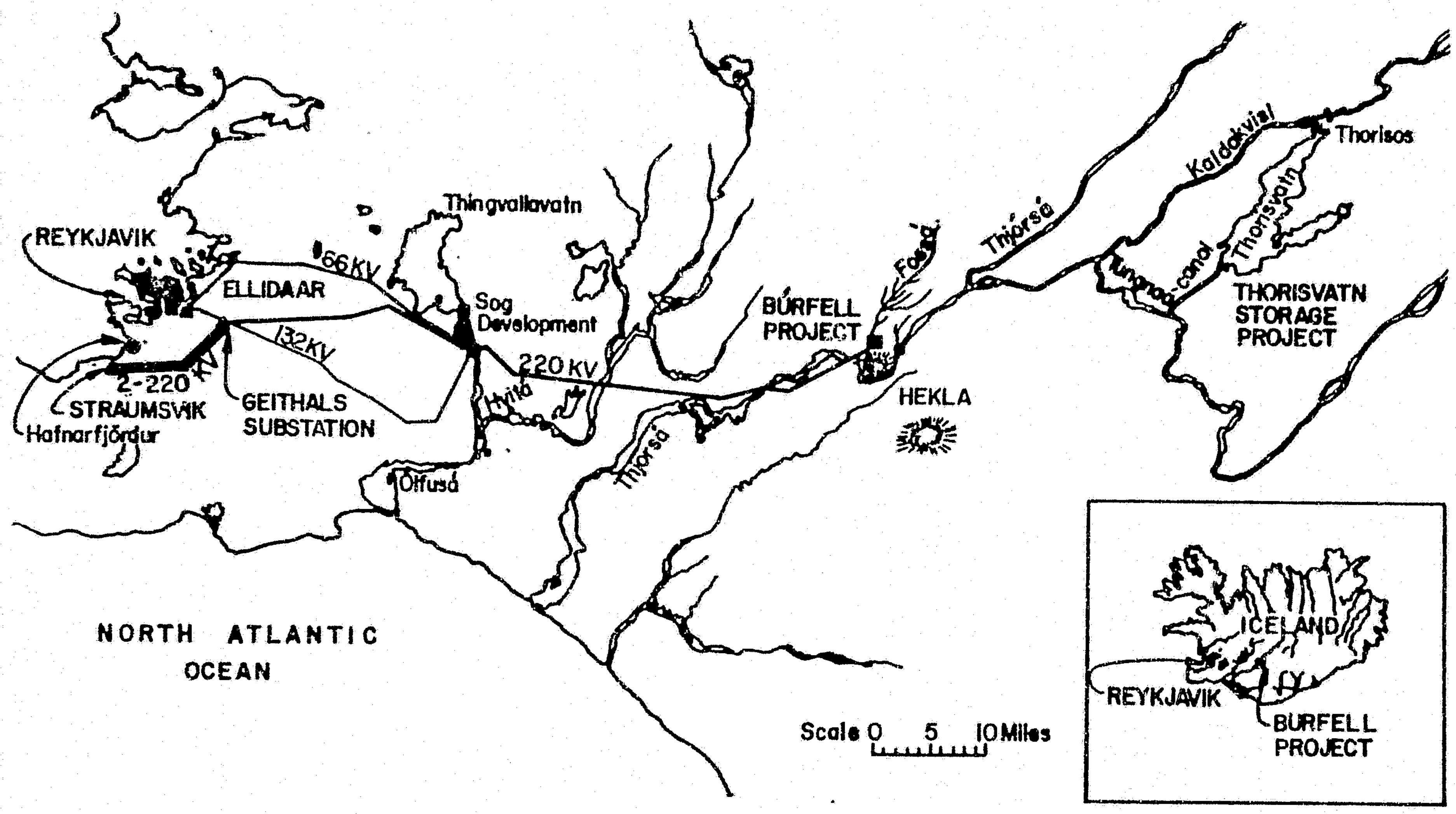


FIG. I - MAPS

OF TASKS PROJECT CONTROL INTRODUCTION

geothermal and hydroelectric form. Fossil fuel resources, however, are lacking. A small portion of the geothermal energy has been used for domestic heating, greenhouse agriculture, and some industrial processes, but not as yet for electric energy generation, except for one small industrial plant.

The development of Iceland's power and energy potential started at the beginning of this century, with expansion since World War II being especially rapid. The completion of plants currently under construction will see development of about 9% of the country's resources, estimated at about 30,000 GWh of economically harnessable annual firm energy. The level of development of hydro generation together with some existing thermal generation means that Iceland may be the world's most electrified nation in terms of per capita power capability and annual electrical energy consumption. Electricity is available to over 97% of the population, including nearly all of those living on the widely scattered farms.

The Burfell Hydroelectric Project, with 210 Mw of rated capacity when the last 3 (of 6) units now under installation are on the line, dominates Iceland's electric energy generation. A high percentage of the Burfell generation is sold to an aluminium smelter. Burfell is Iceland's first power station with over 50 Mw and its size was dictated in large measure by the requirements of the smelter, although rapid growth in the general load of Southwest Iceland was also an important factor. The Project is owned by Landsvirkjun, the National Power Company (NPC), a corporation jointly owned by the State and the Municipality of Reykjavik, the nation's capital city. The corporation has primary responsibility for generation and transmission in Southwest Iceland, the nation's dominant economic region with respect to population, urbanization and industry, including agriculture. Landsvirkjun is searching for additional power intensive industries and has under active planning other relatively large hydro projects and transmission lines to follow Burfell.

The large hydro potential in Iceland is the result of favorable physical conditions. These include a moist climate which is relatively warm in consideration of the northerly latitude, a mountainous terrain providing head, a youthful and glaciated geology providing head concentrations and glacial lake storages, a volcanic setting providing good groundwater storages and natural construction materials, several large rivers, and highland glaciers providing summertime flow without large floods.

The nation's need to industrialize by utilization of its hydro resources to supply a power intensive industry required a development on a large river with a substantial head concentration and location reasonably close to the load center such that a low delivered energy cost could be achieved. This requirement resulted in the selection of the Burfell Project. Earlier development studies for a large project at the site had been made by Norwegians in 1915-17. Construction started in 1966 according to designs prepared by the Harza Engineering Company International. The first 3 units, totalling 105 Mw of rated capacity, started production in September 1969 while the last 3 units are now under installation. The location of the Burfell Project within Iceland is shown on Figure 2.

GEOLOGY AND CLIMATE

Burfell is a run-of-river project located on the River Thjorsa about halfway along that river's course where there is a fall of nearly 400 feet below elevation 800 in 8 miles while circling the small mountain, Burfell. The drainage basin above the Project, shown on Figure 2, is 2450 square miles extending between the 64° and 65° parallels, the latitude of Fairbanks, Alaska. About 30% of the basin is covered by 2 glaciers (ice fields) which extend between about elevations 5500 and 2000 feet in the headwaters of the Central Highlands. The average flow is 11,900 cfs, the maximum recorded flood about 70,000 cfs, and the minimum recorded flow about 2,500 cfs.

Geology and climate exercise important influences on the natural flow at Burfell. The former affects control of the appearance as streamflow of the precipitation furnished by the latter.

The segment of the drainage basin shown on Figure 2 and located to the right (northwest) of the Thjorsa, Lower Tungnaa, and the Kaldakvisl is composed of relatively impermeable older basalts and moraine such that direct runoff of the precipitation is provided and groundwater storage is low. To the left of that general line, the geologic formations consist mostly of highly permeable recent lavas, palagonite, pyroclastics, and pumice; all with virtually no surface runoff. The precipitation enters the vast underground reservoir and becomes almost completely regulated to provide a uniform flow entering the river from springs. The glaciers

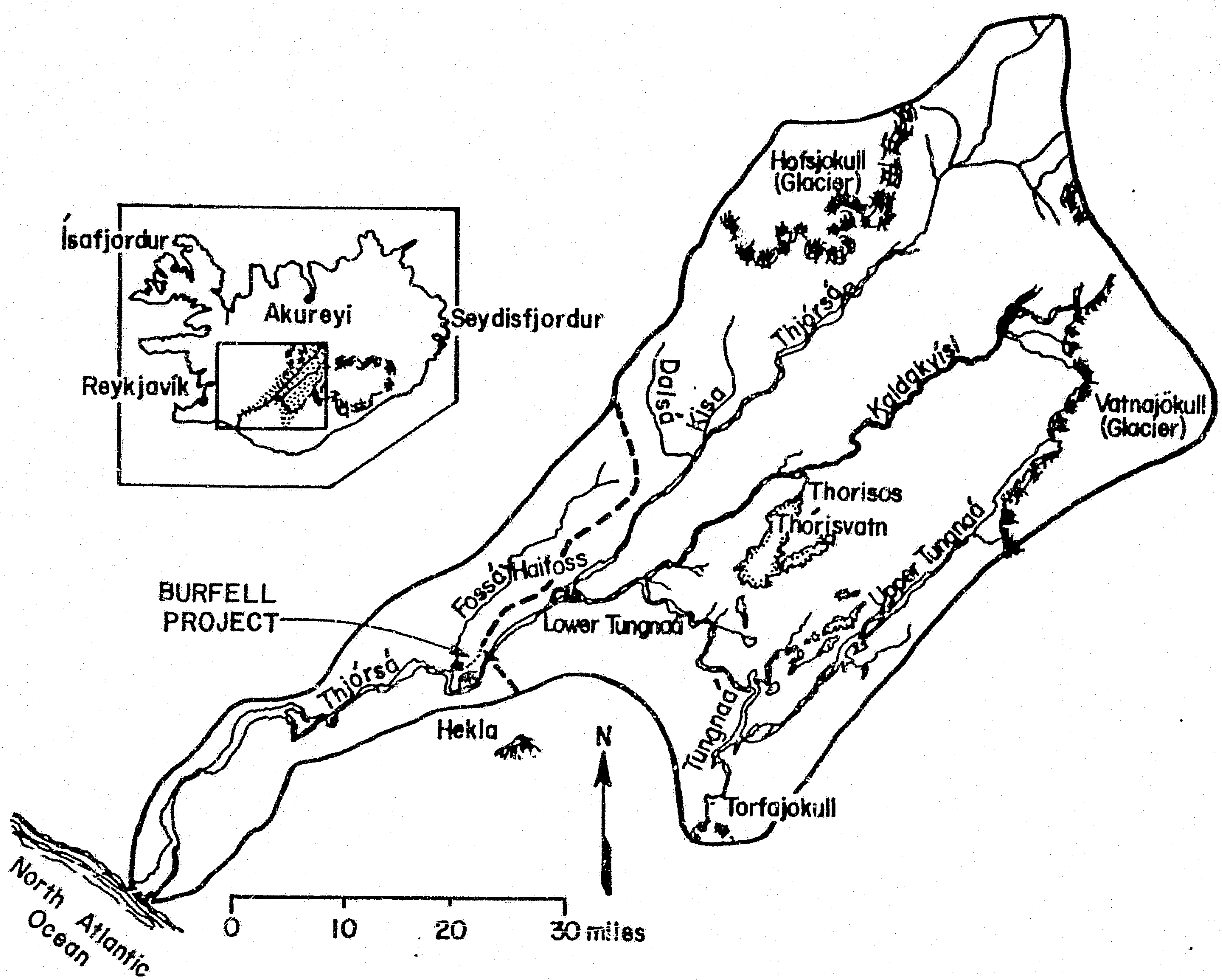


FIG. 2 - THJORSA RIVER DRAINAGE BASIN

represent exceptions to the above in that they provide direct runoff, nearly all by melting phenomena in the summer months.

Iceland is a boundary zone of both air and ocean currents of tropical and of polar origins which affect the climate. Offshoots of the Gulf Stream touch most of the island although a branch of the East Greenland polar current affects the east coast. Arctic drift ice also exerts influence some winters. The climate, then, on the whole is cold-tempered oceanic, but is much warmer in winter than might be expected considering the northerly location.

The weather in Iceland, especially in the winter, is very changeable with the frequent temperature and precipitation fluctuations dependent on the tracks of the atmospheric depressions crossing the North Atlantic as they pass Iceland. There is therefore a constant interchange throughout the year between warm rainy weather from off the Gulf Stream and cold, frequently windy but dry, weather from off the Greenland ice fields. The latter, however, is influenced by the relatively warm seas and the drift ice. The winter temperature is, therefore, relatively mild and the summer temperature relatively cool. Precipitation is usually greatest in the fall and early winter months and lighter in the spring and summer. Orographic influences in the Thjorsa Basin result in precipitation on the higher slopes being considerably heavier than on the lower plains. The normal annual precipitation on the Basin is estimated to vary between 30 and 140 inches depending mostly on altitude. Floods, however, usually occur about March as a result of heavy rain with some snow melt on frozen land surfaces, including some runoff from the normally permeable areas referred to above.

DEVELOPMENT PLAN

The method of development of the Burfell Hydroelectric Project is as shown on Figures 3 and 4. The head of nearly 400 feet is developed by a 3.25 mile long diversion north of the mountain Burfell into the River Fossa, about one mile upstream of its confluence with the Thjorsa. The design power diversion represents a full gate, six-unit plant discharge of 8500 cfs, 70% of the average flow. This power flow is diverted from the Thjorsa through the Diversion Inlet into the Diversion Canal by a low, partially gated, concrete Diversion Weir occupying the river channel and supplemented by low fill dams to high ground on either side. Another low dike extending from the Diversion Inlet to high ground upstream serves to prevent ice from entering the Canal during high river stages. A gated Control Structure in the Diversion Canal provides some control of the flow in that Canal into the Bjarnalon, a pondage reservoir located in a natural depression. An Approach Canal connects the Bjarnalon to the Power Intake which is the entrance to the Power Tunnel passing through the hill, Samsstadamuli. The Tunnel within this hill bifurcates into two partially concrete and partially steel lined Penstocks, each serving three 35 Mw generating units located in a surface, interior type Powerhouse. A Surge Tank is provided in each Penstock. The Tailrace leads from the draft tubes to the Fossa. Transmission lines extend from the Burfell Switchyard to other switchyards interconnecting with other plants and serving load centers in the vicinity of Reykjavik.

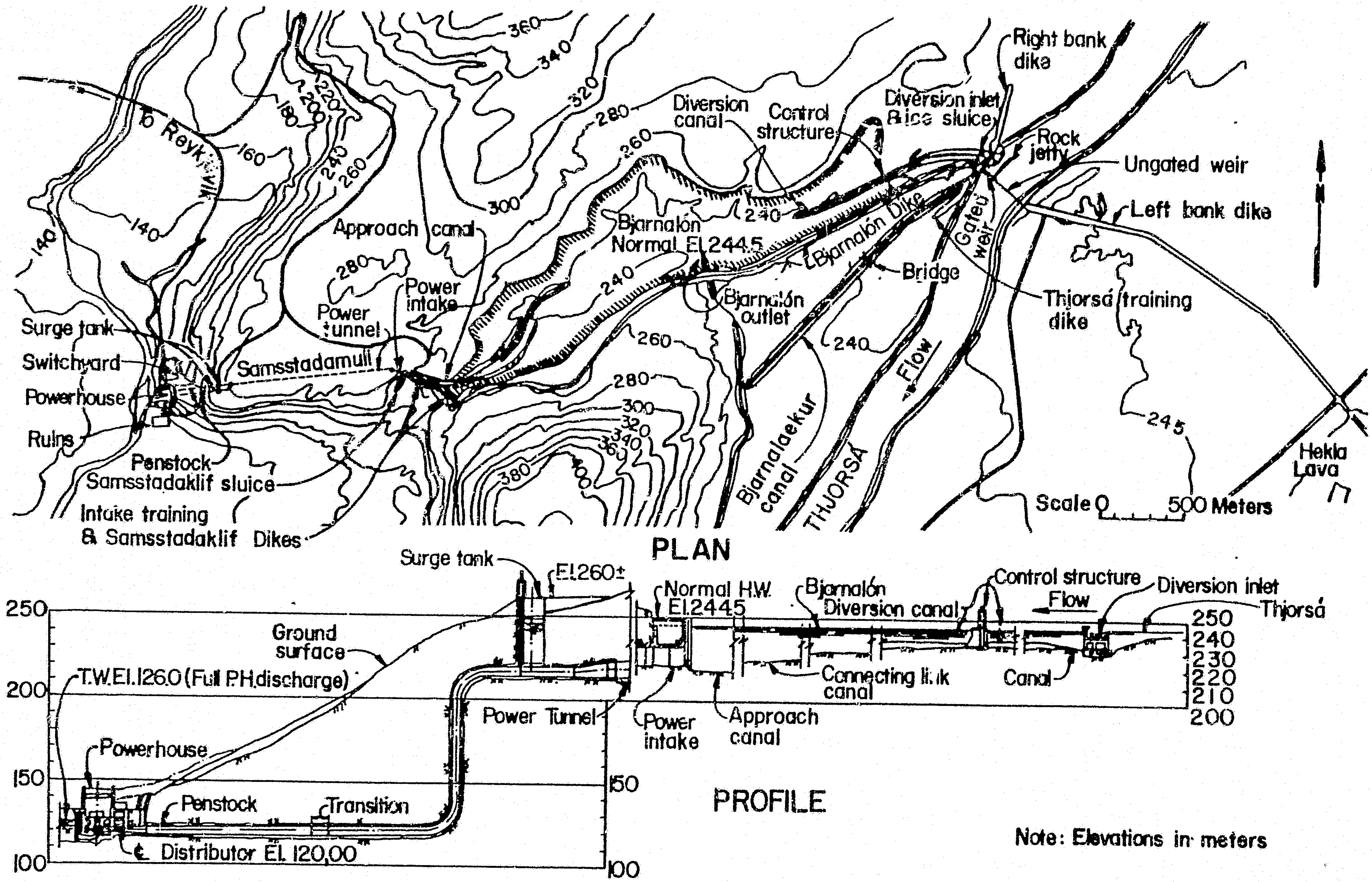


FIG.3 - BURFELL HYDROELECTRIC PROJECT - PLAN & PROFILE

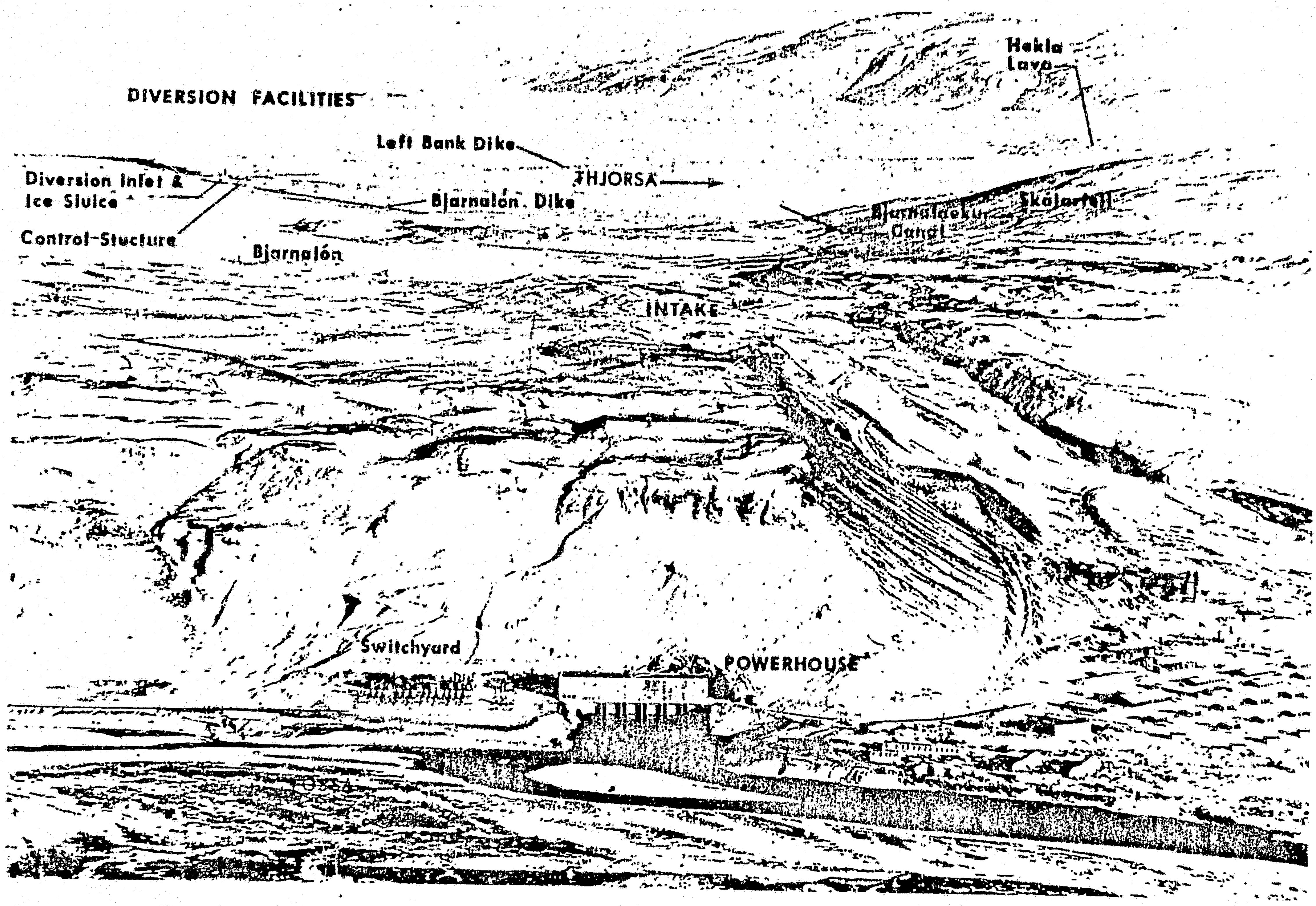


Fig. 4 - OBLIQUE AERIAL VIEW OF THE BURFELL HYDROELECTRIC PROJECT LOOKING EAST

ICE AND BEDLOAD PROBLEMS

The fact that ice represented the most serious problem associated with the design of the Burfell Hydroelectric Project was recognized at the inception of the engineering. The Thjorsa in the vicinity of the Project carries during cold periods extraordinary quantities of ice which must be prevented from interfering with power operations. The problems involved included those associated with the great magnitude of moving ice masses and also those associated with the changes of physical qualities at different stages of ice production, transportation, and accumulation.

The physical and climatic characteristics of the Thjorsa Basin referred to above result in the formation of relative quantities of ice in that river which are probably very rare in rivers anywhere else in the world. The varying climatic conditions produce, to a greater or less degree each winter, a number of incomplete to complete ice cycles on the river upstream of the diversion point. Each cycle includes some degrees of freezing, staying frozen, and thawing; with cycles repeating sometimes even at less than weekly periods. This climatic instability is a principal cause of the Thjorsa ice problems.

The ice in the Thjorsa which presents the major problem is represented by sludge ice. Frazil ice is formed on the broad, shallow, frequently braided, but swiftly flowing reaches of the river upstream from the site, particularly on the Thjorsa up to the mouth of the Tungnaa, and for a few miles up that tributary. The water flows at depths generally less than 2 feet, widths of a quarter of a mile, and velocities too high to permit the formation of sheet ice, except locally during extended severe frost periods. This open water surface in the river system above Burfell may amount to an area of 4 square miles or more when there is no bank ice or ice jams and after the upper reaches of the river system are largely frozen over. Frost periods are usually accompanied by strong winds generally blowing down river upon this open water surface to result in great heat loss by convection and consequent production of huge quantities of frazil ice. Some sludge ice is also added by blowing snow from off the land surfaces. Waterfalls and rapids tend to expose the entire flowing water mass to supercooling mostly by extremely cold entrained air with a resulting tremendous heat exchange and production of frazil ice. The importance of this intermixing factor is perhaps too little realized. Sludge ice under the more severe conditions tends to form almost a complete moving "carpet" over the open water surface, thus cutting back on the increasing rate of frazil ice production and presenting a sort of partial "self-limiting" production phenomena.

The ice produced under the more severe physical and climatic conditions can amount to over 15 tons per second flowing down the Thjorsa at Burfell. This amounts to over 1500 cfs or more of loosely packed sludge ice. Extended frost periods reduce the free water surface by one half or more with an accompanying but not quite equal reduction in sludge ice production. But the cold and accompanying barometric pressure increases reduce the natural flow such that severe ice conditions are still maintained from the power operations standpoint.

Most all of the flow during frost periods consists of groundwater at an entrance temperature of about 40° F, thus supplying heat to halt sludge ice production and start thawing even before the air temperature reaches back to the freezing level. This thawing also loosens both anchor ice from the bottom and bank ice from the shore, all of which is transported downstream, some melting along the way.

There is a tendency for the floating sludge ice, in some combination with anchor ice and cake ice, to form ice bridges in certain areas of the river, particularly gorges and the braided reaches. These partial ice dams create backwater and resulting head until the pressure produces a rupture which releases a torrent of water, cake ice, and sludge ice, all of which pass as a flood wave downstream, usually destroying similar ice dams in its path and adding the volume of each. These floods, referred to as "step bursts", may reach a discharge rate of 20,000 cfs and require from a few minutes to more than an hour to pass a downstream point such as the Burfell Diversion Weir.

There was very little information available in the technical literature relative to ice production and control under conditions similar to those on the Thjorsa when the design engineering program was started in 1963. The Icelandic government therefore stepped up its field investigations and research on ice problems, with particular emphasis on the Thjorsa. Special assistance was also provided by a team of experts under a grant of the United Nations Special Fund. The preliminary results of these studies provided some information for project designs, especially initial ones.

The sludge ice was observed to form and move somewhat in clusters, having a unit weight of about 20 lbs per cubic foot. All or nearly all of the clusters were noted to flow at or near the surface when the water velocity was below about 3 feet per second. With increasing velocity and turbulence the clusters tended to be carried more in the full river profile. This knowledge led to the thought that one solution to the problem included skimming the sludge ice from the water to be diverted for power, using some of the available water for skimming supplemented by some additional water for flushing the separated ice to downstream.

The sludge ice, when gathered into an ice bridge or dam, was noted to become somewhat more compacted with an estimated weight of about 40 lbs per cubic foot in the uppermost layer, increasing to nearly 55 lbs per cubic foot in the lower layer. This quality change resulted principally from regelation effects. However, the production of these ice dams also included the combined effects of supercooling, crystal growth, sludge ice drift and dynamic compression to give the mass a degree of stability adequate to form the temporary dams referred to above. The nature of this ice and the other ice formed in association with these ice dams and appearing at the diversion point as a result of step bursts was such as to render any feasible skimming facilities inadequate and provisions would therefore be necessary to pass the step burst ice debris and water to downstream in its entirety. Some of the ice blocks have been observed to be over 10 feet on each side.

The important consideration in the design of the Burfell Project was to reduce, insofar as feasible, the effects of ice on power generation. Reservoir storage at Burfell of the ice was ruled out by economic reasons; there being no suitable section or foundation for a dam to create a reservoir of adequate size. This led to the decision to develop facilities to separate the ice from the water, flush the ice to downstream and divert the remaining water to the power features to the extent required or available. Such facilities must give reasonable assurance that ice would not accumulate and block the power diversions. Other partial solutions to the ice production problems at Burfell include the reduction of the open water surface upstream of the dam, preventing blowing snow from entering the river, and retention of ice in artificial upstream reservoirs, including ones created by ice dams.

The Thjorsa being a glacial river carries a fair amount of bedload, mostly basalt sand with some lightweight volcanic cinders and pumice. It was considered necessary to provide a silt excluder at the Diversion Inlet in order to prevent the bedload from entering the Diversion Canal and to pass it to downstream, thus reducing the requirements and cost of maintenance dredging from within the Diversion Canal and the Bjarnalon. The water requirement for this bedload sluicing, which need not be continuous, would represent no problem during the summer high flow glacial meltwater season when the bedload is highest, but would represent some sacrifice of water for power at most other times. This sluicing water during ice periods would supplement the water from the ice skimming operation for sluicing both ice and bedload to downstream.

It was recognized that this sluicing of ice and/or bedload to downstream would have the hydraulic requirement of a deep and narrow channel of adequate grade and length to provide a velocity sufficient to carry the material downstream to a point where it could be discharged without creating detrimental deposits beyond the release point of either material. The Diversion Inlet and Ice Sluice would be on the right side of the river and therefore the sluice discharge channel would need to be on the same side.

This channel could be located along the right side of the Thjorsa, but in order to meet the criteria it would need to extend from the Diversion Inlet to the foot of the waterfall, Trollkonufoss, almost 4 miles downstream. Further, the channel would need to be protected by a training dike to exclude the Thjorsa waters released past the dam. As a desirable and selected alternative to this long and expensive canal, there existed, fortunately, a lava marginal tributary on the east side of the Burfell mountain flowing at a grade well below that of the Thjorsa such that a canal, designated the Bjarnalaekur Canal, only 1.2 miles long extending from the Diversion Inlet to this stream, called the Bjarnalaekur, could be constructed to meet the velocity criteria. Further, the grade and section of the Bjarnalaekur for the 4 miles of its length downstream to where it joined the Thjorsa were such as to provide adequate velocity to move the ice and sand back to the main river to the head of a long stretch of falls and rapids.

The base width of the Bjarnalaekur Canal was made 20 feet, the minimum for construction convenience. There was enough elevation difference between the lower level of the Diversion Inlet, which level was controlled principally by geologic considerations, and the elevation of the bed of the Bjarnalaekur to provide a canal grade of 0.0048. These dimensions resulted in a velocity within the Canal of about 10 feet per second for the usual flow ranges, and that velocity was adequate to move the separated ice and bedload without creating any appreciable additional sludge ice on the surface.

The Bjarnalaekur Outlet Structure was constructed to pass through the dike retaining the Bjarnalon where that dike crossed the Bjarnalaekur. This gated, double culvert, concrete structure permits releasing up to about 2500 cfs from the Bjarnalon into the Bjarnalaekur to supplement the removal of any ice or bedload deposits which might accumulate in the Bjarnalaekur downstream of the Bjarnalaekur Canal. The utilization of that discharge after 2 winters of operation has not yet proven necessary for that purpose; however, future operations will require more and more use of the available river flow and it will be necessary to reduce the sluicing and skimming water most of the time during the winter to the lowest feasible minimums. Such operation might increase slightly the risk of blockages within the Bjarnalaekur.

A design flood of 140,000 cfs was selected as a basis of the capacity for a spillway to be located in the entire main river channel. This capacity was provided by 4 fishbelly flap gates and a section of uncontrolled spillway. Each hydraulically operated gate was 65.5 feet long and 8.2 feet high and equipped with splitters following the face circumference. Twenty-inch high flashboards which could all be released instantly, each to pivot in the flow, were provided on the 870-foot long uncontrolled crest. The crest portion with flashboards would only be required for the larger floods. The gated section was sized to pass the flow of the largest expected step burst and equipped with gates which could all be lowered quickly at the same time, and be of a design to permit unobstructed flow over the top.

An Ice Sluice structure was positioned at the right end of the gated spillway and at the beginning of the Bjarnalaekur Canal. It contains 3 slide gates, each 6.55 ft. square, at its lowest level to sluice bedload. Crest control for the ice skimming was provided by two 23-foot long by 14.75-foot high fishbelly flap gates, hydraulically operated, and without an intermediate pier.

HYDRAULIC LABORATORY TESTS OF RIVER STRUCTURES

The basic design of the structures in and related to the river, developed as discussed above, were then subjected to tests in a hydraulic laboratory. The River and Harbour Research Laboratory at the Technical University of Norway at Trondheim was selected for the tests.

The primary purpose of the model studies was to investigate the particular part of the ice problem concerned with movement of sludge ice and of bedload in the dam area, but without consideration of freezing processes. The greater part of the studies were carried out on a large distorted model covering over 6,000 square feet, with horizontal and vertical scale ratios of 1:50 and 1:20, respectively. This main model was calibrated with an initial secondary distorted model of smaller size and scale. A third model with an undistorted scale ratio of 1:40 was set up in a flume and constructed towards the end of the work. It was used to study conditions downstream of the dam, flow conditions in front of the Diversion Inlet, and to check general results of the large distorted model.

The basic concept for the study of ice movement was the assumption that ice particles in motion can be considered as sediments with negative submerged density. Thus, methods for study of sediment movement were modified to fit the ice. Ice was reproduced by polyethylene shavings of similar buoyancy as natural ice. The test results provided qualitative results primarily. The quantitative approaches were made somewhat conservatively.

Model studies were started in October 1964, with testing conducted from March 1965 to April 1966. A few supplementary studies were made also after that period.

The hydraulic model studies of the initial design showed some situations when the sludge ice was largely blocked from passing over the flap gates leading to the Bjarnalaekur Canal and was diverted into the Diversion Canal in quantities large enough to ultimately produce blockages to the power diversion. That initial design utilized only the conventional shear wall above the diversion ports to guide the floating ice to the flap gates. This failure was corrected by adding a shallow sloping trough just below the water surface on the upstream face of the shear wall, supporting this trough from the bedload excluder undersluices. A long, low gate controlled weir, almost paralleling the shear wall, for use in skimming the ice to the trough was included. This skimming weir was centered over the diversion ports which were positioned at the intermediate level. It was found desirable to place the first of these ports somewhat upstream from the gated spillway to allow space in the river channel for the ice carrying eddy which formed immediately upstream of these gates. The structures associated with the river diversion are shown in plan on Figure 5. The details of the Diversion Inlet and Ice Sluice as refined by the hydraulic model studies and as constructed are shown on Figure 6. Photographs of the structures are shown on Figure 7.

Occasional operation of the spillway gates was found desirable to prevent a massive ice build-up upstream of the gates. However, passing this ice to downstream by gate manipulation at occasional intervals would not provide adequate water to continue movement of the ice downstream in the wide, shallow river channel. To overcome this difficulty, the model studies developed the desirability of deepening the spillway apron to provide a concrete lined Runway Channel leading to the Bjarnalaekur Canal. A vertical lift control gate was provided between this Runway Channel and the Ice Sluice plunge pool. Small discharges of water and ice over the gated spillway could be passed into and through this channel to the Bjarnalaekur Canal and flushed to downstream. Alternatively, ice passed over the skimming weir and Bjarnalaekur flap gates could be passed back to the main river channel in the event of a blockage in the Bjarnalaekur Canal, but this requirement appears very unlikely. This Runway Channel represents a type of side channel spillway as

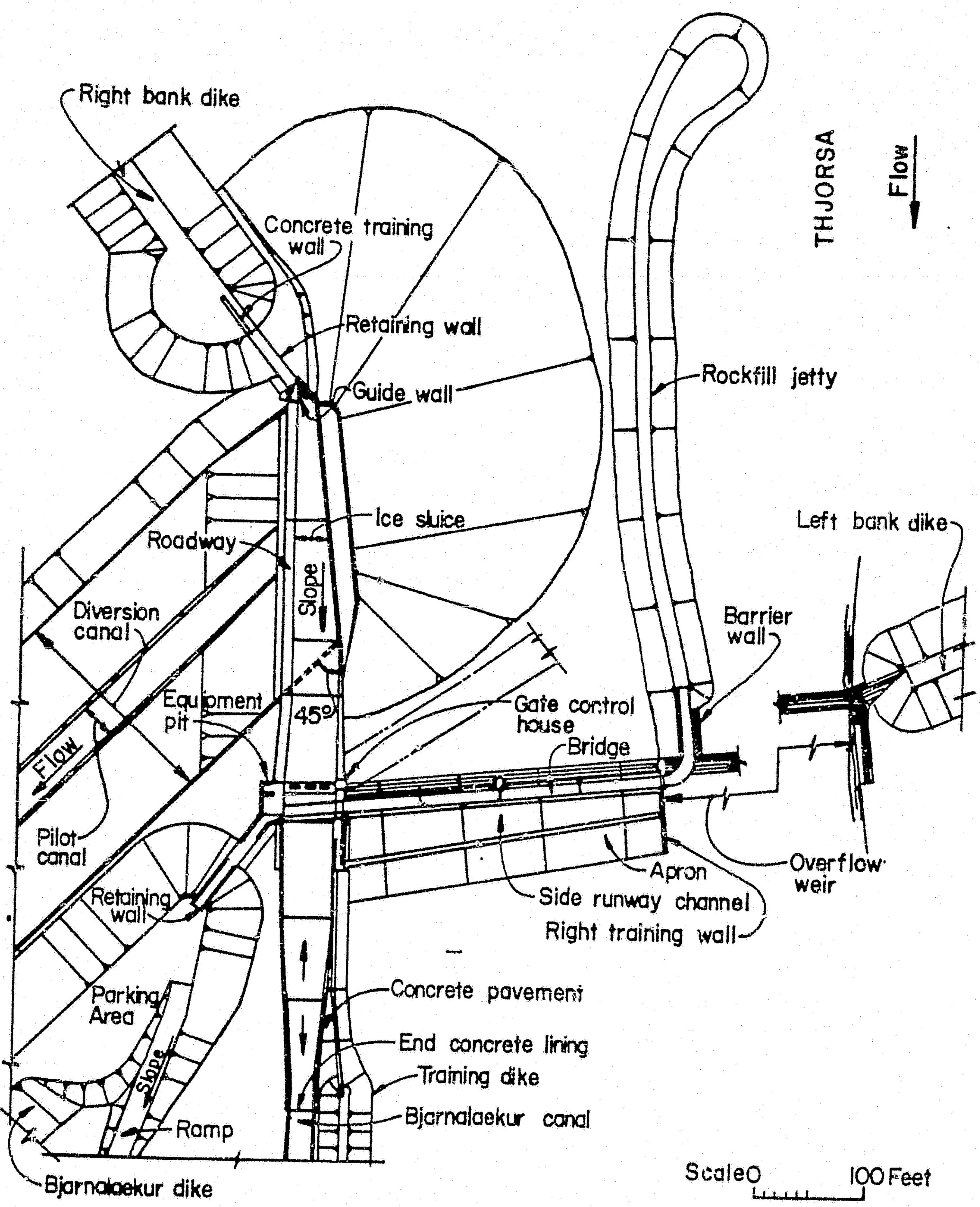


FIG. 5 - DIVERSION STRUCTURES & SPILLWAY GENERAL PLAN

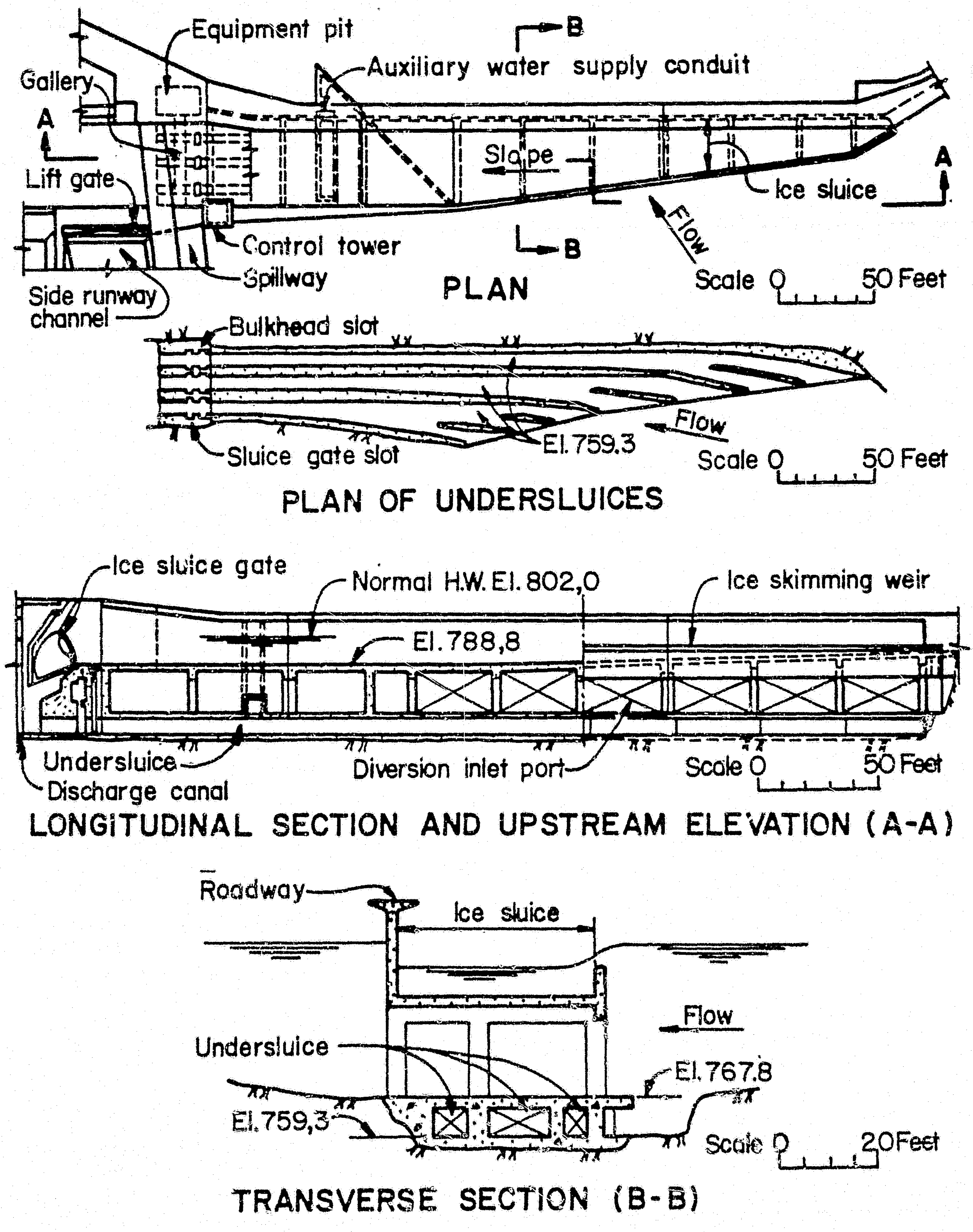
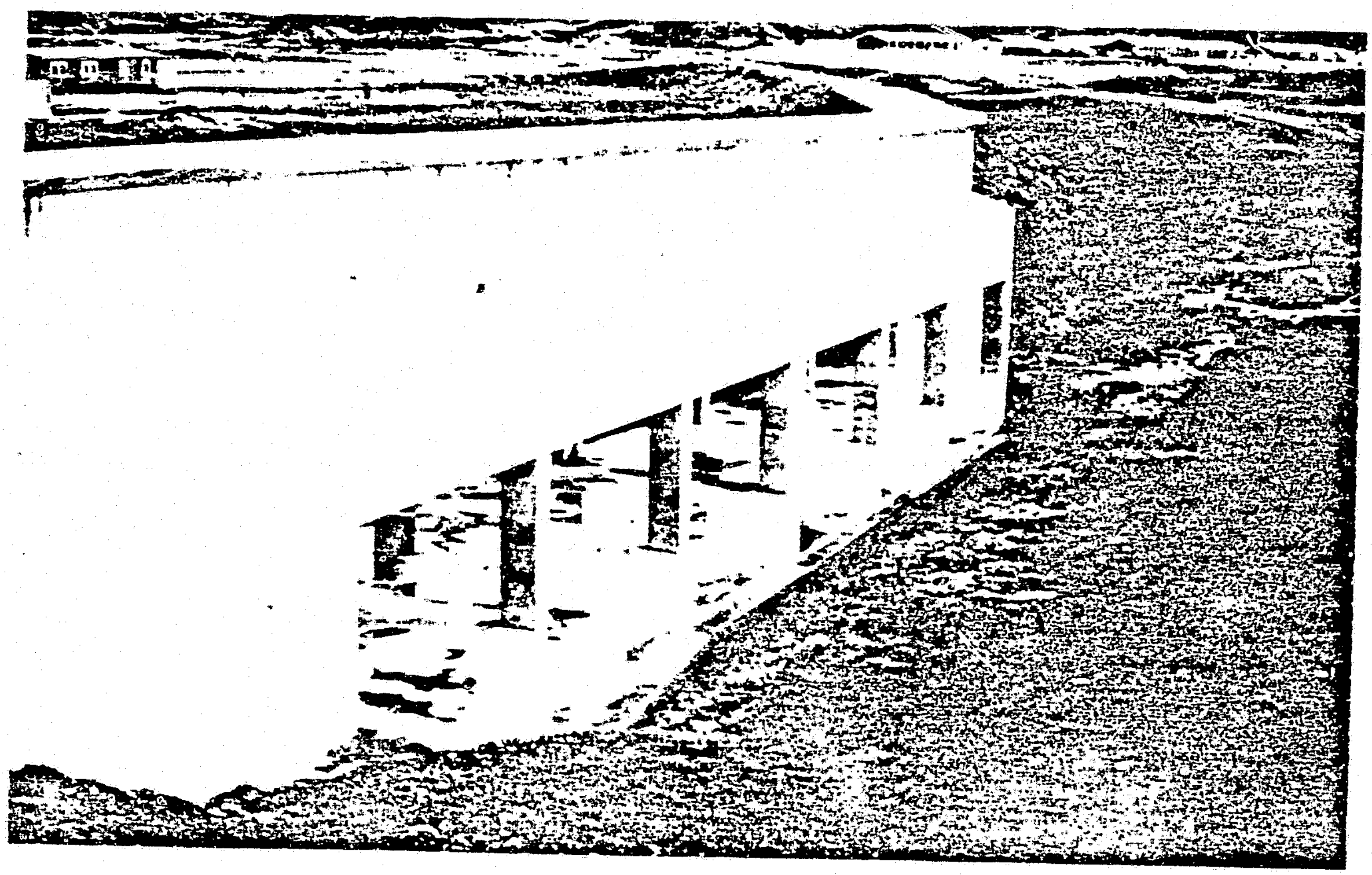
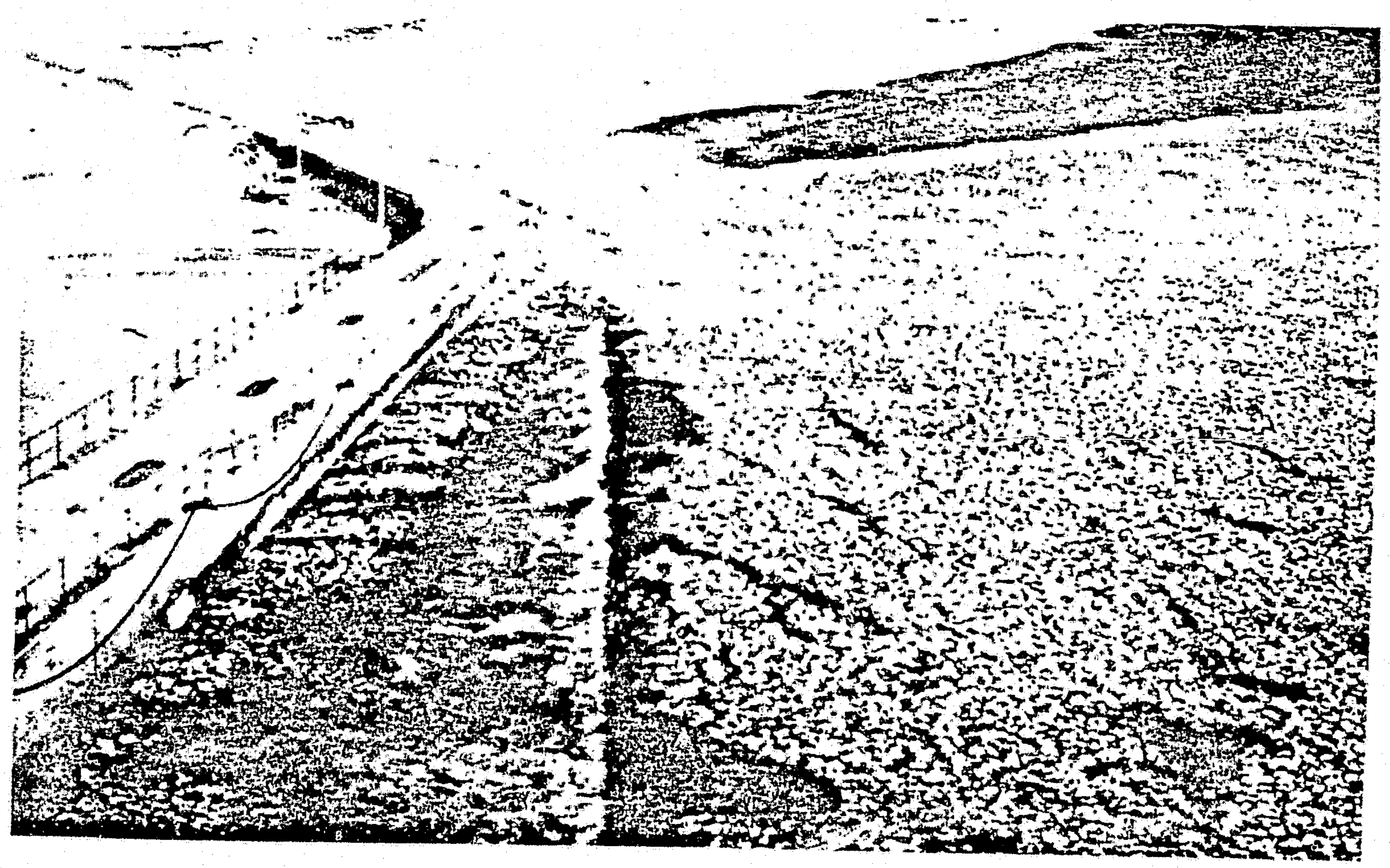


FIG.6 - DIVERSION STRUCTURES - PLANS AND SECTIONS

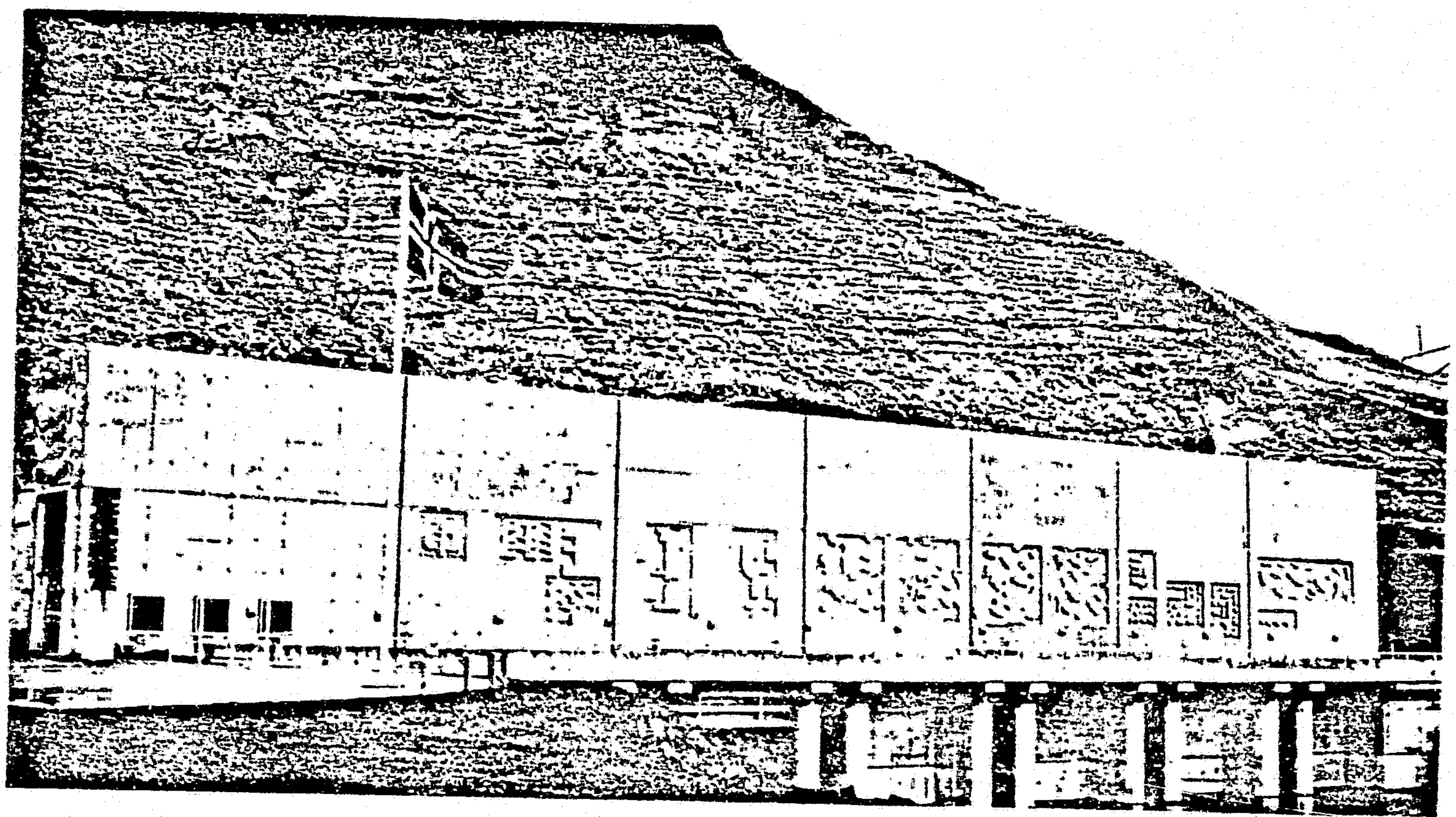


Unwatered diversion structure showing the three-level water passage.

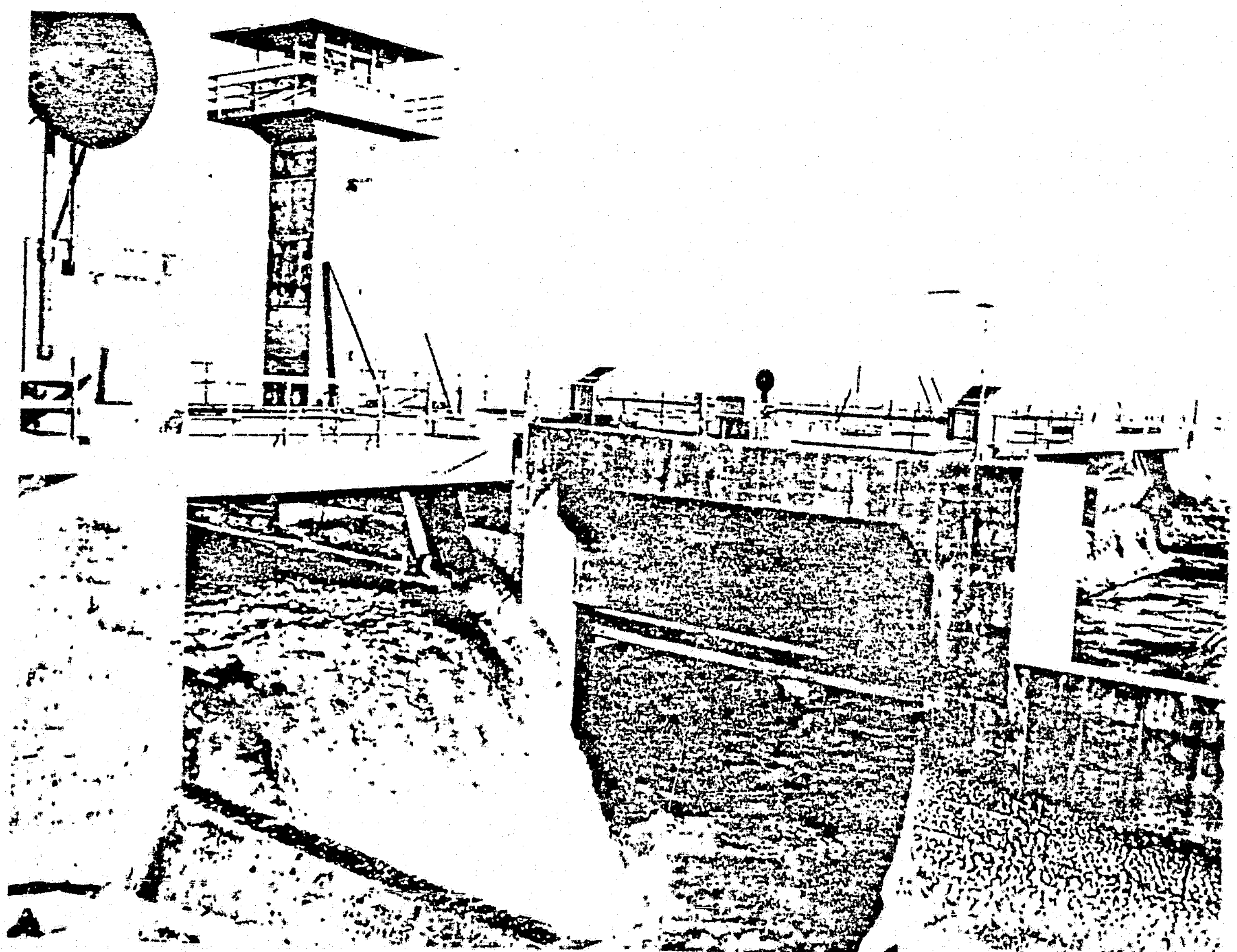


The diversion structure showing ice being skimmed and sluiced.

Fig. 7 - PHOTOGRAPHS OF STRUCTURES



Downstream face of powerhouse.



Sludge ice passing over ice sluice flap gate.

Fig. 7 (Contd.) - PHOTOGRAPHS OF STRUCTURES

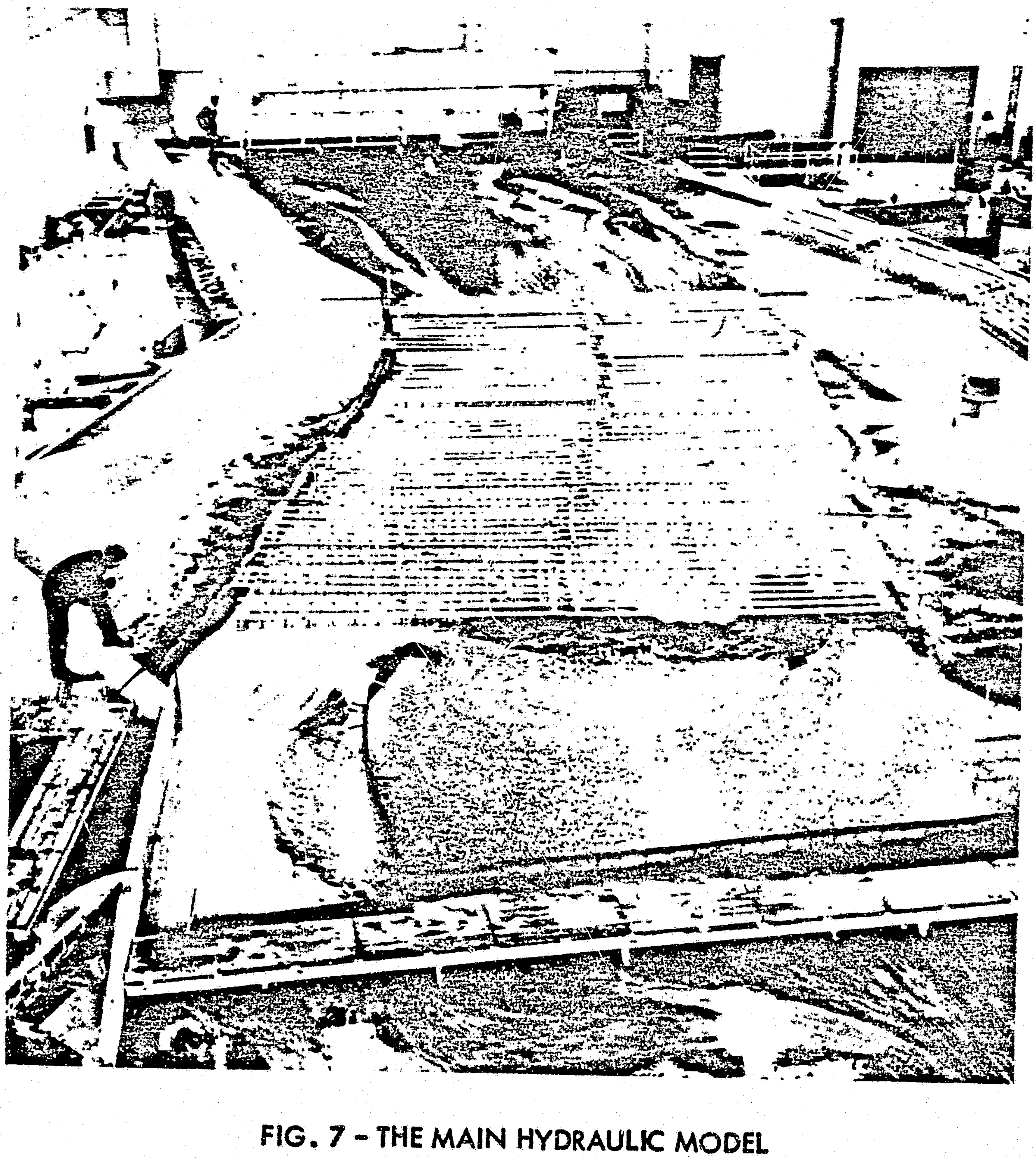


FIG. 7 - THE MAIN HYDRAULIC MODEL

well as a spillway bucket for energy dissipation during normal operation of the gates with the Runway Channel gate in a closed position. The dimensioning and shaping of this Channel was established from the model studies. The hydraulic design of the Plunge Pool at the beginning of the Bjarnalaekur Canal and downstream from the Ice Sluice was verified by hydraulic model studies.

The model studies also showed the desirability of placing a rock fill jetty extending upstream from the left end of the gated spillway to somewhat upstream of the upstream end of the Diversion Inlet. This jetty tends to guide the river flow carrying ice and bedload to the separation facilities. However, the real need for this jetty in the prototype has not yet been established. It may be more important to bedload movement than to ice movement.

The model studies included some studies relative to bedload movement. The shaping of the rock excavation in the riverbed in front of the Diversion Inlet to guide the approaching ice to the skimming weir and the bedload to the undersluices was worked out in the model and seems to be satisfactory in the prototype. The details of the undersluices were worked out largely in the hydraulic model. To permit clearing a blocked undersluice, an auxiliary water supply intake equipped with a slide gate is provided to supply flushing water from the Diversion Canal to any one of the 3 undersluices. The design of the inlet to this supply was developed by the model studies.

The model studies also provided some guides for initial operation of the diversion and ice passing facilities. However, optimum operation can only be learned from prototype experience. In general, this experience has shown that the Reservoir should be operated at higher levels than indicated by the model tests. On the whole the facilities have operated somewhat better than was to be expected by the model results. Several times massive ice jams have been created upstream of the Diversion Weir and Inlet, yet the ice skimming facilities have continued to operate with relatively minimal escape of sludge ice to the Diversion Canal and no ice blockage to the water for power generation. Most or all of these ice jams were probably instigated by operating even briefly at too low Reservoir levels. The ice bridge would form in a matter of seconds and remain until removed by the next thawing spell of weather.

OTHER PROJECT ICE CONTROL FEATURES

All of the control gates are provided with local and remote control, with the latter representing the normal operation. A glass-enclosed operating house is positioned on a tower located on the spillway right pier with the operating console on the operating floor about 30 feet above the deck level. Remote control floodlights are also provided. Remote control closed circuit T.V. surveillance was provided in the design but has not yet been installed. That installation could permit also remote control of the gates from the power station as well as surveillance of these operations from the home office in Reykjavik.

The maximum average velocity in the Diversion Canal and Approach Canal was set below about 1.5 feet per second in order to provide a sheet ice cover early in each winter and thus prevent the formation of sludge ice. A fishbelly flap gate, 19.7 x 14.8 feet, located in the Samsstadaklif Sluice adjacent to the Power Intake was provided to permit skimming of ice and other debris reaching that structure through those Canals or from the Bjarnalon. The water and debris skimmed from the surface will cascade down a small creek to join the Fossa downstream of the powerhouse. A pump well was provided in the Intake to permit the future installation of flow inducers to direct the floating material towards the flap gate but this installation is not now believed necessary. The principal use for this flap gate so far has been to pass a considerable volume of floating ash from the eruption of the nearby volcano, Hekla, in May 1970.

The Control Structure located in the Diversion Canal permits shutting off all flow to the Bjarnalon from the river. It contains 3 vertical lift gates, the center one being deeper than those on each side and equipped with automatic controls designed to maintain a constant level on the upstream side as the Bjarnalon level may fluctuate by peaking operations. Closing the Control Structure gates and opening all gates at the river permits some degree of backflushing of ice and sand deposits from the Diversion Canal back to the Diversion Inlet for flushing to downstream.

ICE CONTROL IN RIVER

The prevention of the creation of ice such that lesser amounts will reach the diversion structures can be accomplished by several types of construction. These methods are aimed mostly to reducing the area of open water upon with frazil ice may form. Canalization is considered a suitable procedure for the river for a few miles upstream of Burfell. Construction to achieve this end, although included in the Project's design stage, is only now getting under way to some degree.

Construction of low overflow dikes and permeable weirs to confine the main river current to a single channel in the two main braided reaches, accomplished to some degree this past winter, appears to have reduced ice production and vastly decreased the incidence of step bursts. The construction of the low dikes with coarse rock fill may require some annual replacement after the summer and fall floods. The permeable weirs consist of rounded, durable glacial boulders in sizes from one to 6 tons or more, as available. These boulders are placed in rows with individual stones separated by about 3 feet. The optimum spacing has not yet been determined. The principle is that this type of construction will precipitate the formation of ice dams to block the flow to the channel, but represent little interference to ice-free flood flows. Similarly, successive rows extending out from each bank will tend to reduce the open width of the river in the wide shallow reaches, thus reducing the open water area exposed to undercooling and ice formation. This type of temporary canalization by ice itself can be supplemented by the more permanent construction involving deepening and narrowing the main river channel by artificial excavation. This method appears to have great promise in some reaches of the Thjorsa but has not yet been tried.

The erection of snow fences to collect blowing snow and prevent it from reaching the river to become sludge ice also has some promise in selected favorable locations. Again, while included with the Project's original design, it has not been tried in this application but its eminent success in highway and railway transportation in trapping blowing snow is well known.

Artificial reservoirs to reduce the area of sludge ice development or for ice storage can hardly be justified upstream of Burfell except in association with seasonal storage and/or power generation at upstream plants. Thorisvatn, a 27-square mile natural lake, is now being developed as a seasonal storage reservoir by the installation of an outlet with control works and by the diversion of the Thorisos and Kaldakvisl tributaries into that lake. This diversion will reduce ice production in the lower reaches of the Kaldakvisl, but this reduction may be more than offset by the exposure to ice production in the high gradient outlet channel from the lake and from the augmented flows in the river from storage releases which will occur during low flow periods of freezing weather.

SUMMARY

The ice passing facilities have been in operation for the past two winters. This operation has been with the initial 3 generating units, and the full design capability will not be tested until the winter of 1972-73 when all 6 units will be in operation, with flow regulated by the Thorisvatn Storage Development, including the two river diversions. It is considered that the soundness of the basic design has been proven. The operating success has been somewhat better than expected. Substantial improvements in operating success can be expected as more experience is obtained both by the supervisors and the at-site operators. On the other hand, experience has shown the opportunity for improvements in the structures. Most of these relate to the gates, and except for a few minor matters, must be reserved for the next similar project.

HARZA-EBASCO

C(D) MANAGEMENT OF DESIGN

This section describes the management, technical and related services which the Joint Venture will provide to ensure that the project is executed in accordance with specific technical, cost and schedule requirements. Certain of the services described in this section (eg., preparation of procurement contract terms and conditions, preparation of estimates) are provided as true support services to the technical engineering and design tasks. To indicate the interrelationships between these support activities and the technical tasks, the support activities have been identified as subtasks within each engineering and design task.

The Management functions and support services are described below.

HARZA-EBASCO

D(a) REVIEW OF PRIOR WORK AND IDENTIFICATION OF FURTHER STUDIES

INTRODUCTION

Previous Studies

It is assumed that the Contract between the Alaska Power Authority and the Joint Venture for the next phase of engineering for the Susitna Project will be formalized by January 1, 1983. The Joint Venture will assemble a transition team for the review of the Feasibility Report and its appendices, all Power Authority External Review Panel reports, all reports of field investigations and field data collected to date, the scope and status of the field investigations underway. The Transition Team will formulate the conceptual design of the Project and identify critical areas for detailed investigation and study. This team is discussed further in Part B, "Statement of Work".

The review team will be composed of experienced, high level professionals with broad backgrounds in large fill dams and underground power facilities. The team will consist of environmental scientists, geologists, engineering geologists, geotechnical engineers, hydrologists, structural engineers, hydraulics engineers, mechanical engineers and electrical engineers. Special consultants will also be brought in for specialty areas peculiar to the Watana Project Site, such as seismic analysis and permafrost.

During the review process, the team will assess all the studies that were included in the work completed at the feasibility level and will prepare a report to the Power Authority to detail which areas require additional studies. It will describe the scope, extent, schedule and cost for the additional studies. Moreover, the team will establish a schedule to ensure the acquisition of at least the minimum amount of field foundation data required to firm up the Project Conceptual Layout by the end of 1983. A tentative schedule for these investigations is presented below in D(k).

Critical Factors

The critical factors to the Susitna Project are the early optimization of the Main Dam Layout and the scheduling of contracts for the diversion tunnels. This first represents more than 30 percent of the Watana Dam direct construction costs, and its location will exert a direct impact on the location of the diversion tunnels and cofferdams, power intakes, outlet works, spillway, and tailrace tunnel outlets.

The first scheduled technical facilities construction contract is Work Task 10, Contract Document C-1, Diversion Tunnels. It is scheduled for issuance to bidders immediately after the FERC license is obtained (January 1, 1985). This first construction contract is critical to the project schedule. The Project Conceptual Design and, in particular, the Main Dam layout must be developed by the Joint Venture and approved by the Power Authority and its External Review Panel by late 1983 in order to have the C-1 Construction contract ready for bidding at the beginning of 1985.

ENVIRONMENTAL STUDIES

A substantial review of prior environmental work on the project will be required, as well as the continuation of many studies and the modification of some. Our program for this review and for further investigations is presented with other aspects of the environmental program in Section D(c).

GEOTECHNICAL

The major features of the Project associated with geotechnical engineering are the following:

- The foundation treatment for embankment dam
- Locating suitable materials for the core and shells of the embankment dam
- Treatment of the Watana and Fog Lakes relict channels
- Underground chambers and tunnels
- Foundations for structures
- Permanent and temporary cut slopes
- Reservoir slopes

We will review all pertinent data and complete additional studies required to fix the design of the major geotechnical features. These activities will include:

- Review and analysis of pertinent geotechnical data. This includes data collected by various agencies and by Acres during past and current site investigations programs and data to be collected during future programs.

- Confirmation of basic design concepts and preparation of design memoranda

- Detailed geotechnical analyses of the selected design concepts

- Design of instrumentation systems to monitor performance during construction, reservoir filling and project operation

Review and Analysis of Pertinent Data

A detailed review of the data collected during previous site investigations at Watana will be performed as a first step toward establishing the site specific characteristics required to confirm the basic design concepts. The data and reports to be reviewed include:

- Seismic studies performed by Woodward-Clyde Consultants for Acres American, 1982.

- Susitna Hydroelectric Project - 1980-1981 geotechnical report prepared by Acres American.

- Corps of Engineers 1978 Geotechnical Studies, including seismic refraction studies (Shannon and Wilson), drill holes, backhoe test pits, auger borings, and geologic mapping.

- Seismic refraction surveys performed by Dames and Moore for the Corps of Engineers in 1975 and the initial feasibility report.

- Expanded geotechnical investigations at the damsite, reservoir and potential borrow pits performed by the U.S. Army Corps of Engineers during the 1970's.

- Preliminary reconnaissance work performed by the United States Bureau of Reclamation in 1957 and 1958.

All prior work will be synthesized and summarized to provide a quantitative measurement of the work performed to date and to determine qualitatively the strengths and weaknesses in the data obtained.

The review of prior work will lead to the preparation of a detailed plan for additional site investigations (see D(k)), concentrating on those items where present information is insufficient. We will establish priorities of work and specific locations for drill holes and other explorations. These will be shown on topographic and geologic maps.

For the early construction contracts, we will use all available geotechnical data gathered in the various site and laboratory investigations to establish the design. Data gathered during these early construction contracts (diversion tunnels, excavation, cofferdams, adits, drilling and grouting) will provide detailed in-situ information on the geology and geotechnical properties of the foundation rock for use in the preparation of later contracts concerning the underground power structures, the embankment dam, the spillways and the foundation treatment of the various structure.

Design Concepts and Design Memoranda

After completing the review of the geotechnical data, we will establish basic design concepts and select design criteria for each project feature and for the analyses supporting the design. During this critical phase of our work, we will involve our senior geotechnical staff and consultants to develop concepts that can be tested by detailed site investigations and analyses. It is during this stage of activity that judgements must be made without full knowledge of foundation conditions and borrow source characteristics and without the results of subsequent detailed analyses. Upon completion of the development of design concepts, a series of investigation memoranda (see Table D(a)-1) will identify the critical factors and provide a detailed investigation program that will define the criteria, parameters, methods and procedures for the various analyses.

Detailed Geotechnical Analyses and Studies

Detailed analysis will substantiate the selected design of the dam, the treatment of relict channels and foundations, the geometry and support of underground openings, and the stability of cut slopes and reservoir slopes. The analyses will be documented in reports and subjected to close review by our internal staff, our consultants and by the External Review Panel prior to being finalized.

Embankment Dam

The detailed analyses of the embankment dam will be discussed in the following categories:

- Studies to estimate the performance of the dam under various construction and operating conditions

- Studies to determine materials characteristics, the cross-section and details

- Studies to estimate foundation response and to define foundation treatment

- Studies of the cofferdams and dewatering

Dam Performance. A series of finite element analyses will be used to estimate dam performance. First we will perform a finite element analysis of the stresses, deformations and pore pressures that will occur within the body of the dam during the

Table D(a)-1

Design Memoranda

1. Diversion Tunnels and Portals: Excavation and Support
2. Cofferdams
3. Dam: Foundation Grouting and Drainage
4. Dam: Excavation and Rock Surface Treatment
5. Dam: Material Characterictics
6. Dam: Cross-Section, Zoning and Details
7. Freeboard Dike
8. Relict Channels: Characteristics of Glacial Deposits
9. Relict Channels: Treatment
10. Main Spillway: Excavation and Foundation Treatment
11. Emergency Spillway: Excavation and Foundation Treatment
12. Outlet Facilities: Excavation and Support
13. Power Facilities and Access: Excavation and Support
14. Fuse Plug
15. Aggregates for Concrete, Filters and Drains
16. Switchyard Foundations

construction period. The transfer of stress from the more compressible core material to the less compressible shell zones will be estimated and evaluated. Settlement and pore water pressure generation and dissipation will be predicted and then, during construction, will be compared with measurements from piezometers and settlement gages placed in the core. Predictions of stress, settlement and pore pressure will be based on parameters derived from appropriate laboratory triaxial shear, consolidation, and permeability tests. The initial analyses will be refined on the basis of data collected using in-situ measurements during the early stages of construction, to predict performance during the later construction stages.

Second, we will perform a finite element analysis of the change in pore water pressure within the core during reservoir filling. This analysis will predict the time required to estab lish the steady-state seepage pressures and their magnitude. It will provide input to the subsequent static and dynamic analyses, which will predict stresses and deformations of the dam that will result from various stages of reservoir impoundment.

Third, we will perform a finite element analysis of stresses and deformations resulting from the gradual development of seepage through the core. The results of this analysis and of the seepage analysis will be compared to the field measurements of stress, displacement, and pore water pressure. Input parameters will be derived from laboratory tests and from the measured performance of the dam during construction.

We also will perform a study of the performance of the dam under a rapid drawdown condition. The study will include the analysis of the change of pore water pressure in the core during the reservoir drawdown and the analysis of the stresses in the dam resulting from the change of pore water pressure in the dam from the reservoir unloading.

The fourth study for the dam will be a dynamic finite element analysis of the dam during the maximum credible earthquake (MCE). As a first step, the time history of bedrock motion associated with the MCE will be chosen on the basis of a review of the seismic studies by our geologists and by our consultant, Dr. Clarence Allen. Other inputs will include the static stresses and steady-state pore pressures derived from previous analyses. Dynamic shear stresses and accelerations will be determined for various locations in the dam and compared to the strength of the embankment materials as determined in dynamic laboratory tests. Based on this study, an evaluation of the performance of the dam will be made. Permanent deformations that might occur during the MCE will be predicted and mitigating features will be designed to lessen the impact of such an event.

Dam Cross-Section. Other studies and analyses will define the cross-section of the dam. These will include analysis of the several borrow and quarry sources of materials. This requires an accurate delineation of these sources and knowledge of the stratigraphy, permafrost occurrence and the material properties. Our site investigations program (D(k)) will include a careful exploration of material sources aimed at determining the characteristics of the sources of core material, filter and transition zones and gravel and rockfill shell material. The Joint Venture will be assisted by Harding Lawson and Associates in obtaining the necessary data. Laboratory testing will be conducted on-site and in Anchorage. Special tests such as those required for the dynamic analysis will be performed at laboratories outside Alaska.

We also will analyze the use of material in the embankment to guide decisions concerning processing requirements and the location of materials in the embankment considering the location of their sources.

The interpretation and analysis of the data obtained in the geotechnical exploratory program, homogeneity and extent of stratigraphic units, extent of permafrost, amount of moisture present in the units, and grain size distributions, will provide the basis for a plan to manage the sources of materials and their distribution in the embankment.

Laboratory model tests of the interfaces between shell and filter material and filter and core material will be performed under design gradients to ensure that the Standard Terzaghi filter requirements will provide the necessary protection against filter or core material erosion and the ability to heal cracking of the core. Gradations of filters and processing requirements will be established.

We will analyze details such as crest geometry and zoning, freeboard, slopes protection, and foundation contact geometry.

Foundation Responses. Analysis of the foundation response during construction and response to the long-term effects of the reservoir will be required. These studies will include several aspects.

Analysis of the methods and procedures required to thaw ground ice prior to foundation grouting will needed. Effective foundation grouting will depend on effective methods of thawing ice in the rock joints in advance of the work. Techniques such as water or steam treatment and their associated costs and difficulties will be evaluated.

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We will evaluate the thermal disturbance associated with the grouting, drainage and access adits, the grout and drain curtains, and the excavations required for the core and shells.

We will analyze the transient thermal regime of the embankment and its foundation during the sequence of construction, first filling of the reservoir and the operating life of the project. Permafrost within the abutments can be expected to thaw with time. This could lead to increased leakage through the abutments and/or to additional settlement of the foundation as ground ice thaws.

We will evaluate the long-term steady state thermal regime of the embankment, reservoir and foundation. Two-dimensional finite element methods developed by EBA Engineering Consultants will be used to model the thermal effects of construction, reservoir filling and project operation.

Foundation Treatment. A detailed analysis of the foundation treatment for the dam will include analysis of the layout of grouting and drainage adits and the depth, spacing and attitude of grout and drain holes. The analysis will depend on the results of rock drilling and water pressure testing along the alignment of the grout curtain. This data will be obtained starting in May 1983.

Also included will be analysis of the requirement for excavation for the core, filters and shell and the near surface rock treatment. The competence of the alluvium in the river will be determined using careful exploratory techniques to obtain the detailed stratigraphy. Standard penetration tests, as applicable, will be used to evaluate the liquifaction potential of the alluvium. If it is not possible to determine the characteristics of the alluvium with confidence or if the material has marginal competence, in which case excavation to rock below the shells will be required.

Cofferdams and Dewatering. Analyses of cofferdams and foundation dewatering will be required to establish the diversion scheme. Although much less detailed than the design analyses for the dam, studies will be needed of material requirements, sources of materials, zoning of the cofferdams, and foundation treatment such as slurry wall cutoff.

Relict Channels

Presently, there is no detailed information concerning the configuration, stratigraphy, hydrogeology and competence of the relict channel deposits. However, the fiscal year 1983 site investigations will explore these channels. The Joint Venture site investigations will include substantial additional work during 1984 and 1985.

At present, the required treatment of the relict channels has not been defined. Treatment options for the Watana relict channels range from filter blankets placed on downstream slopes to partial or full cutoffs, or an underground dam. No treatment options have been suggested for the Fog Lakes relict channels except in general terms.

Detailed analyses will be required to determine the treatment of the relict channels or to support a decision to provide little or no treatment. These include the following:

1. Analysis of seepage quantities through the relict channels. These studies will require knowledge of the hydrogeology of the channels and of the permeability of the various strata. Pump-out tests will be needed. Analysis will utilize relatively simple models using a range of values for the significant parameters and complex models, if warranted, using two- or three-dimensional finite element methods.

2. Analysis of the potential for internal erosion and piping associated with changes to the hydraulic gradients within the channels. Gradations of materials in adjacent strata will be studied to determine whether fines from one stream could work into another.

3. Analysis of the stability of upstream channel slopes and their effects upon thawing of permafrost and under the effects of the reservoir. The study will include an assessment of the presence of permafrost and the nature of its occurrence and an evaluation of the competence of the channels to resist movement when saturated by the reservoir or when subject to drawdown. Sampling of undisturbed materials, total moisture contents, in-situ densities, standard penetration and core penetration tests will be needed to evaluate stability of channel slopes in contact with the reservoir.

4. Analysis of the effects of the maximum credible earthquake on saturated relict channel slopes. The data gathered for the static stability studies will be used to evaluate earthquake effects and the potential for liquifaction.

The selection of relict channel treatment will depend on the outcome of the detailed studies and analyses which, in turn, rely on obtaining quality data during the field and laboratory testing programs. Because the quality of the site investigations are vital to the correct evaluation of the relict channels, the Joint Venture has selected Harding Lawson and Associates to perform the necessary drilling, sampling, in-situ and laboratory testing.

Underground Chambers and Tunnels. The intrusive diorite at Watana has high strength such that the response of chambers and tunnels during excavation will be dominated by the structural geologic features. The diamond core drilling and exploratory adits described in Section D(k) will allow a detailed assessment of rock quality at critical locations and the opportunity to perform in-situ rock mechanics tests.

Various stress and deformation analyses will be needed to assist in the selection of spacing between openings and in establishing tunnel and chamber support requirements. These include:

- Parametric analysis of the general arrangement of the power structure caverns. These studies will be conducted using two-dimensional finite element or possible boundary element models. A range of values for the in-situ stress conditions and for the elastic parameters will be used.

- Stress and deformation analyses will be refined upon completion of measurements of in-situ stresses. These analyses will be used to check and refine the underground chamber support systems and to define the detailed shape of excavations and tunnel intersections.

- Stress analysis of the highly loaded pillars between draft tubes.

- Analysis of the excavation sequence of the major chambers to model and predict the deformation response of the rock mass surrounding the chambers. This study will compare predicted response to the measurements made in the field during excavation. Data obtained during the driving of the exploratory adits will allow reasonable predictions of response during construction.

- Analysis of the grouting and drainage requirements adjacent to the power structures.

Foundations for Structures, and Permanent and Temporary Cut Slopes. Detailed analyses of the foundation conditions for the spillway and other structures will be needed to determine the structural competence of the foundation and the requirements for grouting and drainage. These studies will be based on the geotechnical data pertinent to each specific feature.

Permanent and temporary excavations in overburden and rock will be evaluated to establish the geometry of the slopes and support requirements to maintain stability. Study of the geologic structure, the occurrence of shear zones, and the competence of the overburden will define the slopes and their support.

Reservoir Slopes. Preliminary reconnaissance mapping of the Watana Reservoir area was performed during the feasibility study. The principal rock types, the general character of surficial material and the types and causes of slope instability were identified. The feasibility study concludes that minor slides will occur but that these will pose no threat to the Project.

Our detailed analysis of reservoir slope stability will include:

- Mapping of materials within the reservoir which will be subjected to saturation, thaw and reservoir drawdown.

- A survey of slide potential based on the topography, slope inundated and materials encountered. The type and size of potential slides will be identified.

- An evaluation of the wave that could be generated by a slide and its effects will be needed.

- Design of mitigating features, such as increased freeboard or a rock parapet on the crest of the dam, should such be considered prudent.

Reports. The detailed design analyses will be presented in a series of reports. A tentative list of reports is shown on Table D(a)-2.

Table D(a)-2

Reports to Support the Design

1. Materials: Characteristics, scheduling and use in the dam

2. Seepage through the dam and its foundation

3. Embankment stresses, deformations and pore water pressures during construction, reservoir filling and project operation

4. Seismic design parameters

5. Seismic response of the embankment dam

6. Stability of the dam using limiting equilibrium methods

7. Methods and procedures to thaw ground ice in advance of grouting

8. Construction and reservoir effects on the permafrost in the dam abutments and foundation

9. Rock deformations resulting from permafrost thaw in the dam foundation

10. Hydrogeology and potential for reservoir leakage through the relict channels

11. Static and dynamic stability of relict channel slopes

12. Permafrost thaw in relict channels and its consequences

13. Design concepts for relict channel treatment

14. Stresses, deformations and support of rock surrounding the power chambers

15. Reservoir slides: size, effects and mitigating features

HYDROLOGIC AND HYDRAULIC STUDIES

General

The hydrologic and hydraulic design concepts as well as the available data used in the preparation of the Feasibility Report will be reviewed. We will develop programs to obtain additional information in the field and through model tests. The details, schedules, costs, and reasons for the programs and model tests will be included in a report to the Power Authority requesting approval to proceed.

Hydrologic Studies

The prime purpose of hydrologic studies will be to provide basic input to environmental and engineering studies. The scope and methodologies of the hydrologic studies will depend primarily on the results of agency and public review of the FERC License Application. We anticipate, however, on the basis of our past experience in FERC License Applications and the preliminary review of the existing studies that we performed for this proposal, that the following seven hydrologic work tasks will be necessary.

- Review and evaluate previous studies
- Continue hydrologic and meteorologic data monitoring
- Update and/or upgrade river-reservoir flow depth and velocity studies
- Update and/or upgrade river-reservoir temperature studies
- Perform river sedimentation modeling studies
- Perform river-reservoir water quality studies
- Update and/or upgrade river-reservoir ice cover studies.

In addition to the above seven tasks, two-dimensional river-reservoir temperature modeling may be required, if one-dimensional model studies prove to be too crude for environmental impact studies. These two-dimensional model studies are presently viewed as optional work tasks.

Review and Evaluation of Previous Studies

We will carefully review previous hydrologic studies in light of the License Application to identify and formulate additional studies required. Key hydrologic studies subject to review and evaluation will include:

- River-reservoir sedimentation, temperature, ice cover and water quality studies
- Hydrologic and meteorologic data monitoring programs
- Water supply and design flood studies

Memoranda will be prepared to summarize the results of review and evaluation.

Continued Hydrologic and Meteorologic Data Monitoring

The primary purpose of hydrologic and meteorologic data monitoring program is to define baseline hydrologic and meteorologic conditions. It also will provide input to prediction of with project conditions through appropriate techniques, such as mathematical modeling studies.

We propose to continue existing data monitoring program, with appropriate modification in number of monitoring parameters, monitoring locations, monitoring frequency and instrumentation. The level of modification will be determined through field investigation and review of existing monitoring program, with an eye to the responses to the FERC License Application. It is anticipated that much of data monitoring will be completed in a 12-month period. Key monitoring activities will include:

- Meteorologic data collection for river-reservoir temperature, water quality, and ice cover studies
- Water quality and sediment data collection
- Stream gaging including discharge measurement for river flow, depth and velocity studies
- Ice observation including, ice thickness
- Side channel groundwater data collection including groundwater temperature for river temperature and water quality studies
- Side channel discharge and stage data collection and dissolved oxygen for river flow, temperature, depth, velocity and water quality studies
- Water temperature and turbidity data collection at Eklutna Lake for river-reservoir temperature and turbidity studies.

R & M Consultants, Inc. will be retained to perform the monitoring activities, under the coordination and supervision of the Joint Venture. Periodic data compilation reports will be prepared to describe and summarize the data collection activities.

Update and/or Upgrade River-Reservoir Flow, Velocity, Depth Studies

The purpose of river-reservoir flow, velocity and depth studies is to provide input to environmental studies, including fishery studies. Depending upon results of agency and public review of the FERC License Application, the level of studies will vary from updating the existing studies based on HEC-2 steady-flow model, by incorporating new data, to upgrading the existing studies by improved methodologies and an improved data base. We anticipate that, in addition to updating the existing studies, we will need to determine river stage under unsteady flow conditions at key side channels and sloughs.

The studies will result in flow velocity and depth at key locations along Susitna River with and without project conditions for combination of different discharge levels, times of year, and modes of reservoir operation. Emphasis will be placed on analyses of velocity and depth at side channels and sloughs.

Update and/or Upgrade River-Reservoir Water Temperature Studies

The river-reservoir water temperature studies will be aimed at providing input to the studies of environmental impacts on fisheries. Although the level of studies will depend on the outcome of agency and public review, we anticipate that the existing studies, based on one-dimensional models, should be updated by incorporating new data, including side channel groundwater temperature data and Lake Eklutna temperature data. The same one-dimensional models as used in the previous studies will be utilized, if they are made readily available and are fully documented. If this is not the case, similar (perhaps somewhat better) one-dimensional models will be used, for example:

- WQRRS model developed by U.S. Army Corps of Engineers for reservoirs and river

- For the reservoir, the one-dimensional Reservoir-Lake Temperature and Dissolved Oxygen Model developed by U.S. Geological Survey; for the river, the Unsteady Stream System Temperature and Solute-Transport Simulation Model (Lagrangian Transport Model) developed by U.S. Geological Survey for river.

The model studies will result in vertical temperature profiles in the reservoirs and longitudinal average temperature profiles in the river under with- and without-project conditions. Different discharge conditions, modes of reservoir operation, seasonal variation and unsteady flow conditions will be accounted for.

River Sedimentation Modeling Studies

Depending on data availability and outcome of agency and public review, a one- or two-dimensional river sedimentation model will be used to support the environmental impact studies. The model output will include longitudinal and lateral river bed profiles and bed-material size distribution, (longitudinal variation only if one-dimensional model is used), sediment transport rates and flow depths under existing conditions without project and future conditions with project. Different river discharge conditions, modes of reservoir operation and seasonal variation will be modeled.

Dr. John F. Kennedy and Dr. Forrest M. Holly, Jr., of Institute of Hydraulic Research, University of Iowa, will be retained as special consultants, as they have extensive experience in river sediment transport studies and are thoroughly familiar with the proposed models.

River-Reservoir Water Quality Modeling Studies

Selected water quality parameters will be modeled to predict project impact on river water quality. The water quality parameters to be modeled will include dissolved oxygen, suspended sediment, phosphate, nitrate, total dissolved solids, turbidity, and pH, as they are important to environmental studies. The WQRRS Model developed by U.S. Army Corps will be used.

The model studies will depict the water quality variation in the vertical direction in the reservoirs and longitudinal direction in the river. Conditions to be studied will include:

- With and without the project
- Different modes of reservoir operation
- With and without reservoir clearing
- Different reservoir outlet locations
- Different river flow conditions including wet, medium and dry-year conditions

Update and/or Upgrade River-Reservoir Ice Cover Studies

Existing river-reservoir ice cover studies will be updated and upgraded by incorporating new data including field ice observation. Change in the ice-cover period and ice thickness due to the project will be predicted by accounting for change in river-reservoir temperature and streamflow due to the project.

Dr. John F. Kennedy will be available as a special consultant, if needed.

Optional Subtasks

Two-Dimensional River-Reservoir Temperature Modeling Studies. In the event that one-dimensional temperature models are too crude for environmental impact studies, two-dimensional models will be used.

Longitudinal and vertical temperature profiles in the reservoirs will be determined by using the Laterally Averaged Reservoir Model developed by Waterways Experiment Station, Corps of Engineers. Conditions to be modeled will include:

- With and without project
- Different river discharge conditions including wet, medium and dry years
- Different modes of reservoir operation
- Seasonal effects

For stream reaches, longitudinal and lateral temperature profiles will be determined by applying the one-dimensional unsteady Lagrangian Transport Model developed by U.S. Geological Survey to each longitudinal segment (i.e. along main channel and along side channels). The number of longitudinal segments to be modeled will depend on the number of side channels and available data for model calibration. The conditions to be modeled will be the same as those listed above for reservoir modeling.

The results of two-dimensional temperature modeling studies will be used to approximate two-dimensional variation of other water quality parameters which are strong functions of temperature.

Hydraulic Studies

Dam

Hydraulic studies for the detail design of the dam and its foundations will determine the water seepage gradients and pore pressure gradients within the dam, considering alternative dam cross-sections and foundation conditions. These hydraulic studies will be important in finalizing the dam zoning and foundation treatment. The pore pressures thus determined will be input to the dynamic analyses for the dam.

Diversion Tunnels and Cofferdams

We will conduct hydraulic studies for the Project Conceptual Design development, to establish the economics of tunnel size and cofferdam height versus diversion flood frequency. We will give special consideration to the passage of ice through the diversion tunnels during the diversion and construction period. Confirmation of tailwater levels in the Feasibility Report will be required.

Computer programs to be used in the Project Conceptual Design and in the detailed design phase will model the following:

- Tunnel Water Profile and Pressure Profile (HARZA)
- Flood Routing (HARZA)
- Ice Studies (Corps of Engineers)

Spillways

Hydraulic studies to be done will determine spillway alignment and profile after receiving geologic and topographic definition. The studies will address the hydraulics of the approach channels to the spillway control structures. The flow through the spillway to the receiving channels downstream will also be studied to achieve an alignment favorable to minimizing erosion of the river banks and channel as well as evaluating aggradation or degradation of tailwater levels. Flood routing studies will be done using the design floods to optimize the Project Conceptual Design from the standpoint of the cost of the dam, spillways and diversion tunnels and cofferdams.

Computer programs to be used in the Project Conceptual Design and the final design of the Spillways will analyze:

- Reservoir Flood Routing (HARZA)
- Dynamic River Routing (Corps of Engineers)
- Water Surface Profiles (Corps of Engineers)
- Boundary Layer and Water Surface Profile (HARZA)
- Pressure Profiles (HARZA)

A comprehensive physical model is required to confirm the Conceptual Design. Information from this model will be used in the final design and construction-contract drawing preparation. The model studies will be done at a facility convenient to the design office. We have used the model facility at Washington State University for previous projects.

Power Facilities

We will perform hydraulic studies to confirm the tailwater rating curve power tunnel size, surge chamber size and tailrace tunnel size. The hydraulic studies for the detail design will commence after the detailed design criteria and design memoranda have been reviewed and approved by the Joint Venture Internal Review Board, as well as by the Power Authority and its External Review Panel. The hydraulic design criteria and design memo will specify, for example:

- Power plant operating conditions
- Head loss coefficients for bends, expansions, and contractions
- Tunnel friction coefficients to be used in hydraulic transient studies during unit load acceptance and load rejection conditions
- Turbine performance curve to be used in transient studies

The results of the hydraulic studies will be used in the development of (1) structural design criteria and memorandum (2) turbine design memorandum and input to turbine supply contract documents. No hydraulic model studies are required for the power tunnels, surge chamber or tailrace tunnel.

Computer Programs to be used in the Project Conceptual Design and power facilities final design will model:

- Turbine Transients (HARZA)
- Tail Tunnel and Surge Chamber Transients (HARZA)
- Head Losses (HARZA)
- Tailwater (HARZA)

Low Level Release Facilities

Hydraulic studies for the Project Conceptual Design development will confirm the optimum tunnel diameter for the reservoir mid-level release facilities and its outlet valve structures location. The hydraulic studies for the detailed deisgn and contract construction drawing preparation for these facilities will consist of transient studies for the various valve operating conditions and intake gate closure to define maximum and minimum pressure gradients for structural design of the tunnels. The results of the transient studies will be included in the contract documents for supply of the tunnel manifold steel lining, outlet valves, and the design of the intake gate. Tailrace erosion and protection also will be studied. The low-level emergency release facilties in the diversion tunnel will be studied to determine gate chamber head loss and water profile in the tunnel downstream of the plug. Hydraulic model studies will be made if the double head-break gate chamber is used.

Computer programs will be used in the studies to model:

- Transients from Valve Operation (HARZA)
- Tunnel Head Loss (HARZA)
- Open Channel Tunnel Water Profile (HARZA)

POWER SYSTEM STUDIES

Review of Prior Studies

The power generated at Susitna will be transmitted mainly to the Anchorage and Fairbanks load centers by way of a 345-kV transmission system. The Electric Systems Studies performed by Acres and contained in the March 1982 Report conclude that the 345-kV AC transmission system would be the most suitable.

The feasibility level electric system studies concluded that the basic system configuration will provide satisfactory system operation with maximum Susitna output. We will define the system requirements in greater detail to establish component ratings for the design stages of project implementation.

This will entail a detailed review of the previous system studies to determine whether any revision of assumptions for the system analyses is required. Our review of prior studies will provide a data base for the further studies, and will address the following:

- Review of planning criteria used in determining transmission system requirements
- Review of system energizing procedures for initial energizing and routine operations

- Review of load flow and stability studies of the system at different stages of development.

- Review of proposed corrective measures.

- Analysis of proposed system configuration.

- Analysis of proposed Energy Management System (EMS).

Further Studies

Power system studies are required for the preparation of specifications and evaluation of bids. These studies will be made for generators, generator step up transformers, turbine governors and controls, excitation systems, switchgear, transmission lines, surge arresters, lightning protection of substation, and power plant electrical components.

Our studies will be performed in close cooperation with the Power Authority and the Railbelt facilities responsible for design and operation of the interconnected transmission lines and substations. This will allow accommodation of any changes in transmission system design, such as change of transmission line configuration and length, line parameters, reactive compensation, or other parameters that could affect the behavior of the system. We will schedule the studies so as to ensure timely input to the detailed design of the Watana Dam and the associated transmission lines and switchyards.

Specific power system studies will include the following:

Load Flow Studies. These will be performed to meet the following requirements:

- Determine the power flow level for various modes of plant operation and system load conditions

- Determine generator power factor and voltage regulation requirements

- Determine transformer taps, controls, and ratings

- Determine reactive power supply and control requirements

- Determine losses

- Provide a data base for stability and transient network analysis studies

- Determine feasibility of various modes of hydro-thermal generation dispatch

We will use a load flow computer program for these studies, to examine various alternatives under high, medium and low loads and under both normal and emergency conditions, as required by the planning standards. Load flow calculations will be made for various stages of project development.

System energization procedures will be examined to ensure that all voltages will remain within rated limits at each stage of project development, and with provision for outages determined by the established planning criteria. The effect of possible variations in the load shares of the Anchorage and Fairbanks areas will be analyzed.

The reactive compensation studies will consider fixed and switched reactors, as well as the possible use of static var compensators or English Electric trable-triplers. The most effective reactive compensation levels for the system, will be determined.

<u>Transient Stability Studies</u>. These studies will have the following objectives.

- Determine allowable limits of machine inertia to maintain power system stability
- Verify generator and step-up transformer reactance limits
- Verify application of generator excitation and speed governor characteristics
- Provide input to hydraulic studies relative to the power system
- Determine circuit breaker reclosing requirements
- Review the adequacy of three-pole rather than single-pole switching
- Determine need for provisions to maintain dynamic stability.

As the conceptual studies proceed and more detailed information becomes available, the transient and dynamic stability of the system will be evaluated more precisely and design requirements will be identified for implementation.

The stability studies will use a stability computer program capable of modeling the system in adequate detail. Transient stability studies will cover major stages of system development, as well as both high and low load levels. They also will identify those faults judged to be most severe within the requirements of the planning standards.

Dynamic stability evaluations similarly will encompass the full range of applicable conditions. As problems of transient or dynamic instability are detected, we will recommend the best ways of resolving them by changes in equipment parameters or system configuration.

Transient Network Analysis (TNA) Studies

Transient Network Analysis studies will be performed to determine the following:

- Basic Impulse Insulation Level (BIL)
- Basic Switching Surge Level (BSL)
- Insulation coordination
- Determine surge arrester ratings
- Determine transient and sustained voltage conditions at power plant substation
- Investigate ferro-resonant conditions taking into account the saturation characteristics of generator step-up transformers.
- Verify the need for resistors in high voltage circuit breakers for opening and closing operation.
- Analysis of switching surge levels and transient voltage conditions for underground powerhouse.
- Determine grounding requirements.

TNA studies will use one of various analog transient network analyzers available. The TNA laboratories to be considered will be IREQ Hydro Quebec, General Electric, McGraw-Edison, and Westinghouse. As required, the Electromagnetic Transient Program (EMTP) will be used to augment the work done on the analog TNA.

We will evaluate lightning surge protection for lines and switchyard in consideration of available lightning data for the project region. Surge arrester requirements will be determined.

If single-pole reclosing is to be used, the TNA studies will establish the need, configuration, location and ratings for neutral reactors.

System grounding studies will establish the number of transformers that must be grounded in each substation to keep the X_0/X_1 and R_0/X_1 ratios within the limits for effectively-grounded systems. Protective measures will be developed to minimize the effects of geomagnetic storms on transformers.

All studies will use models of the necessary stages of the project and reasonably likely switching conditions of the system.

Short Circuit Studies

We will use a digital computer short-circuit program for the following:

- Providing equivalent impedance values for TNA studies.
- Determining circuit breaker interrupting ratings.
- Providing a data base to calculate fault current levels required to determine relay requirements.

For the purpose of determining circuit-breaker ratings, we will perform short circuit calculations for the fully-developed system. For other purposes, short circuit studies of intermediate stages of development will be made as well.

We propose to calculate three-phase and single-phase-to-ground faults at all significant points of the system. We also will calculate total faults and contributions. We will determine equivalent impedances to satisfy the TNA study requirements.

System Control and Relay Coordination Studies

Using commercially-available computer programs, relay coordination studies will be performed to:

- Ensure selectivity and stability of the system during fault conditions and other disturbances.
- Determine the feasibility of reclosing systems and breaker tripping times assumed in transient stability studies.
- Determine optimal types of relaying and types and signal carriers.

- Select primary and backup protection schemes.

The results of relay coordination studies, load flow studies, short-circuit studies and transient stability studies are mutually interdependent and consistency will be maintained at all times.

Reports. The following reports will be issued at time of completion.

- Electric System Studies Review.
- Susitna Hydroelectric Project and the Updated Electric System Studies.

ENERGY MANAGEMENT SYSTEM (EMS) STUDIES

EMS requirements will include the schedule of required implementation of each subsystem. Functional requirements for the SCADA subsystem, generation control subsystem, power scheduling and load forecasting subsystem, system security subsystem and system support subsystem will also be developed.

We will perform an optimization study of the communication subsystem to identify the most cost effective communication media between each of the monitored links of the power system. This study will consider several carrier systems (power line carrier, owned or leased telephone lines, microwave link) or a combination and determine for each segment of the system the type of carrier that best satisfies the requirements of reliability of communication and cost efficiency. The need for redundancy and emergency communication links will be identified and appropriate systems selected. The results of the Energy Management and Communication systems study will be presented in a report at the time that this study work is completed.

PROJECT LAYOUTS

Project Conceptual Design studies will be executed using criteria established by the Transition Team and approved by the Internal Board of Review. The conceptual design criteria will be based on accepted engineering practice and latest field data where applicable. The conceptual design will be expanded later to result in the final design criteria, which will be used in the preparation of detailed design.

Dam

The conceptual design criteria for the dam will be use as references the criteria used in the Feasibility Report, an assessment of all the pertinent field data collected and the accumulated experience of the members of the Transition Team. The criteria will provide the basis for preliminary dimensions of the dam crest, upstream slopes of the dam section, downstream slopes of the dam section, freeboard, depth of foundation stripping, foundation excavation, foundation treatment, and dam location constraints, based on surface observations and available subsurface investigations. Quantity estimates and preliminary cost estimates will be prepared for the layouts for each of the selected study axes.

Diversion Tunnels and Cofferdams

The conceptual design criteria will include diversion design flood information, hydraulics, structural and geotechnical input in the form of guidance with respect to locating tunnel portals, tunnel alignment and spacing between tunnels. The layouts studied will be compatible with the layout for the dam associated with the selected dam study axes.

Spillways

The Transition Team will confirm the prior hydrologic studies that resulted in the project probable maximum flood and design floods. The team will establish the criteria for routing the various floods through the Project spillways with respect to reservoir elevation at commencement of flood inflow, power facilities discharge, outlet facilities discharge, and spillway gate operation. They will confirm the required dam freeboard with the respective flood discharge. The hydraulic criteria will specify design head on the spillway crest, estimated bulking to add to the water profile to establish the height of the chute walls, and guidance with respect to the bucket locations to be studied, as well as the bucket geometry. Quantity takeoffs and preliminary cost estimates will be prepared for each layout.

Power Facilities

The Transition Team will confirm the number and size of units to be installed at Watana. They will then establish the conceptual design criteria for the power facilities conceptual layout studies. The criteria will include direction in the geotechnical area as to spacing between intake tunnels, intake approach channel cut slopes, minimum spacing between the transformer gallery, generator hall and surge chamber, and optimum orientation for these underground structures based on the latest field information on joint sets and other important subsurface discontinuities. The hydraulic criteria will include direction on allowable velocities through intake trashracks, intake tunnels and tailrace tunnels, as well as with respect to the preliminary surge studies to size the surge chamber. The hydraulic criteria also will include parameters for the temperature control of project water releases through the intake structures.

A list of Project data pertinent to the supply of equipment will be assembled and sent to major equipment suppliers in the U.S. and abroad. The data will include headwater and tailwater elevations, Project elevation with respect to sea level, unit flows, seaport unloading restrictions, railroad and roads clearances and weight limits. Suppliers will be asked to provide preliminary dimensions of the major equipment, weights and sizes of largest pieces and major subassemblies to be shipped. This information will be used to optimize the powerstation access tunnel size and the transformer gallery and generator hall widths and heights.

The studies will include construction access tunnels and also the cable shafts and powerhouse access shaft. In the course of sizing the cable shafts, access shaft and permanent access tunnel, due consideration will be given to the heating and ventilation of the underground chambers. Structural criteria will include floor design loadings, tunnel lining design parameters (concrete and steel lining), and guidance for underground chamber support.

Layouts will be compatible with those of the dam, diversion tunnels, spillways and low level release facilities. Quantity take offs and preliminary cost estimates will be prepared for each layout.

Low Level Release Facilities

Our review team will develop conceptual design criteria for the low level release facilities. Geotechnical criteria will include tunnel orientation, intake location and cut slope parameters, manifold tunnel spacing and foundation treatment at the outlet/spillway bucket. We will prepare layouts for each of the dam axes, as well as quantity takeoffs and preliminary cost estimates.

Project Conceptual Layout

We will screen the layouts and cost estimates for each alternative, optimizing the most favorable alternative from technical, environmental and cost viewpoints. We will provide a report on the selected layout to the Power Authority and its

External Review Panel for approval. Once approved, the layout will be the Project Conceptual Design and the basis for the remainder of work to project completion.

The work associated with the Project Conceptual Layout is done under Work Task 3. The work will be controlled and mainly carried out in the Anchorage office with general support from the Bellevue office.

Support from the Harza and Ebasco main offices in Chicago and New York respectively, will mainly be in the form of specialists on the Internal Board of Review and the Value Engineering Team. Task 3, with its detailed list of subtasks, estimated man days and cost budget, is included in the task breakdown at the end of Section D(b).

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D(b) DESIGN OF TECHNICAL AND NON-TECHNICAL FACILITIES

INTRODUCTION

This section of the proposal presents all of the tasks that have been identified to be accomplished under the contract for the detailed planning and design of the Watana Dam. Certain tasks are described in detail in other sections but all of the required tasks are identified in this section so that the total scope of work can be presented in summary form in one location. This section presents the procedure for document preparation for the Project control system and describes which tasks are required for the design of the Project facilities. It then describes the subtasks within each major task, the schedule for accomplishing the task and the general sequence of activities that is followed. Lastly, it provides examples of the logic diagram for selected tasks that are representative of all of the design tasks. The information presented in this section provides the basis for controlling the entire design program. The Project control system is discussed in greater detail in section D(1), "Management." The description and logic sequence of environmental tasks are Section D(c) "Environmental Program".

Management of the Project will be in Anchorage, with the major production effort on technical facilities in the Joint Venture office in Bellevue, Washington. Support from the Harza and Ebasco main offices will generally be limited to activities of short duration, such as specialist support and review by senior professionals, and special studies that require large computer facilities. Examples of main office support are the sophisticated analyses for reservoir and streamflow models, hydraulic transients, and seepage and stability studies for fill structures. The location of the work is indicated on the manpower budgets for each task presented in the Cost Proposal.

In making our work plan for the design of the Susitna Project facilities, we have recognized two primary goals:

1. To produce a set of individual construction contracts and equipment supply contracts that meet the Project construction schedule and are packaged to encourage bid competition and result in fixed-price bids.

2. To establish a set of engineering tasks with discrete subtasks that facilitate the scheduling and control of the design process and that provide an effective basis for gauging the Joint Venture performance with respect to the accomplishment of each task of our Work Plan.

Our packaging and scheduling of the contracts to meet the first goal has the following objectives:

- To maintain a logical construction sequence
- To provide a manageable number and size of contracts with fixed prices
- To permit adequate time to collect data to produce contracts that will minimize cost overruns generated by quantity changes and claims related to quantity changes
- To provide for maximum competition for contracts
- Make best use of contractors' equipment spreads and expertise in certain kinds of work
- To minimize risk considerations by bidders because of extended contract time
- To optimize the utilization of construction plant
- To provide the opportunity for early project completion by particularly effective contractor performance
- To provide for careful selection of suppliers of major equipment and effective management of their contracts to meet construction schedule needs

These objectives are not entirely compatible with one another. Therefore, tradeoffs are required in order to arrive at contract packaging which optimizes the composite effect. The set of eleven civil construction packages and 15 equipment supply packages, and the necessary trade-offs, are discussed under "Schedule of Tasks", below.

To meet the second goal of the design phase, we have established a program that provides:

- Careful planning and execution of field investigations to provide a timely flow of environmental and geotechnical information resulting in the efficient preparation of designs and contract documents.
- Sensitivity to the requirements of the licensing and permitting processes, with timely and effective explanation of the design process and its output to cognizant agencies and the public, and response to their questions.
- A well-established work flow logic which provides for an orderly development of cost effective design from the con-

ceptual stage through analysis of data, formalized agreement on design criteria, detailed design, preparation of drawings, specifications and contract documents. Appropriately scheduled reviews by the Joint Venture Internal Board of Review, the Construction Manager and the Power Authority's External Review Panel, as well as information exchange with the resource agencies and the public, will assure the quality and acceptability of the project.

- A management plan that provides the required skilled personnel in locations that can most effectively serve the project.

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PROJECT CONTROL OF TECHNICAL DOCUMENTS

The Joint Venture participation in the Susitna Project will be developed through regulatory, environmental, and engineering phases that may be categorized generally as:

1. FERC Licensing Support
2. Environmental Monitoring
3. Conceptual Design
4. Detailed Design
5. Contract Document Preparation
6. Construction
7. Start-up and Operation

Regardless of the number of work tasks or the complexity of their interrelationship, all tasks of the work program lend themselves to control by documents. Some of these documents serve to control technical quality of the work; some serve to control budget and schedule. Satisfactory control of all three factors; quality, budget, and schedule, provides maximum assurance of a successfully completed project. The Joint Venture will use several key documents in execution of the Susitna Hydroelectric Project work program. All have proven to be very effective in past project performance.

In addition to investigation memoranda which apply to the study phase of the work program; design memoranda, quality control and quality assurance memoranda, inspection report forms, test report forms, and other documents applicable to each phase of work will be prepared. In each of these categories, work is to be identified in detail prior to the execution of the work. In most instances, examples of similar work completed previously on other project will be referenced and included so that maximum benefit of prior experience is gained. The control system for all memos, reports and other work packages will be similar to that described for the investigation memos.

Several investigations and studies are required to confirm, refine, optimize, or further develop specific aspects of the Susitna Project. These include, among others, important efforts in the field of geotechnical, environmental, hydrology, and hydraulic engineering. The proposed investigations are described in detail in appropriate sections of the proposal. For each of these work efforts we will prepare an investigation memorandum. The investigation memorandum will identify what work is to be done, what specific methods will be used (including reference to applicable national and/or international standards), who will do the work (including any subcontract groups), where the activity will be conducted, when the activity will start and finish, how much is budgeted in the work, what interim and final products are expected, and how the products are to be used.

Investigation memorandum preparation will be ordered formally by the Operations or Program Manager (Engineering, Environmental and Regulatory, or Project Control) in Anchorage from appropriate members of the project team (e.g.; the head of geotechnical exploration programs). In the case of portions of the project team that report directly to the Project Manager, the Project Manager will issue such requests. The Transition Program Team will advise the Project Management team of the need for several investigation memoranda, and will prepare some of the memos.

Project Control Operations will then insert the approved work program into the overall project control system (EPICS), which is described in detail in Section D(1) of the proposal.

Utilization of the investigation memorandum/EPICS tracking method is of special importance to the Susitna Project. A large amount of costly field and other study work must be started and completed very quickly to maintain a design schedule allowing a construction start early in 1985. There is no room in either schedule or anticipated budget for misdirected effort. The procedure outlined above permits a large Joint Venture staff and the several support organizations new to the Project to be productively engaged in Project activity by ensuring that they are properly guided and directed. The procedure simultaneously provides detailed information for the management team and the Power Authority.

Each of the memoranda discussed above (e.g. design memoranda, procurement memoranda, etc) will have a specific project document as its result. These project documents will be combined and form a singular document know as the Project Specification. Supplementing the memoranda forming the Project Specification will be procedures for documentation control and assignments of task responsibilities. The Project Specification and the Procedures Manual will thus serve the basis for control of the Project, i.e., administrative as well as technical.

The formalized document control procedure will be developed and administered by the Project Control Manager. The purpose of this procedure will be to delineate for all the technical products, the distribution to and designation of those parties

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having responsibility for review and signoff of the each document. It will the Project Control Manager's responsibility to ensure that the procedure is followed and that proper control of all reviews is performed.

The Project Specification will include a listing of the key project documents and the discipline or individual responsible for the item. This discipline/individual will be responsible for all technical and project related matters concerning the document. Generic documents prepared by the responsible discipline/individual will be passed on to the Engineering Manager for acceptance and to the Project Engineering Operations Manager for Project approval. Documents and memoranda relating to design criteria and other factors affecting technical quality of the design and operation of the project will undergo an independent review and approval by the Project Internal Review Board's individual assigned for this document. The Project Specification Document Control section will clearly delineate all Project Documents and the review cycle associated with each document. It will be the responsibility of the Project Control Manager to insure that the Discipline Responsibility Listing is accurate and up-to-date. The Project Control organization will report status to the Project Manager on a frequent, informal basis and will provide formal, regularly scheduled status reports to the Project Manager, the Operations, Manager and the Internal Review Board. Project Management, through the Project control organization, will ensure issuance of significant results to all affected units of the project organization. The Project Control organization will maintain the master file of these and all project documents, including subcontracts and formal communication on significant matters.

The above routine of document flow and control will be practiced in general for all activities taking place throughout the period of development of the Susitna Hydroelectric Project.

A summary listing of reports, design memoranda, drawings and other documents which are the "deliverables" of the Joint Venture work program is presented in the section "Tasks," at the end of this section.

Environmental and Regulatory Program work and Public Participation Program activity will be monitored and controlled in a fashion similar to that described above. The products of these portions of the work program, while not comprised of design, manufacture, installation, and construction of Project components, are nevertheless tangible commodities against which a budget forecast can be made, progress monitoring can be exercised, and interrelationship control can be applied. These products will take the form of licensing and permitting milestones, newsletter reports, mitigation programs, milestone achievement

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meetings, and the like. Project Control Operations will include these functions within the EPICS-CPM for the overall work program.

Fundamental elements of the Joint Venture project control system include these items commonly found in general engineering practices:

- Timesheets, logged and checked by supervisors with entries coordinated to authorized sub-task nomenclature (digitized)
- Drafting Standards Manual
- Design Guide Manual
- Earned value records based on division of tasks into multiple weighted segments
- Progress reports of types suitable for general management overview, and other forms suitable for detailed section and squad-level analysis
- Standard details
- Standard procedures of checking drawings
- Quality Control/Quality Assurance Manuals

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IDENTIFICATION OF TASKS

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IDENTIFICATION OF TASKS

The tasks that have been defined can be divided into three general categories:

1) Management, meetings, and supporting investigations and studies

2) Design of technical facilities

3) Design of non-technical facilities

Management, Meetings and Supporting Investigations and Studies

Management activities in this category include project management, management of the engineering, environmental, and project control activities, and management of the design subcontracts for non-technical facilities. Support to the Power Authority in processing the FERC License Application, in presentations to the External Review Panel, and in the public participation process are also included. The preliminary activities that cover review of the feasibility report and lead to preparation of the Project Conceptual Design Report and the geotechnical and environmental investigations and studies that relate to several features of the project are included in this category.

The following nine tasks are defined to cover the management, meetings and supporting studies and investigations.

Task	Title
1	Project Management
2	Project Support Service
3	Review of Prior Studies, Project Conceptual Design and Detailed Schedules
4	Environmental Studies
5	Geotechnical Field Investigations
6	FERC License Support and License Compliance Activities
7	Electric Power System Studies
8	Meetings for Public Participation Support
9	External Review Panel Meetings

Design of Technical Facilities

Design of the technical facilities is divided into eleven civil construction contracts and fifteen equipment supply contracts. Each contract represents one task in the design program. Home office support and field support during construction to provide quality assurance are two additional tasks that are included with the design of technical facilities.

The technical facilities include the following major project features:

- Construction Diversion Facilities
- Main Dam
- Buried Channels and Reservoir Treatment
- Spillways and Outlet Works
- Power Facilities
- Control Facilities

All of the construction work for the preceding project features will be accomplished within the eleven construction contracts mentioned previously. Table D(b)-1 summarizes the scope of work that is covered in each construction contract and Table D(b)-2 lists the equipment supply contracts.

Table D(b)-1

CIVIL CONSTRUCTION CONTRACTS

Task	Civil Contract	Title	Scope of Work
10	C-1	Diversion Tunnels	Portal and Tunnel Excavation; Design and Install Temporary Support System: Install Concrete Linings; Furnish and Install Concrete Tunnel Linings.
11	C-2	Main Dam I	Excavation of Abutments; Drainage and Grouting Access Tunnels; Drilling and Grouting Inside Galleries.
12	C-3	Main Dam I	Construction of Cofferdams and Diversion of River; Excavation of Dam Foundation Treatment; Consolidation Grouting of Dam Foundation; Dam Embankment to El. 1400; Excavation of Intake Approach Channel and Power Intake Structure.
13	C-4	Main Spillway I	Excavation of Main Spillway (Chute), Foundation Treatment; Excavation of Gallery Under Spillway.
14	C-5	Outlet Facilities	Portal and Tunnel Excavation; Install Concrete Lining; Furnish and Install Steel Liner up to Entry to Discharge Valve House, Power Intake Structure and Outlet Facilities Gate Structure.
15	C-6	Power Facilities	Underground Excavation of All Power Facilities; Design, Install Temporary Support Systems; Install Concrete Linings; Furnish, Install Steel Penstock Linings; Install Steel Conduits in Diversion Tunnel #1 Plug and High Pressure Slide Gates; Mass Concrete and First Stage Concrete in Powerhouse, Transformer Gallery and Surge Chamber.
16	C-7	Main Dam III	Embankment to El. 2210; Excavation of Relict Channel, Emergency Spillway, Tailrace Cofferdam, and

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			Switchyard; Relict Channel Treatment; Fuse Plug Embankment.
17	C-8	Aggregates and Concrete Production	Furnish Concrete Aggregates, Cement and Additives; Provide Batching, Mixing, and Delivery of Concrete for All Project Features except Diversion Tunnel Linings.
18	C-9	Main Spillway II	Construction Concrete Structures Including Outlet Facilities Discharge Valve House, Power Intake Structure, and Outlet Facilities Gate Structure.
19	C-10	Completion and Equipment Installation for Spillway Outlet Facilities & Power Facilities	Install All Owner Furnished Equipment Install Second Stage Concrete; Construct Control Building, Concrete Plug in Diverision Tunnel #2, and Bridge Emergency Spillway; Civil Construction in Switchyard; Supply and Install: Lighting, Heating, Ventilating, General Electrical, General Mechanical, Piping, Architectural Finishes Including in Switchyard.
20	C-11	Willow Control Center Microwave	Construct Willow Control Center; Install Microwave Towers and & Equipment

Table D(b)-2

EQUIPMENT SUPPLY CONTRACTS

Task	Contract Document	Title
21	E-1	Turbines & Governors
22	E-2	Generator & Excitation Equipment
23	E-3	Microwave System & Tower
24	E-4	Willow Control Center Diesel Generator, Uninterruptable Power Supply, Security System, Fire Protection System
25	E-5	Trashracks, Gates & Gate Operators
26	E-6	Cranes & Hoists
27	E-7	Outlet Works Valves, Including High Pressure Slide Gates and Steel Liners for Emergency Release
28	E-8	Transformers
29	E-9	Control Switchboards
30	E-10	HV Switchgear
31	E-11	Generator Voltage Switchgear
32	E-12	Station Service Switchgear
33	E-13	Computer Control
34	E-14	Power Cables - Furnish & Install
35	E-15	Switchyard Structures: Busses & Accessories

The last two numbered tasks are associated with the design of the technical facilities and providing quality assurance during construction. They are:

Task 36 Home Office Assistance during construction.

Task 37 Field support to assure the design intent is accomplished.

NON-TECHNICAL FACILITIES

Management of the design subcontracts for non-technical facilities, Task 38, is the only task that is presently identified for this category of activities under the principal contract. Other non-technical facilities tasks will be defined as the design subcontractors are employed.

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Management of the design subcontracts will be done in a manner that is consistent with the management of the principal contract for the detailed planning and design of the technical facilities. As the principal contractor, we will outline the scope of services, determine the schedule for having the non-technical facilities in-place and, together with the Power Authority, establish qualification criteria to be met by the design firms or joint ventures. Proposals will be invited and evaluated using criteria similar to those used by the Power Authority for the principal contract. A selection recommendation will be made to the Power Authority, and upon approval, a contract will be negotiated with the selected firm or joint venture.

At present we expect there will be six design subcontracts, each of which will be divided into a number of tasks, leading to bid packages for construction and equipment supply contracts. The six subcontracts will be for the Access Roads, Railroad Facilities, Construction Camp, Airstrip, Reservoir Clearing, and the Permanent Town. The following list indicates the bid packages that could be developed to conform to the Power Authority objective of awarding fixed-price contracts for construction and equipment supply.

- <u>Access Roads</u>

  Topographic Mapping
  Roads
  Bridges and Structures

- <u>Railroad Facilities</u>

  Topographic Mapping
  Roadbed and Trackage
  Bridges and Structures

- <u>Construction Camp</u>

  Roads
  Structures
  Furnishings
  Maintenance and Safety Equipment
  Camp Power Supply and Distribution System
  Transmission Line for Power Supply
  Sewage Treatment Facilities
  Water Treatment Facilities
  Fuel Supply & Storage

- Airstrip

  Landing Facilities
  Communication Facilities
  Buildings

- Reservoir Clearing (Including Inventory & Planning)

  Access Roads
  Vegetation Removal and Disposal (Several Contracts)

- Permanent Town

  Demobilization of Construction Camp & Renovation of Useable Buildings
  Furnishings
  Maintenance and Safety Equipment

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The project schedule for Engineering Work Tasks is shown in bar chart form on Exhibits D(b)-1, -2 and -3. There are a total of 38 work tasks. Of the 38 tasks, 11 pertain to civil construction contracts and 15 to equipment supply contracts. The discussion on the following pages deals with Exhibit D(b)-2 and the content and scheduling of these 26 tasks, plus Tasks 36, Home Office Assistance During Construction, and 37, Field Support Staff.

The remainder of the tasks pertains to management, support functions, the critical initial studies related to environmental and geotechnical considerations, and early design layout development, or management and control of design subcontracts. Their scheduling is shown on Exhibits D(b)-1 and -3 and they are discussed in our responses to the other special questions under Management of Design, such as D(c), "Environmental Program." The schedule and concept of construction and equipment contract packaging is based on our current understanding of the Project. This approach will be reviewed in detail during the conceptual design phase and will be discussed with the Power Authority staff and the Construction Manager. Modifications will be made as necessary to attain the technical, financial and management objectives of the Power Authority.

In developing the schedule for Engineering Work Tasks, the following requirements came into play:

1. <u>The FERC License was assumed awarded on January 1, 1985</u>. Additionally, the Power Authority would not award any contract, whether civil construction or equipment supply, until after the FERC License had been awarded.

2. <u>The pioneer access road would not be constructed</u>. That is, there would be no surface access to the site until it could be constructed beginning after January 1, 1985.

3. <u>Other general requirements which entered into the contract packaging</u>:

    a. <u>Limit The Duration of Contracts</u>. This will limit the effect of labor and material escalation costs to a given contract. Most of the construction activities, as scheduled, fit into a three-year time frame. The major exceptions are the dam embankment, which is addressed later, and the two contracts for the power facilities.

b. Accomplish Foundation Excavations In Separate Contracts. Traditionally, major claims for contract changes and delay have related to field conditions affecting design and construction of foundations. Much uncertainty may be eliminated by comprehensive investigation programs. However, separate foundation contracts will limit the impact of any uncertainty just to those contracts and will not affect the follow-on work contractually.

Separate foundation contracts will permit "fixing" the earthwork or concrete quantities and, in effect, allow fixed-price or lump-sum bids for the follow-on work.

c. Minimize "Game Playing" With Pay Items or Quantities By Contractors During Construction. In underground work, both excavation and final lining or support system will be included under the same contract and paid for as lump sum. Where excavation and pay lines and no-pay lines will be established for excavation and concrete. Temporary support systems will be the responsibility of the Contractor. Opportunity for follow-on contractors to challenge safety provisions included in the excavation phase will be minimized.

d. Construction of Complete Structures By One Contractor. This eliminates interfacing problems, delay claims, and management problems which would occur if two or three contractors working on the same structure should be hindered by actions of one of the other contractors.

e. Grouping of Similar Work Scheduled Within the Same Time Frame Into One Contract. This results in more efficient use of the construction plant and materials. For example, the earthwork related to the relict channel, emergency spillway and fuse plug are grouped with the dam embankment work, permitting that contractor to use his expertise to schedule the work and utilize the materials generated to his best advantage and overall efficiency. Similarly, installation of all equipment (electrical, mechanical, and architectural) was broken out into one "completion" contract permitting one contractor to schedule, coordinate and perform this work with others required to use the same work areas and equipment.

f. <u>Eliminate Investment In Duplicate Sets Of High Cost Construction Plant And Equipment.</u> For example, we have proposed that all the Project concrete (except that in the diversion tunnels) be supplied by a separate concrete and aggregates production contractor.

The Watana Construction Schedule, as shown in the Feasibility Report, Volume 3, Final Draft, was utilized as a basis from which the 38 Engineering Work Tasks were programmed. Our review of that construction schedule indicated that a well-conceived approach to the construction had been developed. However, we will analyze the dam construction procedure in detail during the conceptual design phase. If a year could be saved in the construction of the dam, with the possibility of earlier reservoir filling, the early generation would improve the financial feasibility of the Project .

We have examined the possibility of staging construction and unit installation for operation at an intermediate reservoir level. While the structural and construction solutions are possible, we conclude that the relationship of reservoir size and probable maximum flood prohibits project operation with anything less than all safety features in place.

Some changes have been made in the schedule to better comply with the general requirements of contract packaging described previously. These changes are mentioned in discussion of the specific contracts.

<u>Civil Construction Contracts</u>

<u>Task 10: Civil Contract C-1 - Diversion Tunnels and Facilities</u>

Timely start-up and completion of the construction of the diversion tunnels is critical to meeting the project schedule. For this reason, the contract is expected to be awarded immediately following receipt of the FERC license in January, 1985, with bid solicitations and evaluations occurring prior to that date. The scope of work is limited to the diversion tunnel construction, for two specific reasons. First, the critical nature of the work requires that the Contractor concentrate solely on the need to complete the diversion tunnels on schedule. Second, the absence of a pioneer road discourages mobilizing at this early date for construction of features not on the critical path. To keep the contract as simple as possible, the diversion tunnel gates are not included; only the concrete portals with the embedded sill beams, guide rails, and lintels will be furnished and installed at this time.

Task 11: Civil Contract C-2 - Main Dam I

The work scheduled for execution under the C-2 contract pertains to the excavation of the abutments and of the grouting and drainage tunnels, with their permanent and temporary construction adits. It also includes surface consolidation and deep curtain grouting of the abutments and drilling the drainage holes. This work is vital to the success of the Project and must be commenced early-on to maintain the Project on schedule.

The scope of the work is limited, for two reasons. First, the access road will not be completed by the time the work must begin, so the work of this contract cannot require a road for mobilization. Second, the work is highly specialized.

Although an extensive site investigation program will have been conducted to determine foundation conditions and estimates of quantities as accurately as possible, this contract will be on a unit-price basis, except for the construction of grouting and drainage tunnels. These will be handled on a lump-sum basis.

Task 12: Civil Contract C-3 - Main Dam II

The C-3 contract introduces the most critical stage of the dam construction in terms of encountering difficult working conditions, unforeseen conditions and adverse weather. Excavating to the dam foundation in the river channel, performing foundation treatment, and constructing the embankment in the trench thus created are likely causes for most breaks in schedules and cost overruns.

It will be the C-3 Contractor's responsibility to perform these critical tasks. Excavation of the intake approach channel is included in the scope of work to provide a nearby source of rockfill materials at the time embankment construction begins. During this stage, approach channel excavation will not include the detailed excavation required at the power intake or outlet facilities gate structures. This contract will include the detailed excavation at the power intake and outlet facilities' gate structure and associated rock anchors to stabilize the deep cut before the subsequent tunneling contractors portal in the upper end of the penstocks and outlet facilities.

Task 13: Civil Contract C-4 - Main Spillway I

This contract provides for excavation to foundation, foundation treatment, and subsurface drainage facilities for the spillway approach channel and chute. Adequate controls will be included in the contract documents to control excavation to accurate foundation profile. Concrete volumes will be determine a later contract when as-built information from C-4 will be available.

Task 14: Civil Contract C-5 - Outlet Facilities and Power Intake Structure

This contract includes the excavation and tunnel concrete activities required for construction of the outlet facilities tunnel, the upstream gate structure, and the adjacent power intake structure. The contractor will furnish and install the steel tunnel liners, the manifold, and install the branch liners up to the point they enter the discharge valve house. This will avoid conflict with the C-9 Contractor responsibile for constructing the structure.

Task 15: Civil Contract C-6 - Power Facilities and Access Tunnels

Preparation of the C-6 civil contract represents a major engineering effort, in that preliminary information must be gathered from various equipment suppliers and incorporated into the designs so that basic overall dimensions of the various excavations can be determined. The input of information from the suppliers of the turbines, generators and transformers is particularly important to the timely preparation of the C-6 contract documents. For that reason, documents for these supply contracts will be prepared for bid evaluation and award early in 1985.

The most prominent requirements which entered into the determination of the scope of work for the C-6 contract were those of grouping similar types of work under one contract, limiting the number of contractors working within one area or on one structure, and providing for concrete lining and concrete work in underground construction to be installed by the same contractor who did the excavation. This eliminates paying extra concrete for replacement of overexcavation in an earlier contract.

Task 16: Contract C-7 - Main Dam III

Contract packaging for constuction of the embankment dam will require especially careful study, because it is the primary critical path item, as well as the largest cost item. Emphasis must be placed on maintaining the schedule, as well as ensuring firmness and economy of costs. The Construction Manager will provide important input to decisions on packaging.

In preparing our proposal, we have made a preliminary examination of the advantages and disadvantages of contracting the embankment in three roughly equal packages or as a single contract package. We believe that it is better to put all of the fill above elevation 1400 into one contract (C-7). The abutment and foundation excavation and treatment, plus initial fill to elevation 1400 are packaged in Contracts C-2 and C-3, discussed above.

In a comparison of a single construction contract for the dam fill placement with a three-stage construction packaging, we believe the single contract has the following advantages:

1. A single payment would be required for mobilization and demobilization of men and equipment. Through the Power Authority might elect to furnish the construction equipment in order to to lessen the effect of successive mobilizations on the overall project cost, this presents problems such as how to control contractor abuse of the equipment, or how to combat a contractor's claims that the owner-supplied equipment is not optimal or sufficient for the job.

2. Contract administration by the Construction Manager and Engineer is facilitated.

3. Productivity would be better with a single contractor than with multiple contractors because in the latter case each new group of supervisory personnel would require a period of learning and adjustment to the site work conditions.

4. A contractor with a six-year contract could more easily recover from a season of poor work conditions or delay; this would be much more difficult under a two-year contract. Also, there would be more opportunity to shorten the construction time with one contract.

5. A longer contract duration could invite economical purchasing of large or specialized construction equipment or employment of an innovative approach which could benefit project and contractor alike.

Even though we recommend a single extended contract as the appropriate vehicle for purchasing the embankment construction, we recognize that some advantages may be realized by sub-dividing the work. We see such advantages to include:

1. There can be better competition for smaller contracts because the financial and bonding requirements can be met by more contractors.

2. There would be less built-in contingencies by bidders due to their better ability to forecast costs of fuel, labor and equipment.

3. Smaller size contracts would permit the possibility of more competition among contractors of more modest capacities.

4. The awarding of successive contracts gives flexibility regarding changes in site conditions, and scope of work and may achieve better bid prices.

Our alternative approach to the large contract for dam embankment construction which we have presented with the C-7 - Main Dam III, is to divide the contract into three stages:

C-7A Main Dam III - Stage I
Embankment Construction to Elevation 1810

C-7B Main Dam III - Stage II
Embankment Construction to Elevation 2130

C-7C Main Dam III - Stage III
Embankment Construction to Elevation 2210.

Each of the above contracts would include other on-site earthwork operations which are scheduled during the same time period.

In considering that the dam embankment be constructed under one contract, we have developed a design program so that the following actions will be taken to lessen the impact of the longer contract duration. First, the sources of construction materials will be adequately explored to assure sufficient quantities with characteristics suitable for embankment construction. Second, embankment quantities will be accurately determined during previous phases of the work. Third, the contingency for escalation of labor and fuel costs would be reduced by providing in the contract for reimbursement of some percentage, but not the total increase in labor and fuel cost. Bidders are thus given reason to remove such contingencies from their bids, yet are left with an incentive to minimize any increase to such costs during construction.

<u>Task 17: Civil Contract C-8 - Aggregate and Concrete Production</u>

This contract is provided for the purpose of limiting the cost of mobilizing for aggregates and concrete production to the cost of one plant only (except that the concrete for the diversion tunnels will be supplied by a small batching plant several years before the arrival of the equipment of this contract). Besides limiting costs, the provision of one centralized plant for concrete production will facilitate consistent quality control and production capabilities, since more specialized equipment can be economically purchased under such a contractual arrangement. Moreover, the learning curve for producing well-designed concrete mixes will not have to be repeated with each incoming contractor.

Concrete production at the site is scheduled for late-1988. The successful bidder will be given two years of lead time to purchase, deliver and install equipment, and produce sufficient aggregate stockpiles for sustained concrete production beginning at that time.

Task 18: Civil Contract C-9 - Main Spillway II

This contract provides for construction of concrete structures above ground that are related to the spillway and the outlet works discharge valve house. All concrete quantities will be well defined at the time that these documents are prepared, since the spillway control structures, chute foundation, and outlet works valve house will have been previously excavated to grade.

Task 19: Civil Contract C-10 - Spillway, Outlet Facilities, Power Facilities, Completion and Equipment Installation

Contract C-10 includes work requiring expertise in the various trades, in addition to concreting experience for second stage work. The contract provides for one completion contractor who will provide mechanics, electricians, pipe fitters, millwrights and other specialists and a program to coordinate their deployment throughout the job.

The Contract represents a major engineering effort due to the requirement to provide details of all the equipment to be used on the project, whether owner supplied or not, and to incorporate these details in documents suitable for fixed price bidding.

Task 20: Civil Contract C-11 - Willow Control Center and Microwave Building, Install Microwave System

The prime target in this contract will be to have the towers erected and the microwave building ready in time to make the system operational in December 1987, thus providing the Project's first dependable communication from the job site. Six months later in the second phase, the control building should be ready for the Energy Management System Control.

Equipment Supply Contracts

Tasks 21 through 35 have been designated for the preparation of design memoranda and contract documents for supply of owner-furnished major equipment (as distinct from lesser equipment - pumps, valves, HVAC - which will be supplied under the civil construction contracts, particularly the Completion Contract C-10). Some tasks will appear out of numerical order in this list, since we have grouped them functionally.

Tasks 21, 22 and 28: Turbines, Generators and Transformers

Contracts E-1, E-2 and E-8 for supply of turbines and governors, for generators and excitation equipment, and for the transformers are the key schedule items. Their final dimensions and weights will establish the overall geometry of the main power features, of which the first stage will be constructed under Civil Contract C-6, Power Facilities, Stage I. Accordingly, the awards of these contracts are scheduled so that the supplier may submit his design drawings for review prior to issuance of documents for Contract C-6. Also, because the studies that lead to the turbine and generator supply contracts also are basic to the Detailed Conceptual Design Report, we anticipate the start of those studies in July, 1983 about six months in advance of most of the other supply contract work.

Task 25: Trashracks, Gates and Gate Operators

Contract E-5 will cover the purchase of trashracks, gates and gate operators, except those associated with the outlet facilities and the emergency release. Work on this contract is scheduled early to provide to Civil Works Contract C-1, (Diversion Tunnels and Facilities) necessary information on embedded gate parts. After this initial study information, however, the detailed work on contract documents can be delayed for issue in mid-1987.

Tasks 23 and 33: Microwave System and Computer Control System

Contracts E-3 and E-13 provide for purchase of the microwave system and the computer control system. Engineering work on both will need to start early, for these reasons:

- The microwave system will involve a very long delivery time, yet its initiation is considered essential to establishing dependable project communication. It is one of the first supply contracts started.

- The computer control system is actually two systems which must be compatible. For this reason, we recommend award to a single manufacturer under one contract. The first computer is for the Energy Management System (EMS) located in the Willow Control Center. Working out the intricacies of this sytem with the Anchorage Fairbanks Connection is expected to take about two years. Engineering will start in June, 1983.

The second computer is that for the powerhouse. The manufacturer will start on this computer after he is well along with the EMS computer. Long-lead manufacturing and delivery is expected again, tending to force early engineering to permit mid-1991 operation, along with other powerstation equipment.

Task 24: Willow Control Center Equipment

Contract E-4 provides for the Willow Control Center Equipment. The engineering-bidding-fabrication-delivery cycle will be about four years. However, delivery will be tied to the availability of the Willow Control Center Building in about mid-1988. Engineering on control center equipment has been schedule to start in June, 1984, allowing concentration earlier on the more urgent microwave system and computers.

Task 27: Outlet Facilities Gates and Valves, Emergency Release Gates and Steel Liner

Initial studies for the equipment concerned with the outlet facilities (Contract E-7) will provide dimensioning information for the outlet facilities (Civil Contract, C-5). We have scheduled C-5 to start in June 1985 to fit in with other civil works contracts. Work on E-7 will begin at the same time but proceed slowly, after providing the dimensioning information. Award will not be necessary until June 1987.

Tasks 26, 29 through 32, 34 and 35: Other Mechanical and Electrical Owner-Furnished Equipment

The discussion above has covered scheduling of eight of the fifteen proposed owner-furnished equipment supply contracts. Initial engineering work on the remaining seven will start in Janauary 1984 and proceed for about three months to provide preliminary space and arrangements required to set Stage I power station dimensions under Civil Works Contract C-6. Following this initial work, the contracts will be spread for award from late 1985 to late 1987, in order to even out the engineering workload and accommodate required delivery dates.

In Tables D(b)-3 and D(b)-4 we present a detailed scheduling of the various proposed civil works construction and equipment suply contracts.

Network Scheduling of Engineering and Construction

The logical segments of the Watana Dam construction have been the determinant in our proposed engineering schedules. In general, we have followed the schedule presented in the Feasibility Report. The following discussions and Exhibits D(b)4.1 and D(b)4.2 are included in the proposal to indicate the construction and equipment delivery interfaces and restraints we beleive will be particularly important and to show how our engineering schedule recognizes the needs they present.

The construction of the diversion tunnels assigned to Contract C-1 and the cofferdam construction included in Contract C-3 follow the schedule in the Feasibility Report. Concurrently with the diversion work, a separate Contract C-2 will be let to start excavation of abutments and the extensive system of drainage and grouting galleries. Some of the adits daylight into the core section of the dam that will be inaccessible after the embankment rises but access from downstream adits will still be available if special problems arise in achieving a tight grout curtain. The grouting work is scheduled over the first three years.

Contract C-3 includes not only the cofferdams and the power intake approach channel excavation that can be used as a source of fill for the cofferdam and the main dam embankment below elevation 1400. This contract also includes the detailed excavation of the power intake structure and adjacent outlet facilities gate structure so that the upstream portals for the outlet and penstock tunnels will become accessible in 1988. After the foundation conditions for the dam have been revealed by the work of the C-2 and C-3 contractors in 1985-1987, the main dam embankment contract will be put out for bids in 1988.

Excavation of the main spillway, approach channel, control structure, chute and outlet discharge valve house will be part of Contract C-4 together with the drainage gallery. Accurate as-built data on subgrade elevations will be used to facilitate lump-sum bidding in 1989 for the spillway concrete Contract C-9. The control structure will be given priority in the latter contract so that the spillway gates and hoists can be erected in parallel with the balance of the spillway chute.

SUSITNA HYDROELECTRIC PROJECT

TABLE D(b)-3

SCHEDULE OF CIVIL CONSTRUCTION CONTRACTS

CONTRACT	DESCRIPTION	ENGINEERING START	ENGINEERING COMPLETE	CLIENT REVIEW 2 MOS.	INCORPORATE CHANGES 1 MONTH	ISSUE BID PROPOSALS 1 MONTH	BID PERIOD 2 MONTHS	EVALUATION 1 MONTH	APPROVAL BY CLIENT 1 MONTH	CONTRACT AWARD 1 MONTH	MOBILIZATION		REMARKS
C-1	Diversion Tunnel & Facilities	6/1/83	2/1/84	4/1/84	5/1/84	* 8/1/84	10/1/84	11/1/84	12/1/84	1/1/85	(2)	3/1/85	* Slack
C-2	Main Dam I	1/1/83	4/1/84	6/1/84	7/1/84	* 11/1/84	1/1/85	2/1/85	3/1/85	4/1/85	(2)	6/1/85	
C-3	Main Dam II	1/1/83	3/1/85	5/1/85	6/1/85	* 8/1/85	10/1/85	11/1/85	12/1/85	1/1/86	(2)	3/1/86	
C-4	Main Spillway (excavation, foundation treatment)	6/1/85	2/1/87	4/1/87	5/1/87	* 8/1/87	10/1/87	11/1/87	12/1/87	1/1/88	(2)	3/1/88	
C-5	Outlet Facilities, Tunnel Excavation and Concrete	6/1/85	5/1/86	7/1/86	8/1/86	* 9/1/87	11/1/87	12/1/87	1/1/88	2/1/88	(3)	5/1/88	
C-6	Access Tunnels & Power Facilities (excavation and concrete structures)	1/1/84	6/1/86	8/1/86	9/1/86	10/1/86	12/1/86	1/1/87	2/1/87	3/1/87	(2)	5/1/87	
C-7	Main Dam III - Phase I	1/1/87	9/1/87	11/1/87	12/1/87	* 4/1/88	6/1/88	7/1/88	8/1/88	9/1/88	(6)	3/1/89	
C-8	Aggregates & Concrete	2/1/86	6/1/86	8/1/86	9/1/86	* 12/1/86	2/1/87	3/1/87	4/1/87	5/1/87	(18)	1/1/89	(equip ld time & erection)
C-9	Main Spillway - Structure	6/1/85	* 3/1/89	5/1/89	6/1/89	7/1/89	9/1/89	10/1/89	11/1/89	12/1/89	(3)	3/1/90	
C-10	Completion Contract	1/1/86	4/1/89	6/1/89	7/1/89	8/1/89	10/1/89	11/1/89	12/1/89	1/1/90	(3)	4/1/90	
C-11	Willow Control Ctr & Microwave Building	1/1/84	5/1/85	7/1/85	8/1/85	9/1/85	11/1/85	12/1/85	1/1/86	2/1/86	(3)	5/1/86	

SUSITNA HYDROELECTRIC PROJECT
TABLE D(b)-4
SCHEDULE OF EQUIPMENT SUPPLY CONTRACTS

DESCRIPTION		ENGINEERING LATE START DATE	PREPARE SPECS COMPLETE	CLIENT REVIEW COMPLETE	INCORPORATE COMM & ISSUE INQUIRIES	BID PERIOD COMPLETE	BID EVALUATION & RECOMMENDATIONS COMPLETE	CLIENT PURCHASE AUTHORIZED COMPLETE	PREPARE PURCH SPEC - ISSUE PO COMPLETE	VENDOR SUBMIT DRAWINGS COMPLETE	REVIEW & REL FOR FAB COMPLETE	FABRICATE & DELIVER COMPLETE	REMARKS
E-1	Turbines & Governors	7/1/83	8/1/84	10/1/84	1/1/85	4/1/85	5/15/85	7/15/85	8/15/85	12/15/85	2/15/86	10/1/90	Vendor drwgs restrain PH design
E-2	Generators & Exciter Systems	7/1/83	1/1/85	3/1/85	4/15/85	6/15/85	7/15/85	9/15/85	10/15/85	2/15/86	4/15/86	10/1/91	Vendor drwgs restrain PH design
E-3	Microwave System & Towers	6/1/83	7/15/84	9/15/84	10/15/84	12/1/84	1/1/85	3/1/85	4/1/85	6/1/85	7/1/85	5/1/86	Towers (3/1/87 - Electronics)
E-4	Willow Control Center Bldg Support Equip	6/1/84	1/1/85	[illegible]	4/1/85	5/15/85	6/15/85	8/15/85	9/15/85	11/15/85	1/15/86	4/1/88	Vendor drwgs restrain bldg design
E-5	Trashracks, Gates & Gate Hoists	12/1/83	3/1/87	5/1/87	6/15/87	9/1/87	10/1/87	11/1/87	12/1/87	3/1/88	5/1/88	10/1/90	ES of design for imbedded parts
E-6	Cranes & Hoists	1/1/84	1/1/87	3/1/87	[illegible]	6/15/87	7/15/87	8/15/87	9/15/87	11/15/87	1/15/88	5/1/90	Vendor drwgs restrain PH design
E-7	Outlet Work Valves	6/1/85	10/15/86	12/1/86	1/15/87	4/1/87	5/1/87	6/1/87	7/1/87	9/1/87	11/1/87	10/1/88	
E-8	Transformers	1/1/84	3/1/85	5/1/85	6/1/85	8/15/85	8/15/85	10/15/85	11/15/85	1/15/86	2/15/86	3/1/92	Vendor drwgs restrain PH design
E-9	Control Switchboards	1/1/84	5/1/85	7/1/85	8/1/85	10/15/85	9/15/85	1/1/86	2/1/86	6/1/86	8/1/86	10/1/91	Vendor drwgs
E-10	High Voltage Switchgear	1/1/84	7/1/85	9/1/85	10/1/85	12/1/85	1/1/86	3/1/86	4/1/86	7/1/86	9/1/86	9/1/91	Vendor drwgs
E-11	Generator Voltage Switchgear	1/1/84	9/1/85	11/1/85	12/1/85	2/1/86	3/1/86	5/1/86	6/1/86	9/1/86	11/1/86	9/1/91	Vendor drwgs
E-12	Station Service Switchgear	1/1/84	11/1/85	1/1/86	2/1/86	4/15/86	5/15/86	6/15/86	7/15/86	9/15/86	11/15/86	9/1/91	Vendor drwgs
E-13	Computer Control System	6/1/83	6/15/85	8/15/85	10/1/85	1/1/86	2/1/86	4/1/86	5/1/86	8/1/86	10/1/86	6/1/88	Willow Control Ctr complete
E-14	345 kV Power Cables (F&I)	1/1/84	2/1/86	4/1/86	7/1/89	* 9/1/89	11/1/89	1/1/[illegible]	2/1/90	4/1/90	5/1/90	10/1/91	11/1/91 Watana Computer
E-15	Switchyard Structures & Electrical (F&I)	1/1/84	4/1/86	6/1/86	7/1/86	9/1/86	10/1/86	12/1/86	1/1/87	4/1/87	6/1/87	4/1/91	Vendor drwgs restrain Swyd design

* Slack

WORK FLOW

The outlet facilities contractor C-5 will start his tunneling in spring of 1988 from a portal south of the lower end of the spillway chute which will give him access to the manifold upstream from the spillway flip bucket and discharge valve structure. This will let him commence work without interference by the C-4 contractor excavating for the discharge valve structure. He will also have access to the upstream portal after excavation by the C-3 contractor in 1988 as noted above. After the C-4 contractor completes the discharge valve structure excavation in 1989, the C-5 contractor will be able to excavate the six branch tunnels to the manifold. After holing through he can install the concrete lining, steel lining, manifold, and branch linings to the upstream end of the valve structure.

To avoid interface problems, the C-5 Contract will also include the outlet facilities gate structure at the upstream portal and also the adjacent power structure. The latter will have to be coordinated with the C-6 contractor excavating the six penstocks tunnels. Because of the massive size of this 196-foot high structure, concrete work should be started in 1984 and completed in 1989. This will permit installation of intake gates, racks, hoists and hoist structures by the C-10 contractor in 1990. Note that the C-8 Contract for aggregate and concrete production will be bid in 1986 so that the aggregate processing plant and batch plant can be erected and in service by the end of 1988 so it is available for intake structure concrete in 1989.

Excavation of the underground power facilities will start with the C-6 Contract in Spring of 1987 after both diversion tunnels are in service. This contractor will excavate the access tunnels to the powerhouse and the tailrace tunnels simultaneously. The objective is to have one of the tailrace tunnels and at least two of the draft tube tunnels extend into the lower powerhouse so that excavation from the powerhouse cavern below the access tunnel elevation can be dropped through muck shafts for disposal. From the main access tunnel, branch tunnels will be run to the surge chamber, transformer gallery and the penstock manifold. The latter will permit early commencement of excavation of the inclined shafts to the intake structure. The pen-stock tunnel acts as a restraint on construction of the power intake structure. Therefore, this represents one of the major changes we have made from the Feasibility Report Construction Schedule by advancing start of power facilities underground work to spring of 1987.

The C-6 contractor will proceed with first stage concrete in the powerhouse as soon as excavation will permit. Simultaneously, he will follow up with surge chamber and transformer gallery excavation and conrete. The horizontal penstock tunnels will be excavated from the construction adit to the powerhouse cavern and the steel liners installed.

When the main dam embankment reaches elevation 1660, the upper diversion tunnel will be closed and the emergency release facilities installed in the two concrete plugs by the C-6 contractor. Prior to this date, the C-6 contract will have excavated the access tunnel to the vicinity of the two gate chambers. The steel liners will be preassembled in advance of lowering of the diversion gates since their installation together with the nine high pressure slide gates will be on the critical path. Delivery dates have been flagged on the schedule to anticipate these operations. The bonnets of the gates will be encased in the concrete plugs. After the plugs are placed, the mechanical and electrical systems will be installed by the C-10 contractor and the slide gates checked out for proper operation. The trash racks will be installed at the upstream portal at low river flow while the portal is accessible. The gates will then be raised and the emergency release placed in operation.

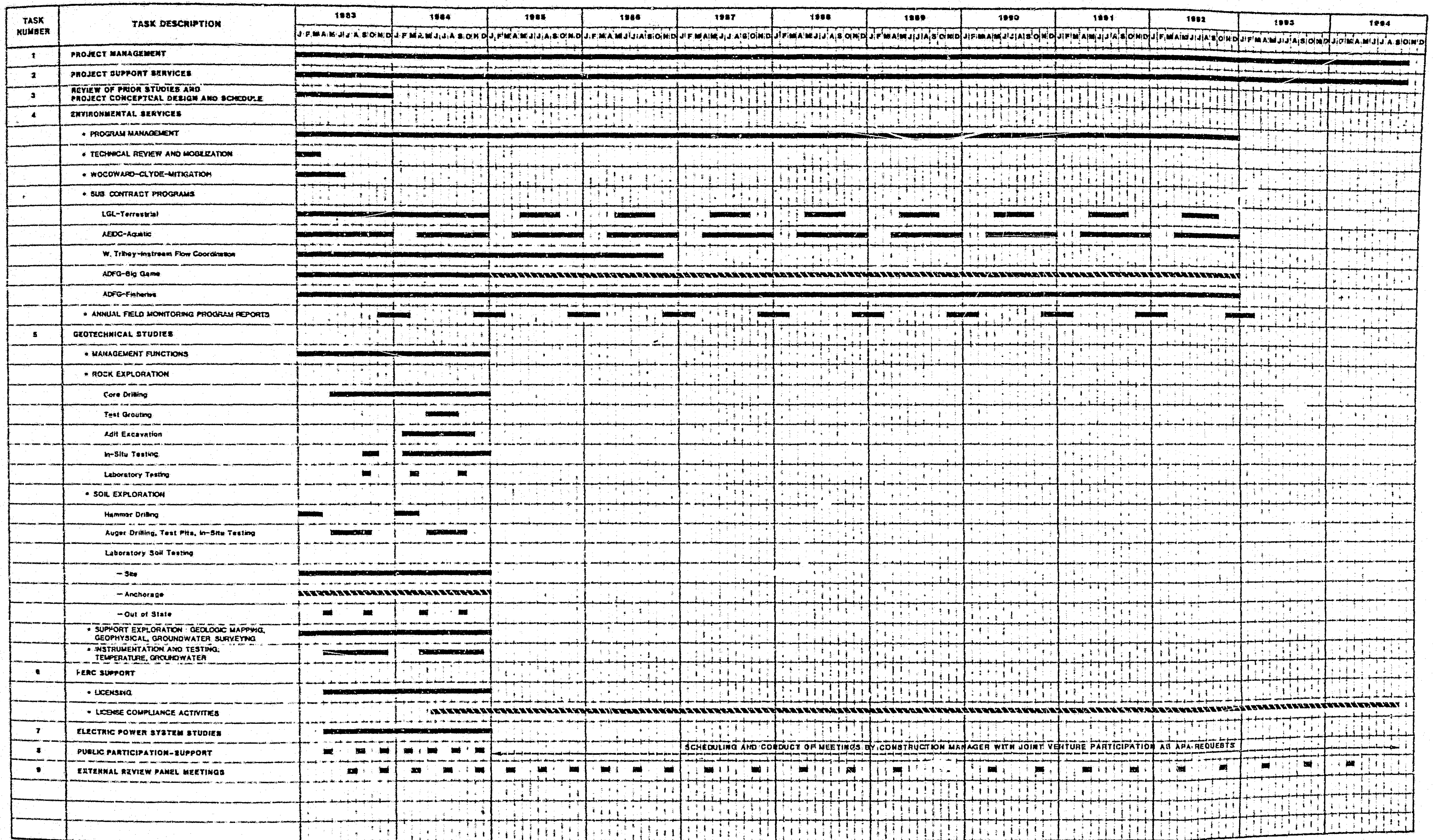
The C-6 contractor will also install the single plug in the lower diversion tunnel after closure and start of reservoir impoundment.

The completion Contract C-10 will include all second stage concrete, installation of all owner-supplied equipment associated with the power facilities, spillway, outlet facilities, supply and installation of electrical and mechanical systems, plant services, architectural finishes, the control building and switchyard civil works. The bid period will be deferred until late 1989 to permit designs of all these systems to be completed based on approved vendor drawings to facilitate firm lump-sum bids.

To avoid interface problems between the C-6 and C-10 contractors, all first stage concrete is scheduled to be completed in the powerhouse chamber by the middle of 1990. The C-10 contractor will erect the powerhouse cranes in 1990 and start turbine erection early in 1991. Deliveries of owner-supplied equipment are scheduled so as to avoid winter hauling.

The intake and outlet facilities gates, hoists and hoist supports should be erected early in 1991, if reservoir filling is to commence in July 1991. A review of hydrology records indicate many years with heavy fall inflows exceeding 20,000 cfs which could bring reservoir levels to the intake invert within three or four months. The gates and hoists should be checked out with construction power pending energizing of the permanent auxiliary electrical systems. That is the reason it is necessary to push penstock erection and power intake concrete to avoid delay of the closure date. The spillway and draft tube gates and the outlet facilities discharge valves should also be installed in 1991. Installation of electrical and mechanical systems in the powerhouse will not be restrained by completion of second stage concrete for each unit since much of the equipment, cable runs, and piping systems are located in side galleries, the service bay and in the transformer gallery. Also, the control building contains the computer and control boards which can provide a more favorable environment for their efficient installation than the underground facility.

The Willow Control Center and the Microwave System included in Contract C-11 and associated supply contracts have a high priority. By starting design of the microwave system early in 1983, the equipment orders can be placed in 1985 and erection of foundations and towers scheduled in 1986. The electronics will be delivered and erected in 1987 so that the communication system will be operational that year providing on-site communication facilities for construction coordination. The Willow Control Center will be constructed in 1987 and the computer and auxiliary equipment associated with the Energy Management Control System installed in 1988. The system will be made operational in 1988, independent but with provision for the Watana Development. This will allow ample time for staffing and training operation and maintenance personnel for the control and scheduling of power of the interconnection. We assume this same staff will also be responsible for the operartion and maintenance of the Watana computer system and therefore will be trained prior to the Plant's becoming operational. This should greatly assist the Power Authority in placing the Watana Project reliably on line in 1993.



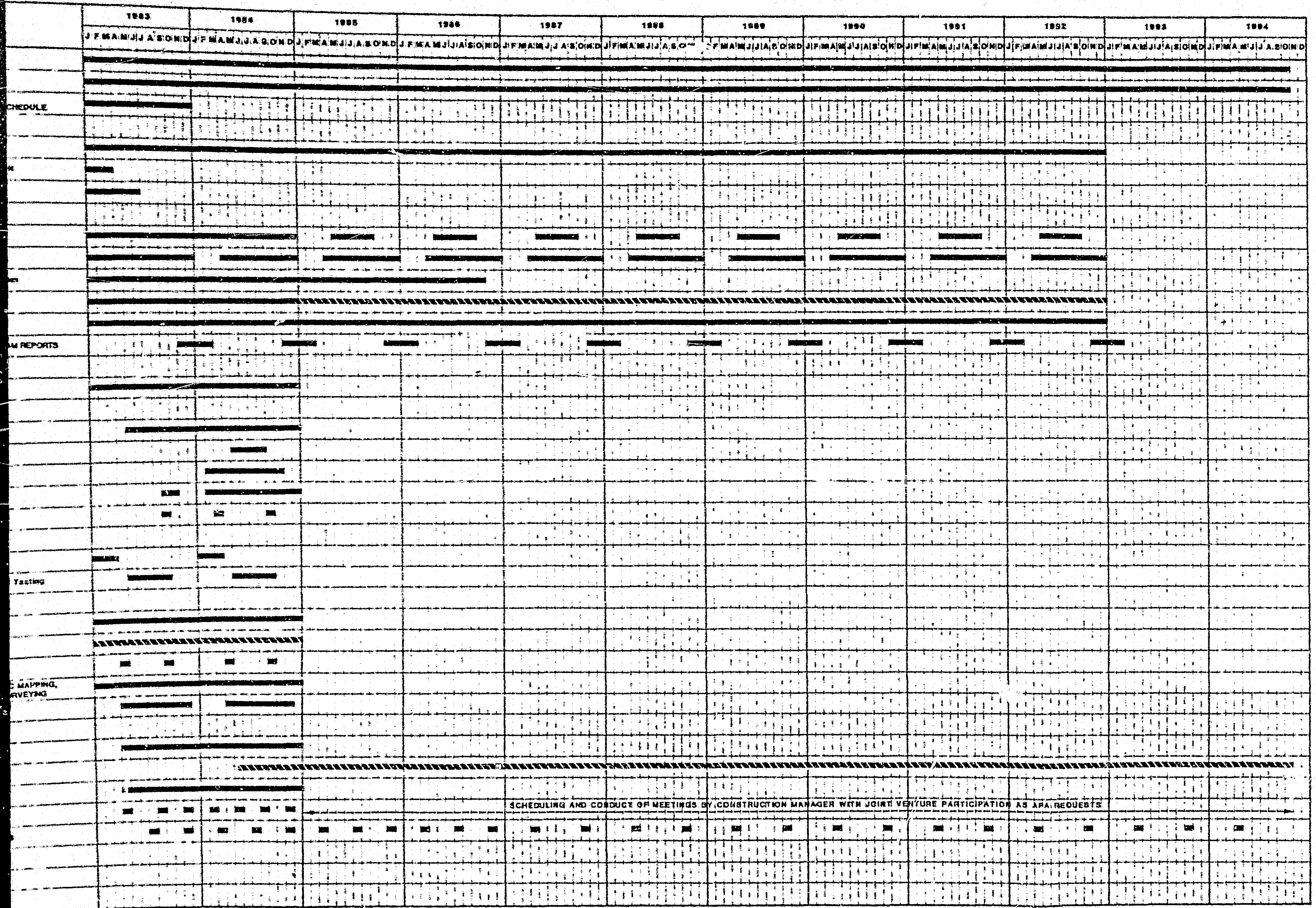
LEGEND

Continuous Intermittent

HARZA-EBASCO

continued

EXHIBIT D(b) - 1

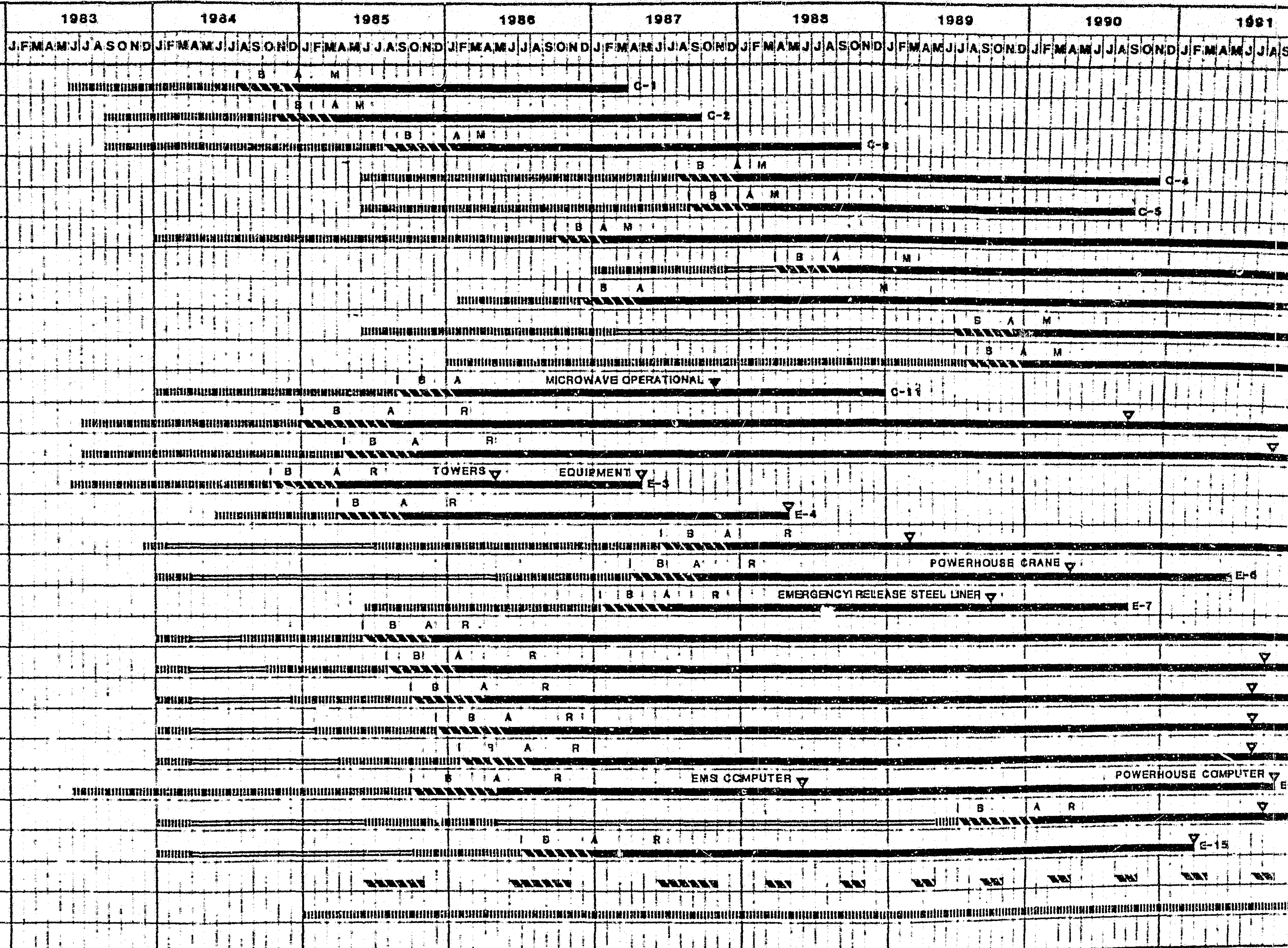


SUSITNA HYDROELECTRIC PROJECT

SCHEDULE OF TASKS I
STUDIES, INVESTIGATIONS
AND
GENERAL TASKS

continued

TASK NUMBER	TASK DESCRIPTION	
10	Contract C-1:	DIVERSION TUNNEL AND FACILITIES
11	Contract C-2:	MAIN DAM I – ABUTMENTS, DRILLING AND GROUTING, INITIAL
12	Contract C-3:	MAIN DAM II – COFFERDAMS, DIVERSION, DAM FOUNDATION, START FILL
13	Contract C-4:	MAIN SPILLWAY I – EXCAVATION
14	Contract C-5:	OUTLET FACILITIES
15	Contract C-6:	POWER FACILITIES, FIRST STAGE, ACCESS TUNNELS
16	Contract C-7:	MAIN DAM III – FINISH FILL, RELICT CHANNEL, EMERGENCY SPILLWAY
17	Contract C-8:	CONCRETE AND AGGREGATE PRODUCTION
18	Contract C-9:	MAIN SPILLWAY II – CONCRETE
19	Contract C-10:	COMPLETION CONTRACT: ALL SECOND STAGE CONCRETE AND INSTALLATIONS
20	Contract C-11:	WILLOW CONTROL CENTER BUILDING AND MICROWAVE INSTALLATION
21	Contract E-1:	TURBINES AND GOVERNING SYSTEMS
22	Contract E-2:	GENERATORS AND EXCITATION SYSTEMS
23	Contract E-3:	MICROWAVE TOWERS AND EQUIPMENT
24	Contract E-4:	WILLOW CONTROL CENTER EQUIPMENT
25	Contract E-5:	TRASHRACKS, GATES AND GATE OPERATORS
26	Contract E-6:	CRANES AND HOISTS
27	Contract E-7:	OUTLET GATES AND VALVES, EMERGENCY RELEASE EQUIPMENT
28	Contract E-8:	TRANSFORMERS
29	Contract E-9:	CONTROL SWITCHBOARDS
30	Contract E-10:	HIGH VOLTAGE SWITCHGEAR
31	Contract E-11:	GENERATOR VOLTAGE SWITCHGEAR
32	Contract E-12:	STATION SERVICE SWITCHGEAR
33	Contract E-13:	COMPUTER CONTROL SYSTEM
34	Contract E-14:	345 kV POWER CABLE
35	Contract E-15:	SWITCHYARD STRUCTURES, BUSSES AND ACCESSORIES
36	HOME OFFICE SPECIALISTS ASSISTANCE TO FIELD	
37	FIELD SUPPORT STAFF	



LEGEND

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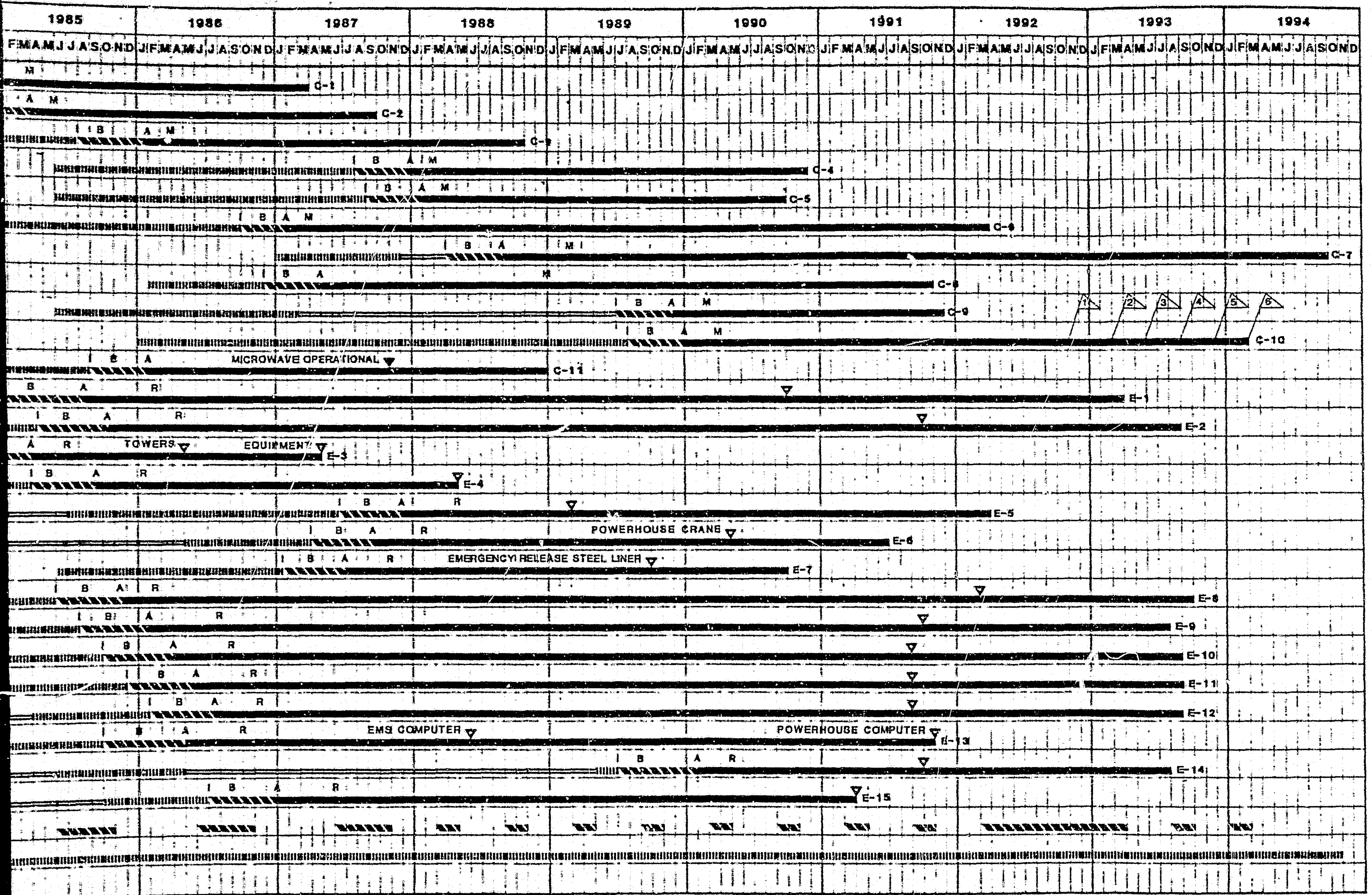
EXHIBIT D(b) - 2



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SUSITNA HYDROELECTRIC PROJECT

SCHEDULE OF TASKS II

ENGINEERING
FOR
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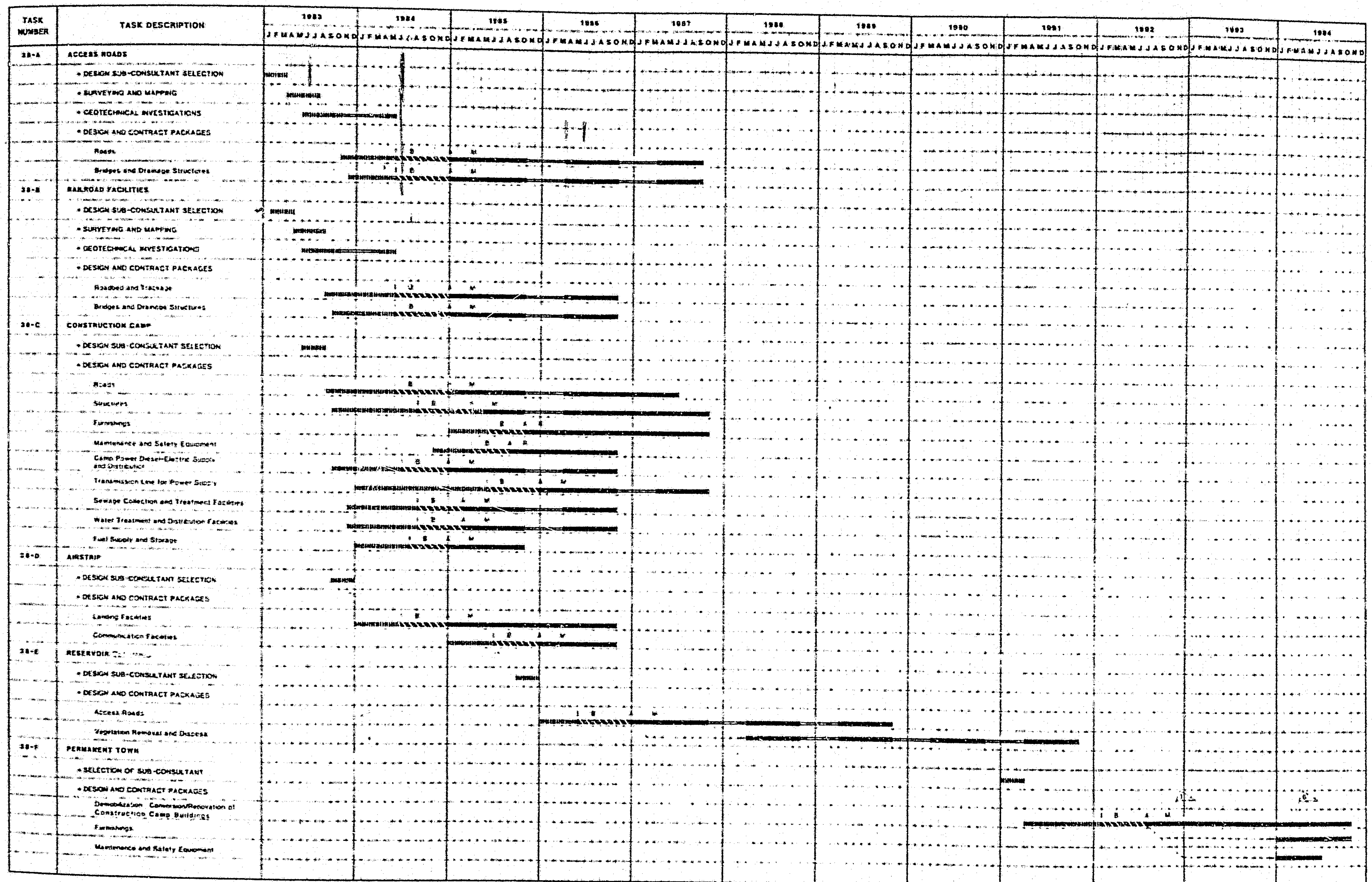

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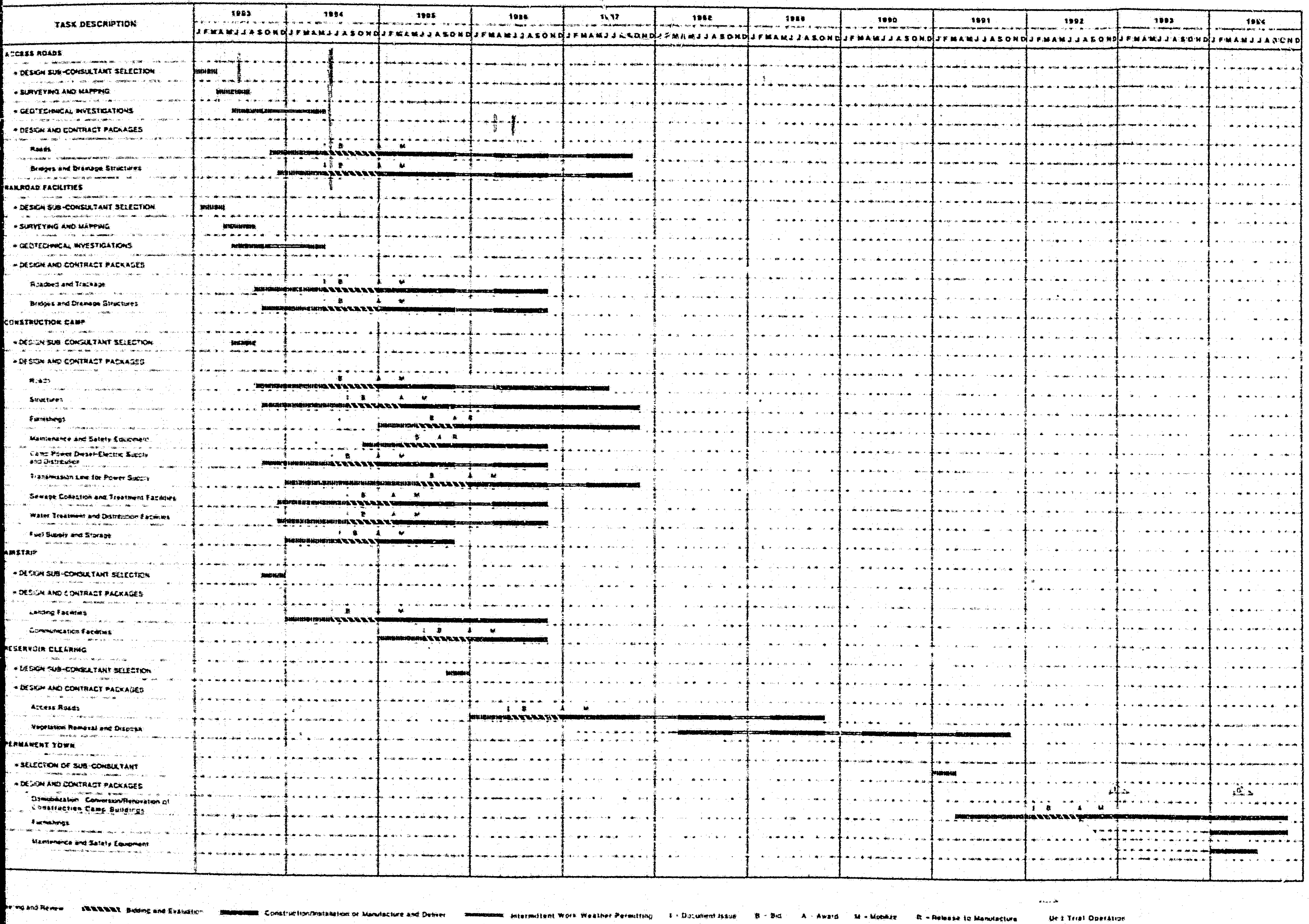
EXHIBIT D(b)-3



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SUSITNA HYDROELECTRIC PROJECT

SCHEDULE OF TASKS III
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Continued

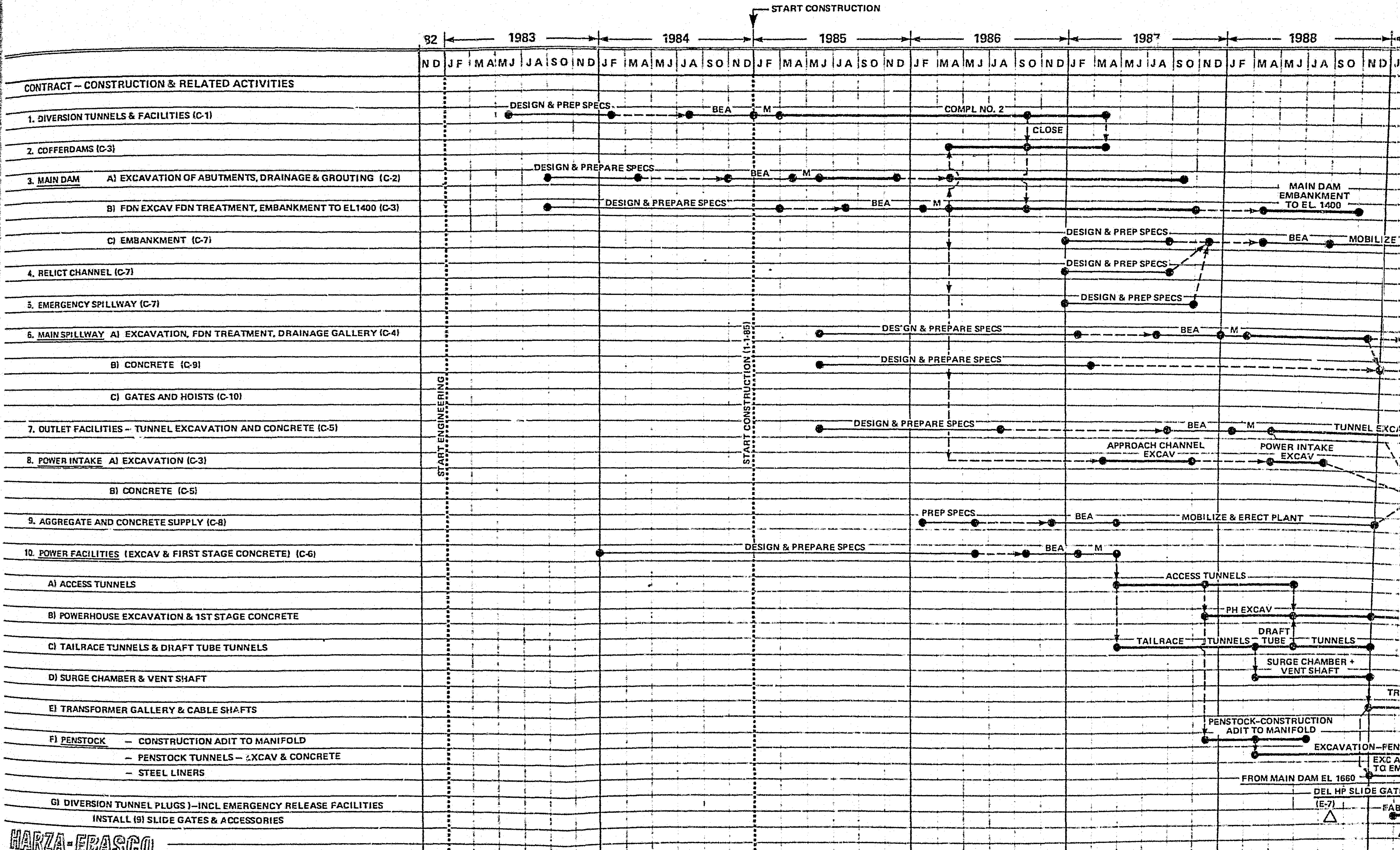

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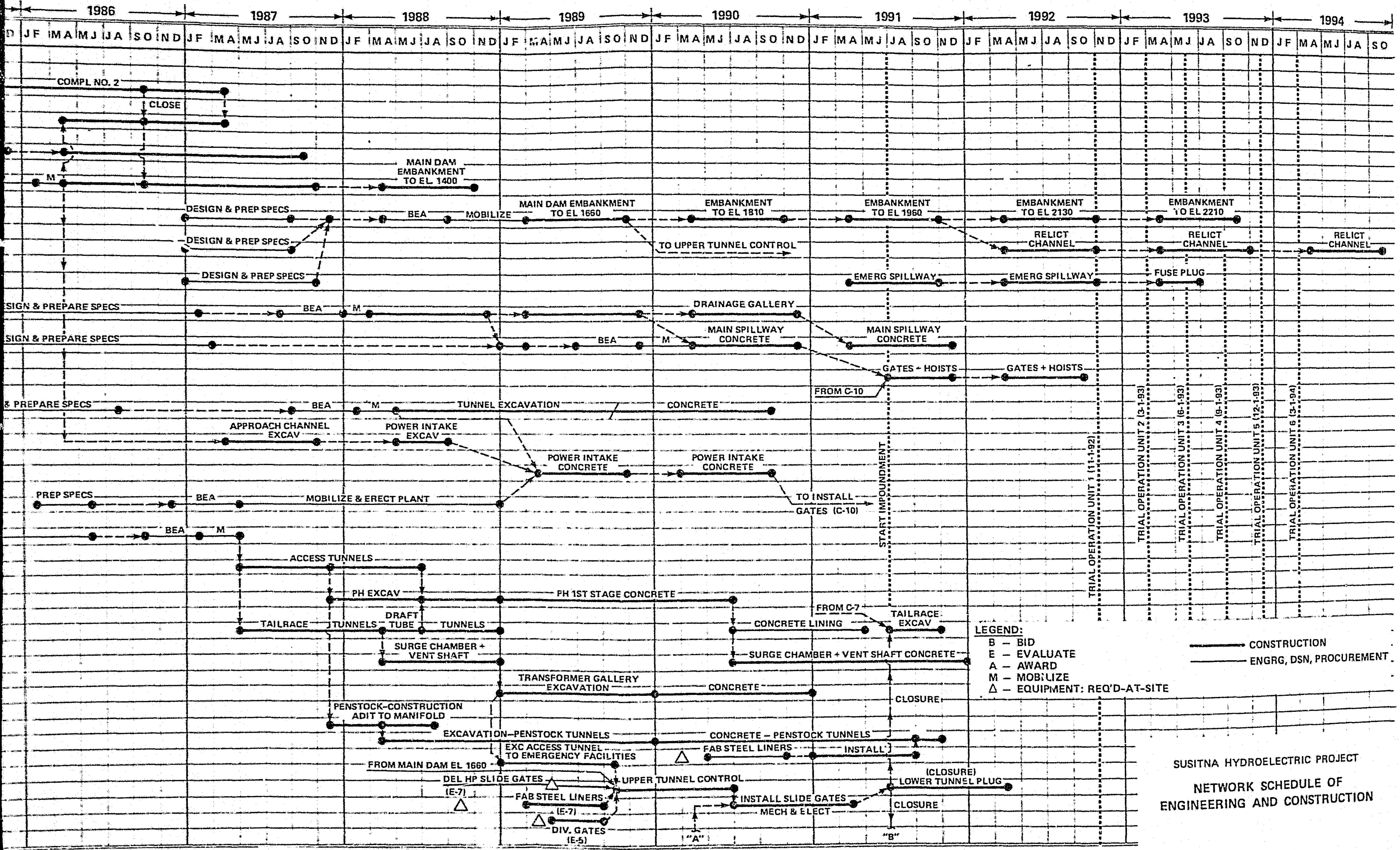
EXHIBIT D(b) - 4
Sheet 1 of 2



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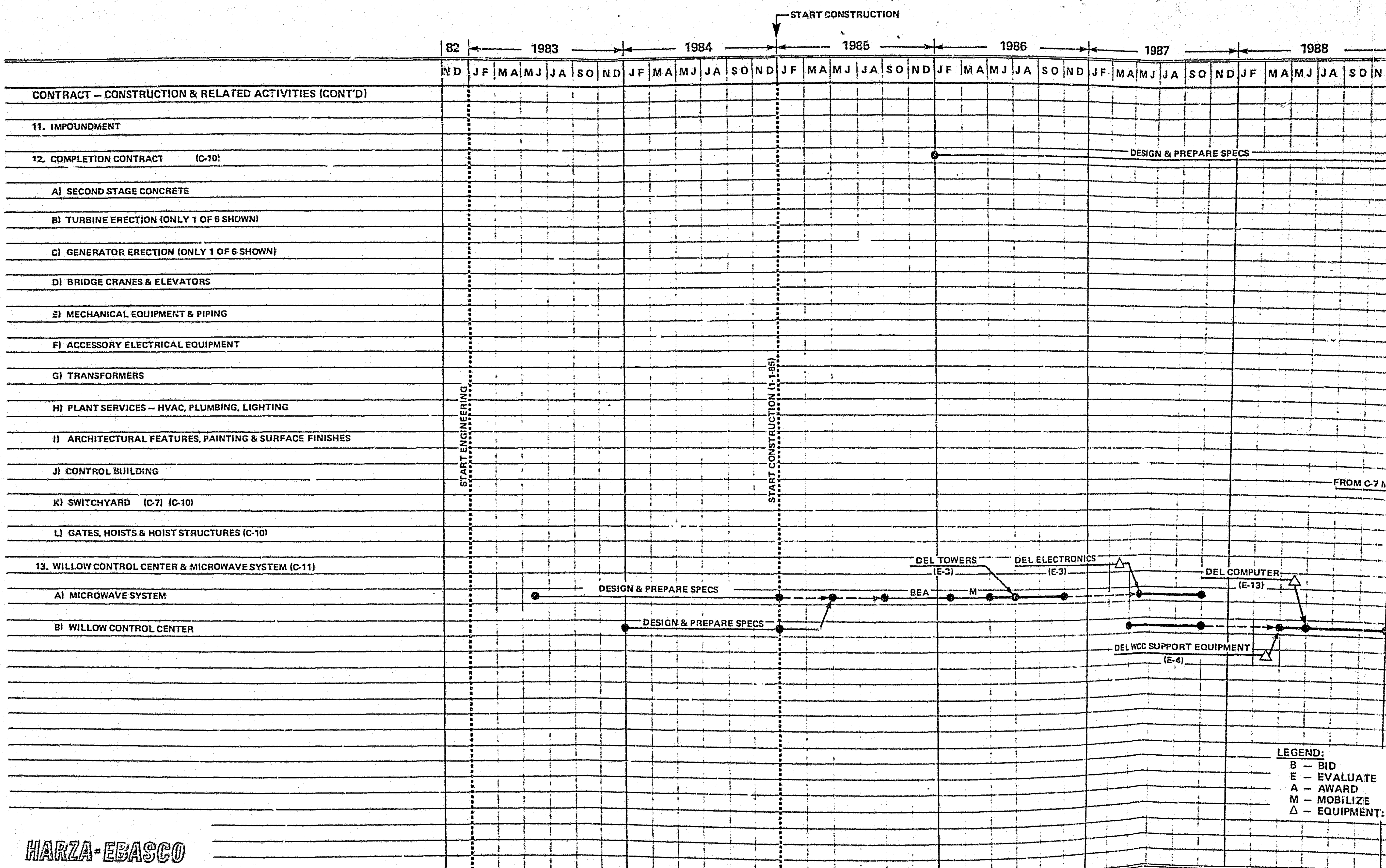

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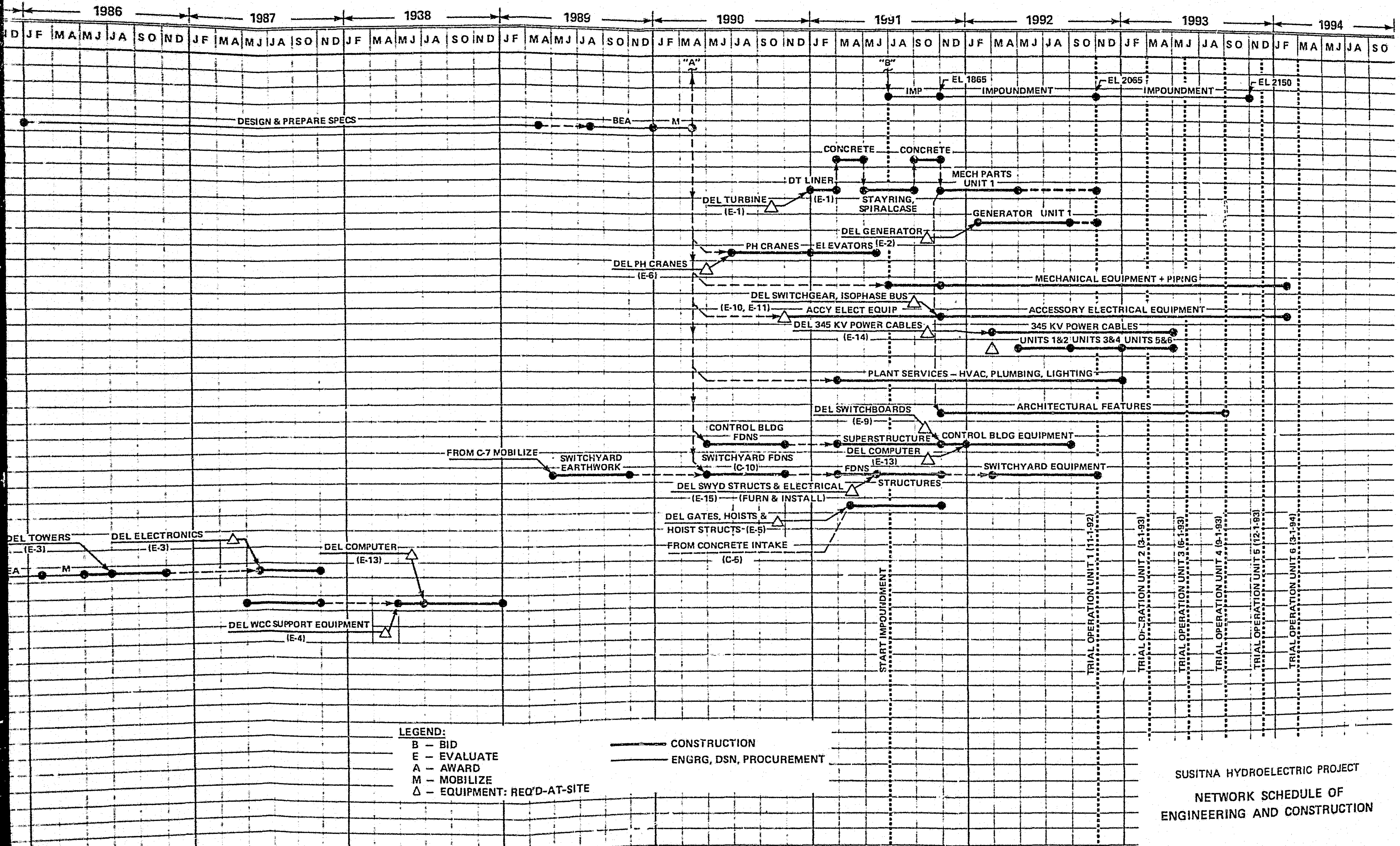
EXHIBIT D(b) - 4
Sheet 2 of 2



SUSITNA HYDROELECTRIC PROJECT

NETWORK SCHEDULE OF ENGINEERING AND CONSTRUCTION

continued

WORK FLOW

HARZA-EBASCO

WORK FLOW OF DESIGN

General Sequence of Activities

A generialized plan of design contract preparation and follow-on activities for any project feature is indicated in the accompanying flow chart (Exhibit D(b)- 5). The chart outlines all activities from the development of the detailed plan and schedule of engineering tasks to the check-out and start-up of the Project.

Where Power Authority review is indicated, the intent is that this review will also include a review by the External Review Panel and the Construction Manager. The flow chart is a logic diagram and not a time schedule of events.

Design

Design activities will start with a detailed review and evaluation of the Feasibility Report and any other existing studies and reports. This review process the additional engineering studies that will be done are discussed in Section D(a). Environmental studies are discussed in D(c) and the geotechnical field investigations in D(k).

The project conceptual design that results from the review phase will be documented in a Project Conceptual Design Report submitted to the Power Authority for approval. At this milestone stage of the Work Plan, a summary of the Project Conceptual Design Report will also be submitted to FERC and released to the public, if appropriate. It will be the basis for preparation of design memoranda that establish the design criteria to be used in the detailed analysis and design of the overall features of the Project.

The detailed design and analysis will then follow, based on design memoranda and applicable Joint Venture standards. The final products from this phase of the design activity will be the engineering documents for equipment supply and construction. The documents will include conditions of contract, technical specifications for materials and equipment and contract/ construction drawings. Construction memoranda will be prepared for guidance of the Construction Manager regarding quality control requirements for construction and equipment installation.

Technical Specifications

The technical specifications will precisely define work procedures, equipment, and materials and the standards applicable to them. The specifications also provide a basis for the development of the quality control construction memoranda. These will describe the measures necessary to ensure execution of the work in a manner compatible with the intent of the design as outlined in the design memoranda and as shown on the construction drawings. The technical specifications will include properly referenced current, applicable standards, codes and specifications, and descriptive information relative to the scope of the contract.

The equipment specifications describe the work, materials and controls for the design (where applicable), fabrication and testing of the equipment. They include the required performance criteria and guarantees and information submittal requirements.

Contract/Construction Drawings

The contract/construction drawings will be prepared using Joint Venture Drafting Standards (similar to those of the Corps of Engineers), based on the project conceptual design, design memoranda, and results of detailed design and analyses, and coordinated with the the technical specifications. The drawings will give complete information on geometric configuration, dimensions, relationships and sizes of the various project features and elements. They will also depict the sequence of construction anticipated in the design.

During this phase of the design process a constructibility review will be performed by the Joint Venture and the Power Authority's Construction Manager. Construction requirements and techniques will be carefully reviewed to ensure an optimum construction plan that will meet the design requirements on schedule and within budget limits.

Construction Quality Control Memoranda

These memoranda define the inspection, testing and documentation activities to be performed during construction, to ensure the achievement of design requirements as stated in the design memoranda, technical specifications and as depicted on the construction drawings.

Conditions of Contract.

Together with the Power Authority and the Construction Manager, the Joint Venture will develop standard contractual provisions early in the Project for the construction and equipment supply contracts. These provisions may be based on standard conditions, such as those of the National Society of Professional Engineers, or specific past contracts that the Power Authority, the Construction Manager, or the Joint Venture tested on previous work and found effective. The conditions of the contract so developed should be reviewed in draft by the Power Authority legal staff before their use in the Project contracts.

For each of the construction and equipment contracts the Joint Venture will review and revise the conditions of contract and as necessary to apply to the specific contract.

Bidders Lists

The Joint Venture, together with the Construction Manager, will prepare a Bidders List, either on the basis of their knowledge and experience with construction contractors and equipment suppliers qualified in major hydroelectric projects or by prequalification through formalized questionnaires. The Bidders List will be submitted to the Power Authority for review and approval.

Bid Package

Upon completion of conditions of contract technical specifications, and contract/construction drawings, the Joint Venture will assemble each bid package, consisting of finalized engineering documents, cost schedule program requirements, including the construction schedules, pay items schedule and a bidders list. During the process of developing each bid package, the Joint Venture will ensure that the bid package is structured to provide an optimized scope of work that can be tendered, controlled, and completed in an efficient manner. The prerequisites in determining the suitability of the bid package are the completeness, clarity and conciseness of the design documents, availability of material and equipment, complete descriptions of site logistics and conditions, and an adequate bid period for responsive and timely bidding.

Final Review of Bid Packages

The Internal Review Board will assess the completeness and clarity of each bid package in the technical and contractual areas. After a review of the scope of work contemplated by the documents, including the specifications and drawings, the payment and readjustments section will be reviewed for comprehensiveness.

Special attention will be given to analyzing areas where potential contract claims may arise to see that they have been defined and properly addressed.

The bid forms will be reviewed to see that all required construction items are properly covered. Particular attention will be given to completeness of all bid items, as well as to the suitability of all bids for analysis on a competitive basis. The bid form must be conclusive and in such form as to require bidders to be responsive to all items. Specific attention will be directed to the ability of competent contractors to assemble a complete, valid and competitive bid within the bidding time frame contemplated.

Each bid package will be sent to the Power Authority and the Construction Manager for detailed concurrent review. After incorporation of their comments and approval, the final bid package should be submitted to FERC by the Power Authority.

During the FERC review period the Joint Venture will participate in describing the contents of the bid package and responding to questions during public meetings.

Engineer's Estimate

The Joint Venture will prepare a detailed Engineers Estimate for comparison with the bids received. Details of the contents of this estimate are provided in Section D(1). Briefly, it will include:

- Quantity take-off from the contract/construction drawings
- Collection of data by examination of the site and project area and research of published data
- Evaluation of construction method, plant and equipment
- Analysis of diversion schemes
- Determination of production rates for labor and equipment and work sequences
- Consideration of construction schedules
- Calculation of Contractor's direct costs and indirect costs
- Calculation of Contractor's profits and contingency allowances

Assistance with Bid Analysis and Contract Award

Following receipt of bids by the Power Authority, the Joint Venture will work closely with the Construction Manager in assessing the responsiveness and technical merits of the proposals. The arithmetic of all proposals will be checked and any errors brought to the attention of the Power Authority and corrections requested if the Power Authority so authorizes. The bids will be ranked in order of price and the three lowest (or greater number if the Power Authority directs) will be analyzed in detail.

<u>Construction Contracts</u>. In the construction contract bids, in addition to price comparisons, this analysis will include:

- Overall appreciation of contract requirements and adequacy of a plan to meet them
- Organization and staffing
- Qualifications of proposed project manager and key superintendents
- Construction schedule and plan to meet key dates
- Acceptability of cost and schedule control input system
- Equipment spread on-hand and to be purchased
- Plant layout
- Experience in similar projects
- Contractual exceptions or deviations and their costs
- Information
- Proposed alternatives and their cost advantages and disadvantages

<u>Equipment Supply</u>. In equipment supply bids, the analysis will include:

- Response to required guarantees
- Proposed detailed design method, where appliable
- Completeness of equipment data
- Availability of shop facilities
- Experience record:
  - Meeting agreed delivery dates
  - Submittal of engineering information
  - Supply of similar equipment of comparable size
- Contractual exceptions or deviations and their costs
- Comparison with Engineer's Estimate for equipment

- Informalities
- Proposed alternatives and their cost

Our analysis and evaluations will be formalized in letters of recommendation of award. These letters will point out areas which must be negotiated prior to final agreement. The Joint Venture is prepared to assist the Power Authority and the Construction Manager, in these negotiations.

Involvement during Construction and Field Information Feed-back to Design

A primary responsibility of the Joint Venture's field support organization (see Task 37) will be to support the Construction Manager in quick responses to the Contractors' questions on the drawings and specifications and to assess field information as it develops during construction, and check its compatibility with the design assumptions. Where possible, any necessary changes in design and documents will be made on-site by the Field Support Staff. Where basic analyses that determined the designs are affected, however, the necessary information will be passed to the design office for review and analysis to confirm or modify the design specifications and drawings.

The Joint Venture's participation during construction is further described in our responses to the following RFP questions:

D(q) Procurement of Long Lead Time Items
D(r) Procedures and Proposed Involvement during Construction.

Project Start-up and Operations and Maintenance Training

The final phase in the sequence of activites will be assistance to APA in putting the various features into operation. Operating and maintenance manuals will be written as part of the Tasks for design of each operating or control civil works feature and each mechanical and electrical system and separate equipment supply procurement.

Generating unit and other project systems' check-out, testing and initial operation will be a joint involvement with the Construction Manager. In addition, we will provide a program for the organization, personnel selection and training of operation and maintenance. Upon approval of the Power Authority, we will carry out this program. Our approach is described in greater detail in Section D(t).

Application of General Sequence of Activities to Specific Project Features

The General sequence of activities described above is applied in the following discussion and exhibits to:

Diversion Tunnels and Facilities, Contract C-1

Main Dam, Contracts C-2, C-3 and C-7

Power Facilities, Contracts C-6 and C-10

Hydraulic Turbine Procurement, Contract E-1

Access Road (Sub-Contracted Design)

The activities in the sequence are:

- Data Collection and Consolidation, Additional Investigations
- Analysis of Data, Preliminary Studies and Designs
- Design Memoranda
- Detailed Analysis and Design

These are unique within each contract, so are discussed separately for each of the examples.

The activities following detailed design -- technical specifications -- drawings, conditions of contract, through issue, bidding, award and services during construction -- are essentially the same for each construction contract. To avoid burdensome repetition, these activities are not discussed for all the examples.

The drawings and specifications for each proposed contract, however, are listed in the outputs of the respective task descriptions in the Section entitled "TASKS".

Diversion Tunnels and Facilities

Our plan for the design of the Diversion Tunnels and Facilities is initiated under Work Task 3, Review of Prior Studies and Project Conceptual Design Schedule. We will commence detailed design and the preparation of construction contract documents for the Diversion Tunnels and Facilities Contract (C-1) upon approval of the Project Conceptual Design Report submitted to the Power Authority, its External Review Panel, and Alaskan governmental and environmental agencies. Work Task 10 -Contract

Document C-1 (Diversion Tunnels and Facilities) is the portion of the project work plan associated with the detailed design and production of the Contract Documents. The Flow Chart for portions of Work Task 3 and all of Work Task 10 is shown on Exhibit D(b)-6. Detailed listings of the discrete subtasks associated with Work Tasks 3 and 10 are included in the section "Tasks."

Design Review of Existing Studies. The design activities will start with a detailed review and evaluation of the Feasibility Report and any other existing studies and reports (see D(a), above). The layout of the diversion tunnels as shown in the Project Conceptual Design Report will become the basis for detailed design.

Design Memorandum. The design memorandum for the diversion tunnels and facilities establishes the design criteria to be utilized in the design and analysis of the diversion works features. A preliminary outline of this design memorandum would be as follows:

- Subject
- Scope
- References
- General
- Description of features:
  - Cofferdams
  - Intake
  - Tunnels
  - Outlet and tailrace channel
- Design Criteria
  - geotechnical
  - hydraulic
  - structural
  - mechanical
  - electrical

The design memorandum will be reviewed by the Internal Review Board to ensure that all pertinent data, design methologies and criteria have been included. After incorporating the Internal Review Board comments, it will be submitted to the Construction Manager and and the Power Authority's External Review Panel for review. After resolution and incorporation of their review comments, the approved design memorandum will be distributed to the design staff.

Detailed Design. The detailed design and analysis will be performed in accordance with the design criteria stated in the design memorandum. The detailed design effort will consist of five concurrent activities: geotechnical, structural, hydraulic, mechanical and electrical.

A. Geotechnical Analysis and Design

- Excavation, tunnel drilling and blasting
- Temporary and permanent support for excavated slopes and tunnels excavation
- Groundwater control and permafrost effect
- Cofferdam design and stability analysis
- Cut-off design

B. Structural Design Analysis

- Diversion intake structures
- Tunnel outlet structures and retaining walls
- Tunnel concrete and steel linings
- Tunnel emergency release gate structure and hoist supports
- Tunnel plugs

C. Hydraulic Design and Analysis

- Flow regimes and velocities
- Head losses
- Pressure profiles for various flow conditions
- Intake and outlet geometry and hydraulic characteristics
- Controls for potential downstream erosion
- Freeboard for wave runup for the cofferdams

D. Mechanical Design

- Gates valves and trash racks

E. Electrical Design

- Power supply to the gates and valves to permit inclusion of embedded conduits for future equipment installation in the C-10 Construction Contract.

Main Dam

The work plan for the engineering and design of the dam is shown on Exhibit D(b)-7. Work flows logically from our review of the feasibility report and other pertinent documents and data through site investigations, confirmation of basic design concepts, design memoranda, and detailed analyses, to the preparation of the documents for construction and the QC/QA guidelines. Data collected during construction will be reviewed to compare the design assumptions and predictions with measurements taken in the field. Regular review by the Joint Venture and its Internal Review Board, by the Power Authority and its Board of Consultants, and by federal and state agencies is anticipated throughout the engineering, design and construction process. Reviews will range from the relatively formal External Review Panel meetings and FERC hearings to the informal review sessions between the Power Authority and the Joint Venture.

Review of Prior Work and Site Investigations Plan

During the first few months, pertinent documents and data will be collected, reviewed and evaluated. Detailed study of the results of past and current geotechnical and geologic data will lead to the plan for additional site investigations and testing programs. Development of the detailed site investigations plan for the dam must be concurrent with review of existing data because rock coring to confirm foundation conditions is scheduled to begin during May, 1983.

The plan will contain the following major elements:

- Scope and purpose of field and laboratory investigations
- Specific locations of borings, adits and geophysical surveys
- Schedule for completion of the investigations
- Contracts required

The plan, submitted in writing during April 1983 must be reviewed and approved internally by the Joint Venture Internal Review Board and externally by the Power Authority. It is anticipated that the plan will be presented to the Power Authority

External Review Panel for their review and concurrence on the general scope and adequacy of the program.

Implementation of Site Investigations

Site investigations will be carried out during 1983 and 1984. Specific standards for drilling, sampling and testing, and close inspection will ensure the quality of work. Data collected in the field and laboratory will be reviewed and processed, then sent promptly to those using the data. It is imperative that the data collected be sufficient in quantity and quality to support the confirmation of the basic design concepts, the design memoranda, and the subsequent more detailed engineering analyses. The data collected must also provide prospective contractors with a complete understanding of the foundation conditions and the material sources so that lump-sum bids can be prepared with a minimum of subsequent claims for changed conditions. Constant analysis and review of the site investigations program will be made during the two-year period and appropriate modifications adopted.

Because the total construction effort will be split into several construction contracts, it will be possible to apply the knowledge gained during the foundation treatment and initial fill contracts to the much larger contract for embankment dam construction.

Design Concepts, Memoranda and Detailed Analysis

Our work plan centers on a progressive confirmation of dam design concepts, the presentation of these concepts in a report on the Project Conceptual Design, the development of design criteria and their presentation in formal design memoranda, followed by detailed analysis and design of the dam. Each step of the process will lead to the finalization of dam design and its foundation treatment. This process is evolutionary and is dependent on the results of site investigations and on continuous review. The relationship between these activities is shown on Exhibit D(b)-8. The activities depicted have separate objectives but are closely connected because of the ultimate objective, i.e., the design of the dam.

Initially, work will be directed toward a confirmation of the basic design concepts such as:

- The location of the dam axis
- The outer slopes of the dam

- The materials and general zoning of the embankment

- The major elements of the foundation treatment

Confirmation of these concepts will be made using all available geotechnical and geologic information. Acceptance of concepts must occur early in the schedule so that guidance is provided to the ongoing site investigations and so that diversion tunnel portals and cofferdams can be located.

Studies leading to the preparation of design memos will be undertaken after design concepts are established. These memoranda will present criteria for foundation treatment, embankment materials, zoning, dimensions and details. A basic cross-section will be presented for subsequent detailed analysis. The memos will also present the scope and methodology of the detailed analyses, an identification of the parameters required and how these parameters are being established through site and laboratory investigations. The following design memos will be prepared:

1. Foundation Grouting and Drainage

2. Excavation and Rock Surface Treatment

3. Materials Sources and Characteristics

4. Cross-section, Zoning, and Details

Detailed analyses of the dam and its foundation will be performed after the scope, methodology, and parameters are selected. Earlier analyses will be performed during the design memo stage using a range of values for the various parameters.

Detailed analyses will include the following:

- Stresses, pore presences, deformations and stability during construction, reservoir filling and project operation

- Effects of permafrost thaw in the dam abutments; mitigating design features

- Methods and procedures to thaw ground ice prior to grouting

- Dam excavation and foundation treatment

- Seepage through the dam and its foundation

- Thickness, gradation and use of filters and drains

- Response of the dam to the maximum credible earthquake and mitigating design features

- Dam and foundation instrumentation

- Constructability, zoning and materials usage in the dam

- Reservoir slides, effects on the dam and mitigating design features

The results of each of the various detailed analyses will be presented in memoranda which will document methods, assumptions parameters, results, conclusions and recommendations. Preliminary results will be reviewed and, if necessary, procedures and parameters modified to accomodate the most current data available.

Instrumentation Systems

The design of the instrumentation systems for the main dam will be based on the requirements of providing groundwater and piezometer information, measurements of stresses, strains and displacements, measurements of temperature, seismic activity and seepage flow from drains and galleries.

The instrumentation programs will be designed after geologic, geotechnical and geohydrological data have been collected and evaluated and after design concepts have been finalized and will include:

- Type of instrumentation

- Quantity and location

- Installation details

- Insertion into the Project Data Management Program

Piezometers will be designed and installed at selected locations and depths both upstream and downstream of the grout curtain to establish baseline groundwater elevations and water chemistry compositions and to monitor the effectiveness of the foundation grout curtain and pressure relief system.

Piezometers will be installed at selected locations and depths in each of the embankment zones, including the core and filters. Information obtained from these piezometers will establish pore pressure distribution within the embankment cross section during construction, reservoir filling and project operation and will monitor the effectiveness of the filter zones and embankment core in reducing seepage through the embankment.

Extensometers, inclinometers and straimeters will be designed and installed at selected locations in the dam, the foundation and abutments and in the rock surrounding the major caverns to monitor horizontal and vertical displacements under loading and unloading conditions.

Settlement devices will be installed a` selected locations and depths to monitor foundation and embankment response to static and dynamic loading conditions, and to compare the response to the design predictions.

Temperature measuring devices will be installed in the foundation, abutments and galleries to monitor permafrost conditions, gallery temperatures, and drainage discharge water temperatures during construction, reservoir filling, and project operation.

Seismographs and accelerometers placed on the foundation bedrock as well as within the embankment will be designed and installed to monitor and record seismic activity at the dam site. Information obtained from these instruments will be utilized to monitor the response of the dam to seismic loadings.

The flow from drains and galleries will be measured during construction, reservoir filling and during project operation to observe the response of the foundation to the reservoir and to the passage of time. Data will be evaluated to determine the need for additional treatment.

Power Facilities

The Joint Venture plan for design of the Watana Underground powerstation and appurtenances is divided into two work packages that will result in the production of two major civil construction contracts. Work Task 15 and its discrete subtasks will culminate in the production of contract documents C-6 for the construction of the first stage civil works for the intake, intake tunnels, access tunnel and transformer gallery, generator hall/erection bay gallery and surge chamber, access and cable shafts and tailrace tunnel with the portal structure. The flow chart for Work Task 15 is shown on Exhibit D(b)-9.

Work Task 19 and its discrete subtasks will result in the production of Contract documents C-10 for civil work completion and the installation of all furnished equipment by the Power Authority in the structures associated with the C-6 contract, the installation of equipment furnished by the Power Authority in the main spillway and outlet works (which will be constructed under Contracts C-4 and C-9) and the construction and installation of equipment in the switchyard and control house. The flow chart for Work Task 19 is shown on Exhibit D(b)-10. Detailed listings of the discrete subtasks and outputs (deliverables) associated with Work Tasks 15 and 19 are included in the Section entitled "Tasks."

Design

The detailed review of the Feasibility Report and other documents (Section D(a)) will result in the Project Conceptual Design Report. After the approval of the Power Authority and its External Review Panel, this will become the basis for detailed design.

Design Memoranda

The design memoranda for the power facilities will establish the design criteria to be utilized in the design and analysis for the power facilities features. A Joint Venture design memorandum includes:

- Subject
- Scope
- References
- General
- Description of Features, Equipment or System

Civil design memoranda typically cover specific features or aspects of design or construction under titles such as, "Foundation Conditions and Materials", "Structural Design Criteria", and "Power Intakes and Power Conduits". Mechancial and electrical design memoranda cover specific equipment items and systems under titles such as "Hydraulic Turbines and Governing Systems," "Station Drainage and Dump Pump System," "Main Power Constructions," and "Lighting System."

Design memoranda originated in one discipline are reviewed by specialists in every other discipline that affects or is affected by the subject design. In most cases for the Susitna Project, mechanical and electrical design memoranda for systems will be initiated and carried through a preliminary stage under Contract C-6; they will be finalized under Contract C-10 when necessary detailed information has been collected under the equipment supply contracts.

A detailed list of the design memoranda to be prepared under Contracts C-6 and C-10 is presented in the output sections of Tasks 15 and 19 in the section "Tasks."

The conceptual design criteria (established by the Internal Review Board) will be expanded upon to include more detailed information from equipment suppliers, subsurface investigations, laboratory tests and other sources that will have been acquired since the approval of the Project Conceptual Design. The design criteria will include:

- Geotechnical
- Hydraulic
- Structural and civil
- Mechanical
- Electrical

The design memorandum and its design drawings will be reviewed by the Internal Review Board to ensure that all pertinent data, design methodologies and criteria have been included. After incorporating the Internal Review Board's comments, the design memorandum will be submitted to the Construction Manager, the Power Authority and its External Review Panel for comment. When their comments have been resolved and incorporated, the revised memos will be distributed to the design staff.

<u>Detailed Design</u>

The detailed design and analyses will be performed in accordance with the design criteria stated in the design memoranda. The detailed design effort will consist of coordinated, concurrent activities by the geotechnical, structural, hydraulic, mechanical, electrical and architectural disciplines.

<u>Geotechnical Analyses and Design</u>. The geotechnical design will include:

- Finite Element Analysis of stress patterns and deformations in rock around the main underground chambers and intersections, using input from subsurface field drilling.
- Design of temporary and permanent support for underground tunnels and chambers where they are not lined with concrete.
- Design of tailrace tunnels and access tunnel portal locations support and cut slope requirements.

- Design of drainage system(s) in rocks adjacent to underground chambers.

- Design of power cable and access shaft support requirements.

- Establishment of allowable foundation bearing pressures and backfill loads for the design of retaining walls associated with the power facilities.

Structural and Civil Analyses and Design. The detailed design and analyses will be in accordance with the approved design memos. Analyses and design will be prepared for:

- Power tunnel linings-concrete and steel

- Tailrace tunnels' concrete linings and portal structures

- Access tunnel portal structure

- Transformer gallery, transformer gallery floor systems

- Generator and erection hall floor systems and crane runway

- Surge chamber, surge chamber floor systems and crane or monorail hoist runway

- Diversion tunnel/tailrace tunnel concrete plug

- Retaining walls associated with the power facilities surface structures

Hydraulic Analyses and Design. The detailed design and analyses, in accordance with the approved design memos, will use information from the turbine/governor equipment supplier for:

- Power tunnel maximum and minimum pressure for a range of governor times

- Surge chamber water surface elevations for various operating conditions

- Detailed head losses

- Intake gate emergency closure for gate loads and tunnel pressures

Mechanical Analyses and Design. The detailed mechanical analyses, in accordance with the approved design memos, will be prepared for:

- Design of drainage system(s) in rocks adjacent to underground chambers.

- Design of power cable and access shaft support requirements.

- Establishment of allowable foundation bearing pressures and backfill loads for the design of retaining walls associated with the power facilities.

Structural and Civil Analyses and Design. The detailed design and analyses will be in accordance with the approved design memos. Analyses and design will be prepared for:

- Power tunnel linings-concrete and steel

- Tailrace tunnels' concrete linings and portal structures

- Access tunnel portal structure

- Transformer gallery, transformer gallery floor systems

- Generator and erection hall floor systems and crane runway

- Surge chamber, surge chamber floor systems and crane or monorail hoist runway

- Diversion tunnel/tailrace tunnel concrete plug

- Retaining walls associated with the power facilities surface structures

Hydraulic Analyses and Design. The detailed design and analyses, in accordance with the approved design memos, will use information from the turbine/governor equipment supplier for:

- Power tunnel maximum and minimum pressure for a range of governor times

- Surge chamber water surface elevations for various operating conditions

- Detailed head losses

- Intake gate emergency closure for gate loads and tunnel pressures

Mechanical Analyses and Design. The detailed mechanical analyses, in accordance with the approved design memos, will be prepared for:

- Station drainage and unit unwatering system(s)
- Station compressed air system
- Cooling water systems
- Fire protection system
- Potable water system
- Sanitation system
- Lube oil system
- Heating and ventilation system
- Generator hall and erection bay crane
- Transformer gallery crane or hoist
- Surge chamber crane or hoist
- Draft tube gate and hoists

The above designs will be in preliminary form at the time the contract documents for the C-6 construction contract are prepared, but will be at a sufficient level to ascertain the space requirements and provide for embedded piping and blockouts that will permit the later installation of equipment in the C-10 construction contract.

Electrical Analyses and Design. In accordance with the approved design memos analyses and design will be prepared for:

- Lighting for intake structure access tunnel, and portal transformer gallery and cable shafts, generator hall and erection bay, surge chamber, and tailrace tunnel portal area
- Grounding system(s) for transformer gallery, generator hall and erection bay, surge chamber and all other electrified areas.

Architectural Design. Architectual studies will center on development of sizes of equipment rooms, work areas, storage areas, maintenance personnel areas such as washrooms, locker rooms and visitors' facilities. The Joint Venture architectural staff has an extensive background in hydroelectric plants, and is familiar with the applicable OSHA requirements. Studies will be prepared and submitted to the Power Authority for review and approval before preparation of detailed drawings and specifications.

Hydraulic Turbine Procurement

The Joint Venture work plan assigns a separate task for the work associated with the hydraulic turbine and governing equipment. The plan for the design activities is shown on Exhibit D(b)-1.

Design

The design activities will begin with a detailed review and evaluation of the Feasibility Report and project drawings. The review will confirm the number and size of turbines and will include the following:

- Turbine rated output and net head
- Turbine rated speed
- Turbine setting relative to tailwater
- Turbine major dimensions
- Powerhouse arrangement
- Preliminary waterhammer and stability calculations

Where required, additional investigations and studies will be made to support or modify the turbine data included in the Feasibility Report. The conclusions reached regarding the turbine equipment, as a result of the initial review and subsequent studies will be incorporated into the Project Conceptual Design Report for submittal and review by the Power Authority.

On the basis of the Project Conceptual Design Report, the design memo for the hydraulic turbine and governing equipment will be prepared. The design memo will expand the design criteria for use in the detailed project design and preparation of the turbine and governing equipment supply specifications. The turbine design memo will establish the following criteria:

1. Operating head water and tailwater elevations
2. Hydraulic transients and governor times
3. Range of turbines operating net heads
4. Principal turbine dimensions

5. Turbine basic features

6. Mechanical requirements for Generator Design

   a. Runaway speed
   b. Maximum turbine output
   c. Turbine hydraulic thrust
   d. Interface dimensions

7. Study of oscillation frequencies.

Technical Specifications

We will prepare the technical specifications for the turbine and governing equipment on the basis of the turbine design memo. The technical specifications will include all commercial and technical descriptive information needed to define the scope of a turbine contract that will be used to obtain competitive bids for supply of this equipment. We will prepare a recommended Bidders List for use by the Power Authority and its Construction Manager.

The turbine technical specifications will define the design criteria, allowable materials, allowable stress levels for the equipment to be supplied. They will establish the specific turbine design features desired, and the requirements for interfacing with suppliers' equipment. Performance guarantee requirements will be indicated. The report also will specify penalties for failure to meet performance guarantees, and will clearly define dates for submittal of drawings and information, and for delivery of equipment.

Bid Analysis

Prior to receiving bids, the Joint Venture will prepare an Engineer's Estimate for the equipment in the bid package. We will assist as requested in evaluating the bids received for the turbine and governing equipment. We would expect the analysis to include detailed review of the four apparent lowest bids and confirm action of compliance with the bidding documents. We will estimate the costs associated with any technical exceptions included in the manufacturers' bids. The bid analysis will result in recommendation of contract award and we will assist the Power Authority in negotiating the contract for supplying the turbine equipment.

Drawing Review and Shop Inspection

We will review the drawings of the turbine governing equipment to confirm compliance with the contract specifications and powerhouse design. We will witness the model test to verify the performance guarantees are achieved on the model turbine. We will inspect the materials, fabrication and shop assembly to confirm the supplier's conformance with the approved drawings and workmanship.

We will also furnish specialists in support of the Construction Manager for on site inspection, testing and start-up of the units. This will result in reports recommending further action by the manufacturer or installation contractor and ultimately in a recommendation to the Power Authority to accept the equipment.

Access Road

The sequence of activities for the Access Road is shown in Exhibit D(b)-12. The sequence differs from that for other examples and from the generalized sequence because design of this non-technical feature is required to be subcontracted.

Selection of Design Subcontractor

We will begin work on this first of the subcontracted designs by developing a system for the subcontracts incorporating selection procedures, development by the subcontractor of his plan and schedule to meet project needs, points of technical review and approval by the Joint Venture and the other reviewers, and engineering cost management. The system will be submitted to the Power Authority for approval.

Selection procedures will involve preparation of a request for proposal outlining the design work and the contract conditions, and codes and design standards under which it is to be done. Interested design firms will be notified of the prospective subcontract and its timing.

While the request for proposal is in preparation, we will make a detailed review of the feasibility study that will provide the basis for selection of the access route. If additional study or field investigation is needed to accurately define the conceptual design, the work will be done during the first three months of 1983.

We expect that the proposal notification will be issued in February 1983, and that proposals will have been evaluated and an award recommended to the Power Authority by May, 1983. It would be appropriate for the Construction Manager to review the proposed selection and subcontract. However, the timing of his selection, noted to be approximately July 1, 1983, and the urgency of getting the access road design underway, may not permit this participation.

Design Subcontract Management

The Joint Venture will utilize the personnel of Frank Moolin & Associates in the design subcontracts for the access road. They will be responsible for monitoring the engineering subcontractor progress and costs, coordinating between subcontractors, scheduling and expediting Joint Venture technical reviews of design memoranda, designs, drawings, cost estimates and specifications; scheduling, and coordinating reviews and approvals (e.g. by the Alaska Department of Transportation, Alaskan environmental agencies, the Construction Manager and the Power Authority), and for preparing the Joint Venture's review of bids and recommendation of award of contracts. The Joint Venture and design subcontractor will also participate in the Power Authority's public information meetings with respect to informing the public on the design and environmental considerations associated with access road and railroad extension work. The work for the access road and bridge design subcontract will in general be done in Alaska. The preparation of the construction contract documents under the design subcontracts will be completed in the fall of 1984 and ready for bidding by the end of 1984.

Design

Before commencing work on the access road engineering, the subconsultant will be required to plan and schedule his work in detail, establishing key milestones, and submit his plan to the Joint Venture for review and approval. Upon approval of the plan, he will undertake the following steps:

- Review of the Feasibility Report and other available data
- Field surveys and detailed reconnaissance
- Final Report
- Design memoranda
- Detailed designs and land use agreements
- Plans and bid packages
- Construction

Review of Feasibility Report and Other Available Data. This review will concentrate on the identification and evaluation of pertinent data previously developed so that additional requirements may be assessed and quantified. To the extent compatible with professional practice and contractual requirement, duplication of effort will be avoided.

Field Surveys and Detailed Reconnaissance. Surveying, field reconnaissance and site explorations will be subcontracted by the design subconsultant and coordinated to minimize effort required to obtain right-of-entry permits and to avoid unnecessary field work. Photogrammetric control and topography will be established along the selected route and near potential borrow sites. Exploratory bore holes and soundings locations will be identified on aerial mosaics and properly located by surveyors in the field.

The need for additional investigative work (hydrometeorological, geotechnical, etc.) will be ascertained on the basis of field observation. Description of and rationale for the work will be presented to APA for approval.

Close attention will be given to applications for entry permits. All environmental and other stipulations will be adhered to as a matter of policy.

Final Report. During report preparation, potential sources for borrow materials and disposal sites will be identified and coordinated with appropriate governmental agencies.

Contact with the Alaska Department of Transporation will be initiated to assure the establishment of alignment and grade criteria which will control roadway configuration. Beyond normal highway criteria, haulage requirements for dam and power house components will be accessed in determining bridge loadings.

Design Memoranda. The basic content of design memoranda will be derived from the final report and reviews. Their purpose is to outline the comprehensive hierarchy of criteria and design elements so that proper decisions necessary for design will be made.

Preliminary memoranda will be reviewed by those agencies and groups deemed appropriate by APA and by the Joint Venture Internal Review Board. Upon receipt of comments, a draft of the final design memoranda will be submitted to the Joint Venture and then to APA for further comment or approval. The final memoranda with all pertinent supporting data will be issued to all parties for execution of design development.

Detailed Designs and Land Use Agreements. While design of roadway and bridges is in progress by engineering subcontractors, land use agreements will be prepared by the Joint Venture with participation by APA. Preliminary plans produced during this phase will be used as basis of land description.

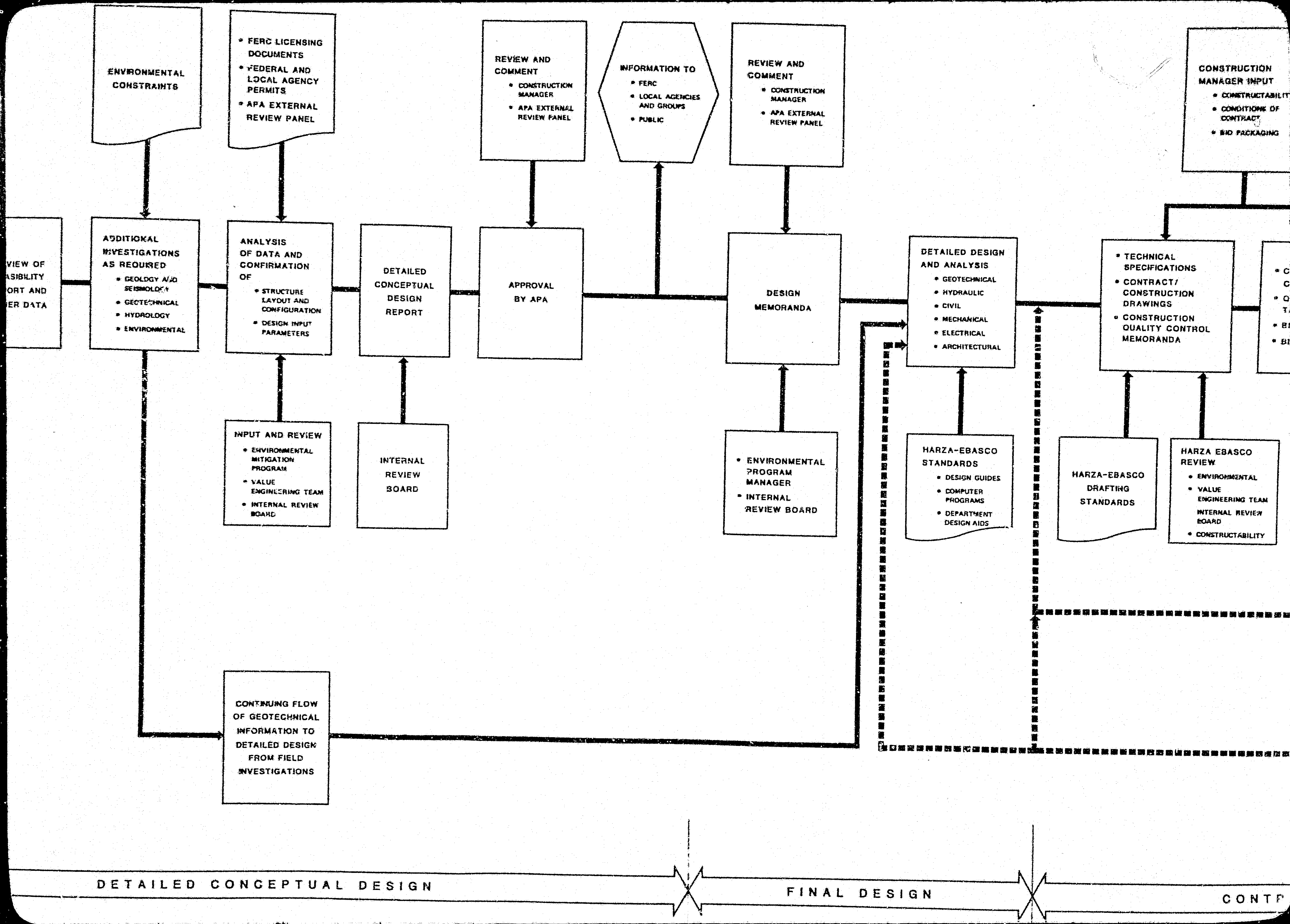
When detailed plans are substantially completed, a constructability and engineering review will be made by Joint Venture Internal Review Board and the Construction Manager. When judged adequate, principal design and construction features will be presented to APA for approval.

Plans and Bid Packages. Final plans and specifications will be prepared and the subconsultant will draft memoranda setting forth construction control and QC and QA policies and procedures.

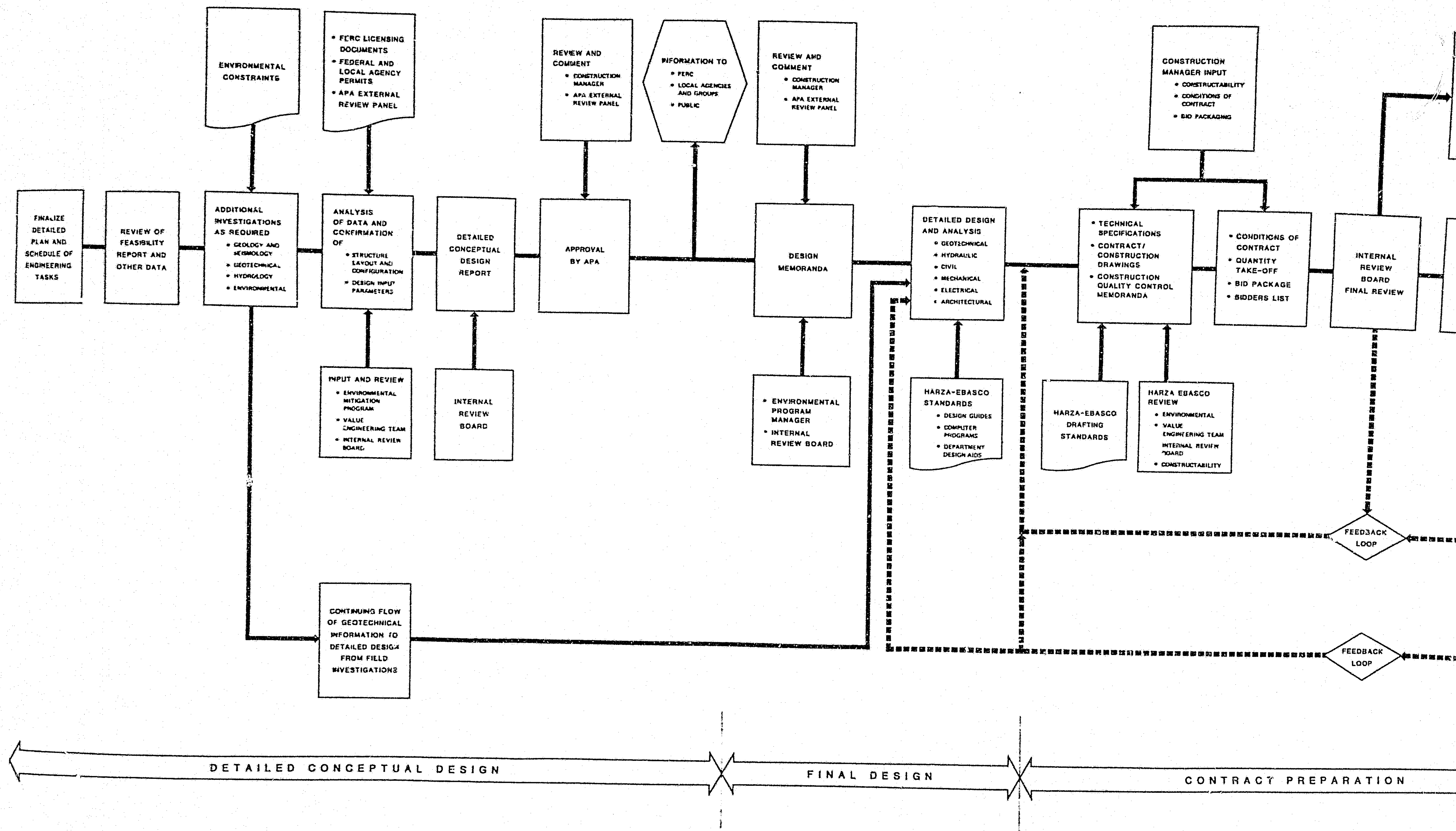
When completed, plans, specifications, and memoranda will again be reviewed for constructability by the Joint Venture. These with other appropriate supportive documents will be assembled to produce bid packages for final review and approval before issue to bidders.

Construction. During the construction phase, the subconsultant, with Joint Venture, reviews changes determined to be necessary and provides field engineering as required. In serving as the design representative during the construction activities, the subconsultant will:

- Coordinate all engineering requirements for construction activities
- Monitor project costs relating to engineering
- Interpret plans and specifications for construction contractor(s)
- Monitor QA/QC programs



ENVIRONMENTAL CONSTRAINTS
• FERC LICENSING DOCUMENTS
• FEDERAL AND LOCAL AGENCY PERMITS
• APA EXTERNAL REVIEW PANEL
REVIEW AND COMMENT
• CONSTRUCTION MANAGER
• APA EXTERNAL REVIEW PANEL
INFORMATION TO
• FERC
• LOCAL AGENCIES AND GROUPS
• PUBLIC
REVIEW AND COMMENT
• CONSTRUCTION MANAGER
• APA EXTERNAL REVIEW PANEL
CONSTRUCTION MANAGER INPUT
• CONSTRUCTABILITY
• CONDITIONS OF CONTRACT
• BID PACKAGING
VIEW OF
ASIBILITY
ORT AND
ER DATA
ADDITIONAL INVESTIGATIONS AS REQUIRED
• GEOLOGY AND SEISMOLOGY
• GEOTECHNICAL
• HYDROLOGY
• ENVIRONMENTAL
ANALYSIS OF DATA AND CONFIRMATION OF
• STRUCTURE LAYOUT AND CONFIGURATION
• DESIGN INPUT PARAMETERS
DETAILED CONCEPTUAL DESIGN REPORT
APPROVAL BY APA
DESIGN MEMORANDA
DETAILED DESIGN AND ANALYSIS
• GEOTECHNICAL
• HYDRAULIC
• CIVIL
• MECHANICAL
• ELECTRICAL
• ARCHITECTURAL
• TECHNICAL SPECIFICATIONS
• CONTRACT/ CONSTRUCTION DRAWINGS
• CONSTRUCTION QUALITY CONTROL MEMORANDA
INPUT AND REVIEW
• ENVIRONMENTAL MITIGATION PROGRAM
• VALUE ENGINEERING TEAM
• INTERNAL REVIEW BOARD
INTERNAL REVIEW BOARD
• ENVIRONMENTAL PROGRAM MANAGER
• INTERNAL REVIEW BOARD
HARZA-EBASCO STANDARDS
• DESIGN GUIDES
• COMPUTER PROGRAMS
• DEPARTMENT DESIGN AIDS
HARZA-EBASCO DRAFTING STANDARDS
HARZA EBASCO REVIEW
• ENVIRONMENTAL
• VALUE ENGINEERING TEAM
INTERNAL REVIEW BOARD
• CONSTRUCTABILITY
CONTINUING FLOW OF GEOTECHNICAL INFORMATION TO DETAILED DESIGN FROM FIELD INVESTIGATIONS
DETAILED CONCEPTUAL DESIGN
FINAL DESIGN
CONTR



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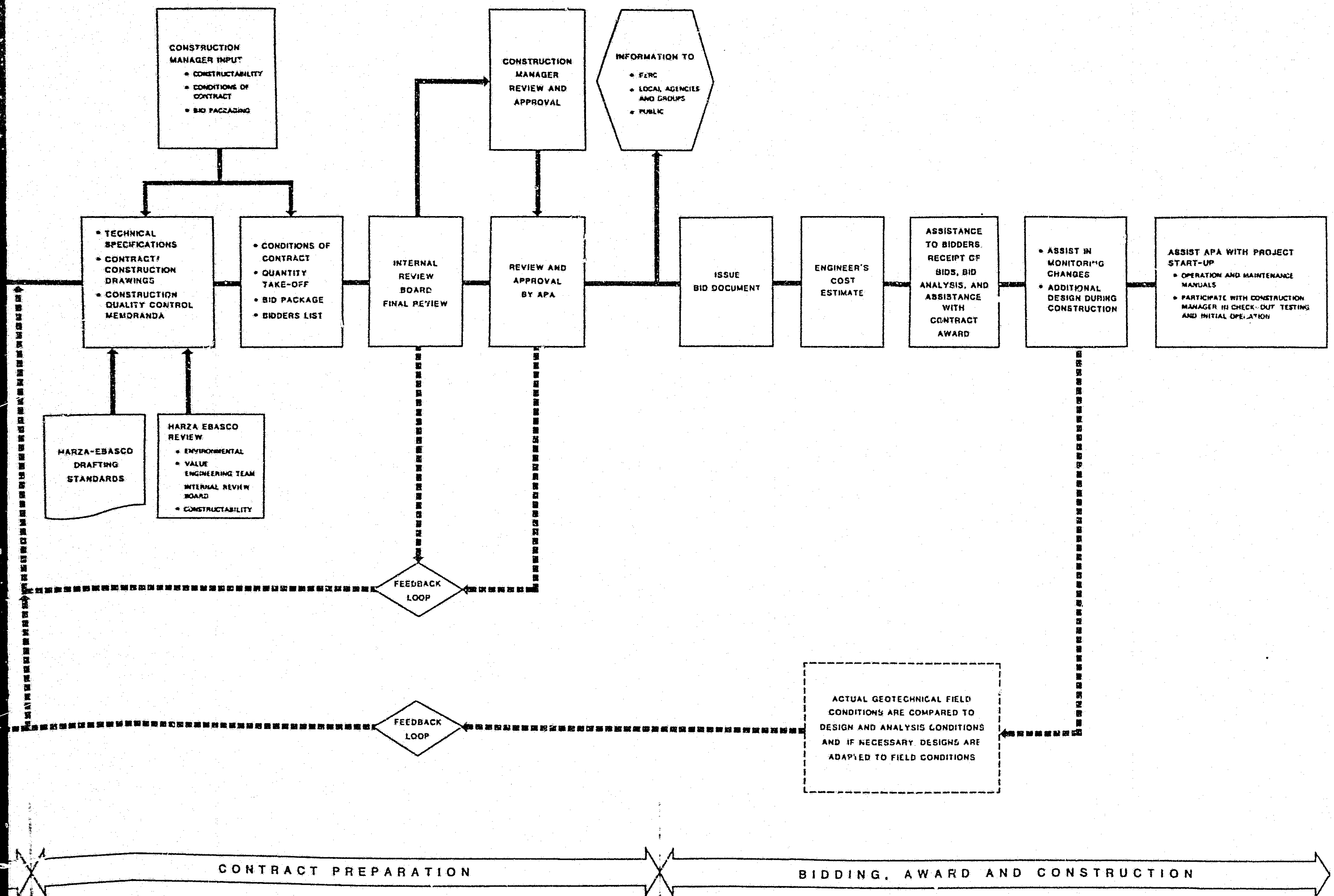

SUSITNA HYDROELECTRIC PROJECT

GENERALIZED WORK FLOW DIAGRAM
DESIGN, CONTRACT PREPARATION AND BIDDING AND SERVICES DURING CONSTRUCTION

Continued

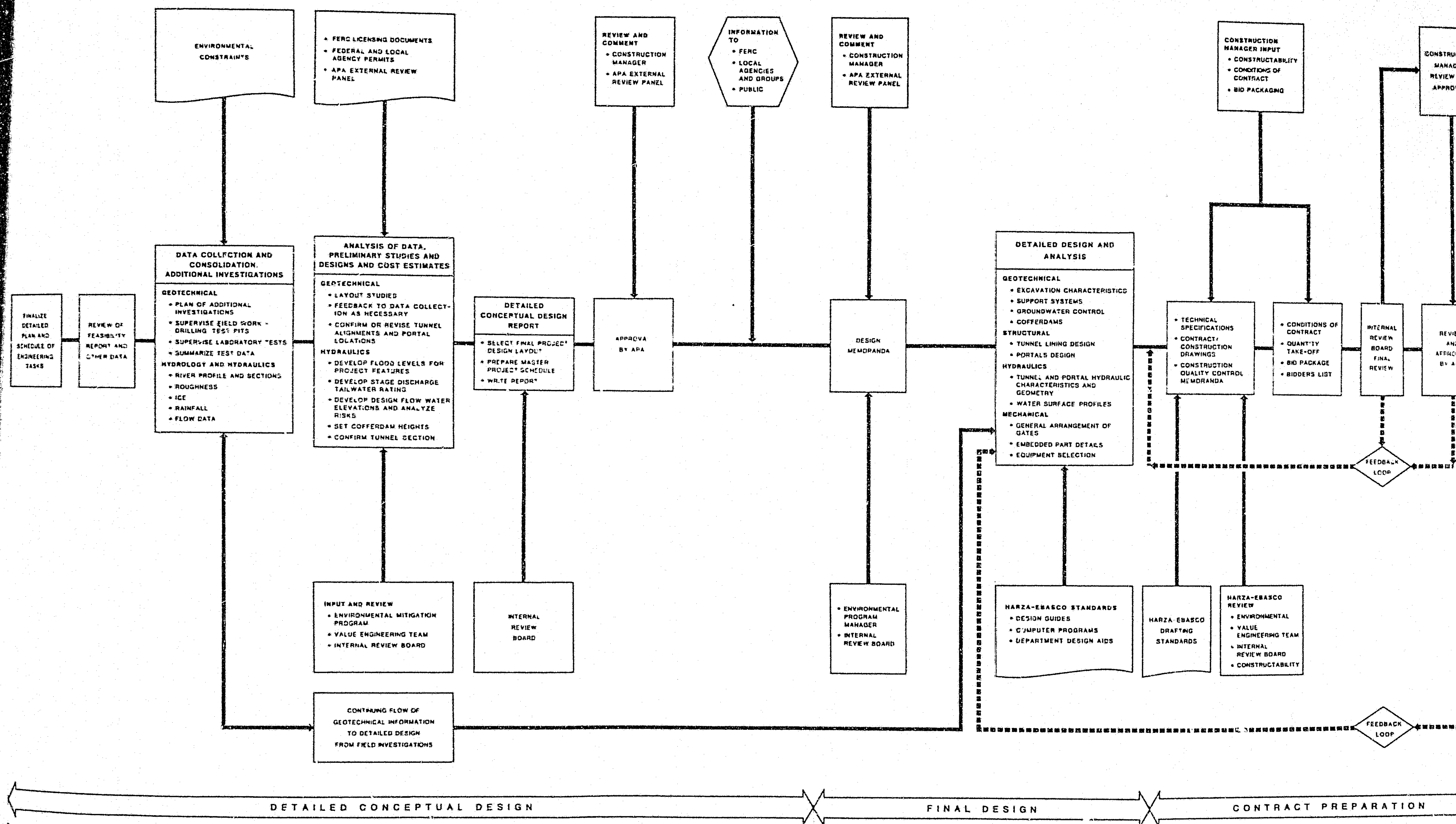

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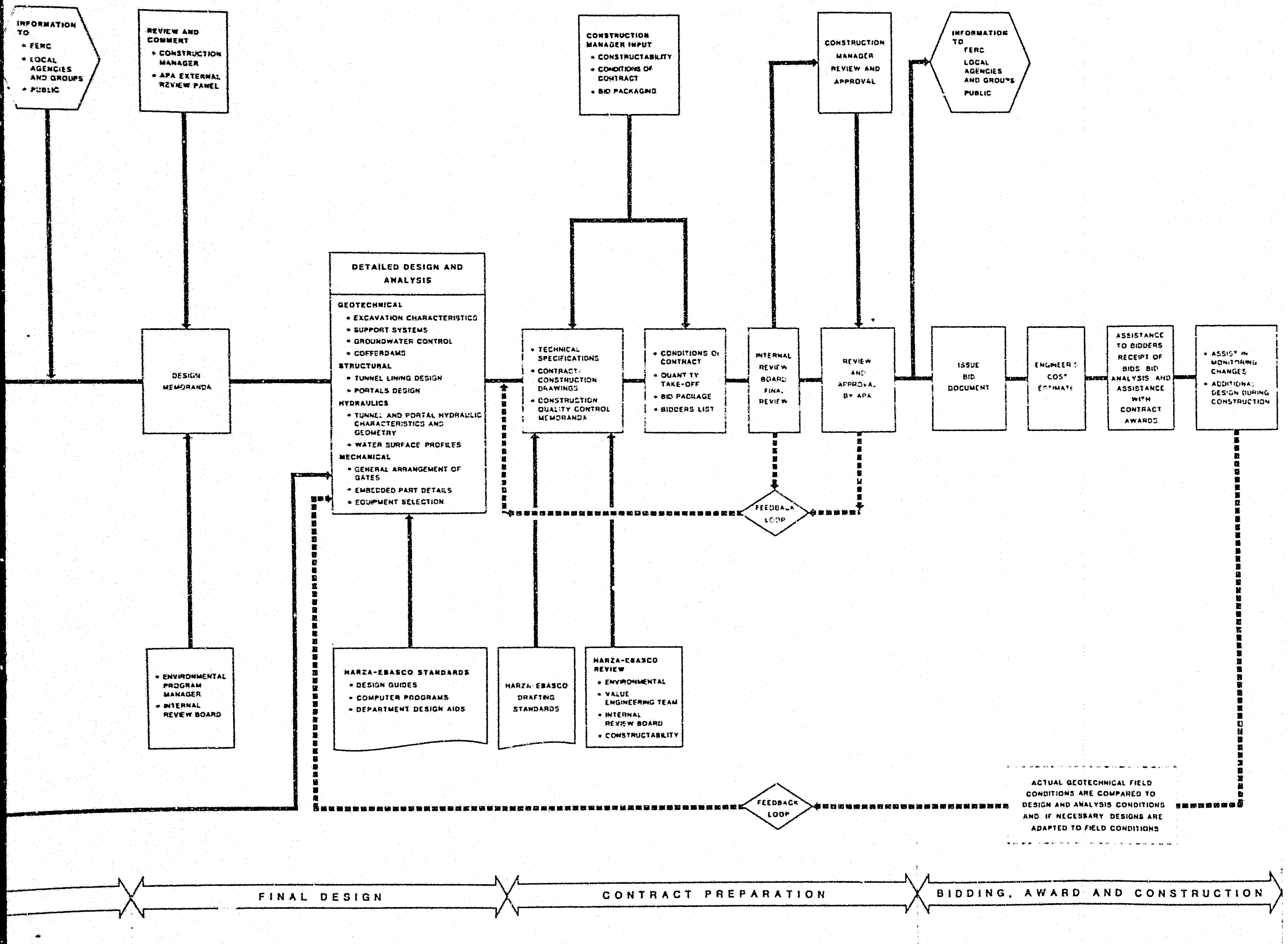
EXHIBIT D(b) - 6



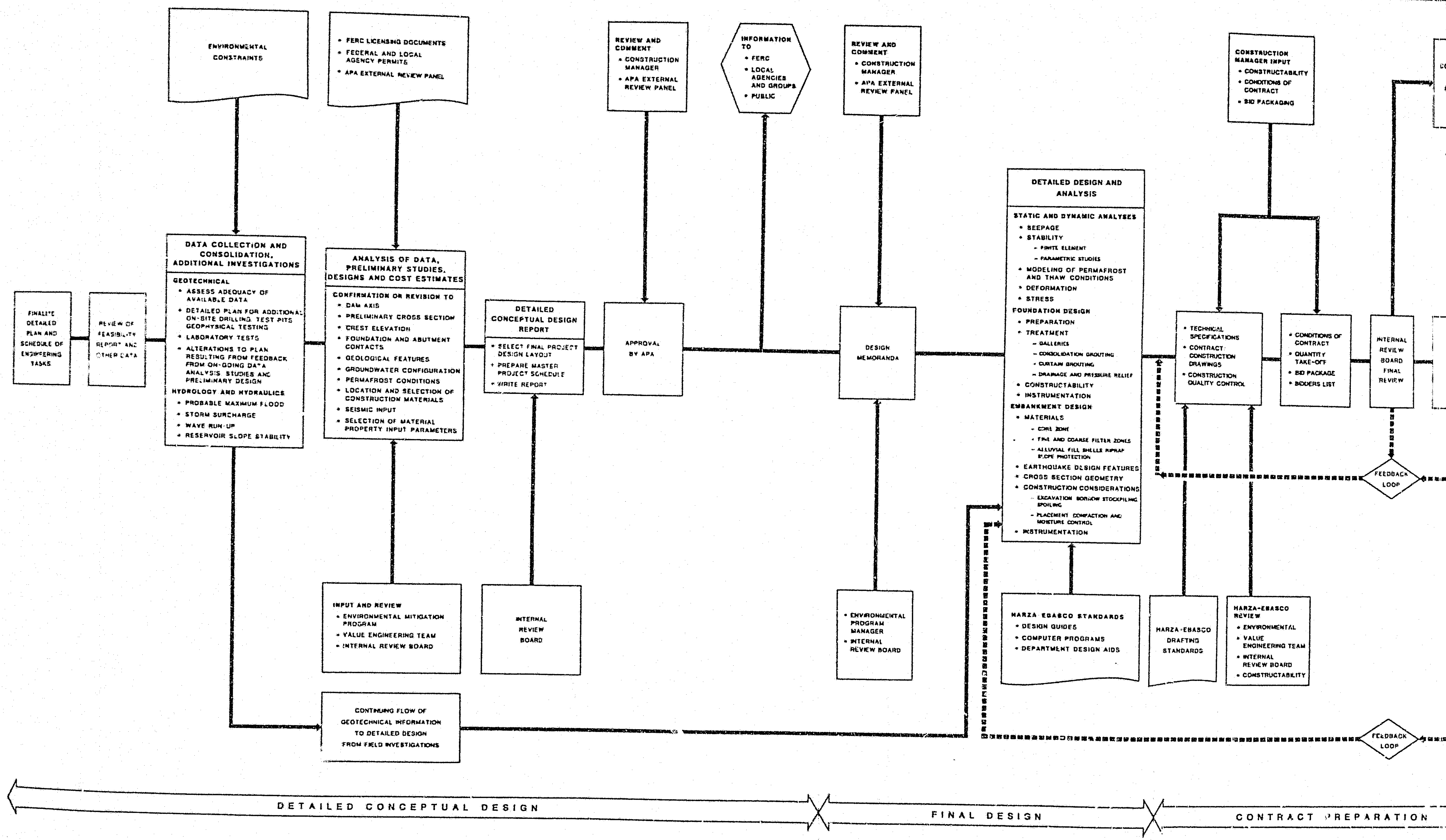
SUSITNA HYDROELECTRIC PROJECT

WORK FLOW DIAGRAM

DIVERSION TUNNELS AND FACILITIES

Contract C–1

continued



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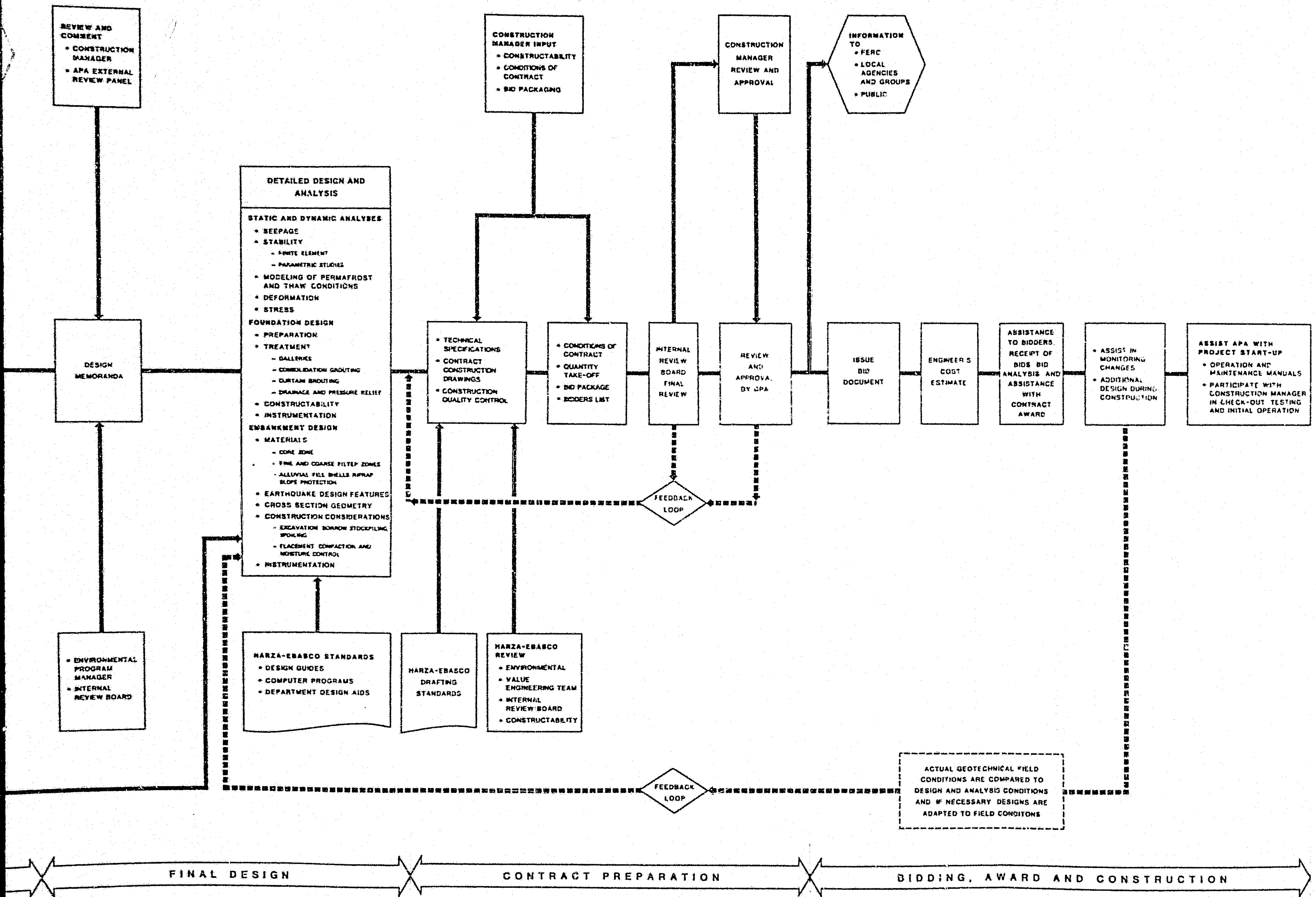


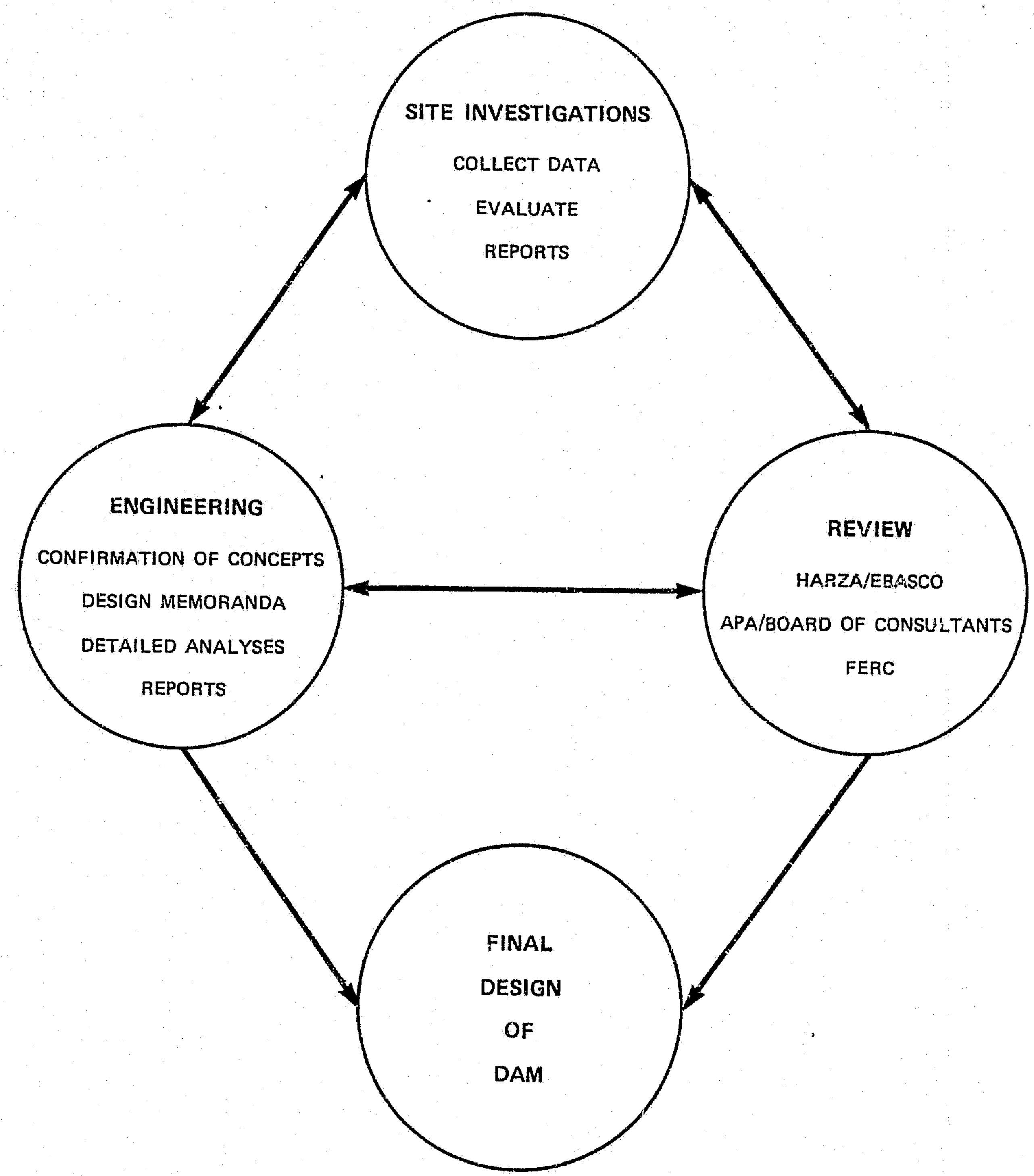
SUSITNA HYDROELECTRIC PROJECT

WORK FLOW DIAGRAM

MAIN DAM

Contracts C–2, C–3 and C–7

Continued



SUSITNA HYDROELECTRIC PROJECT

DAM DESIGN
ACTIVITY RELATIONSHIPS

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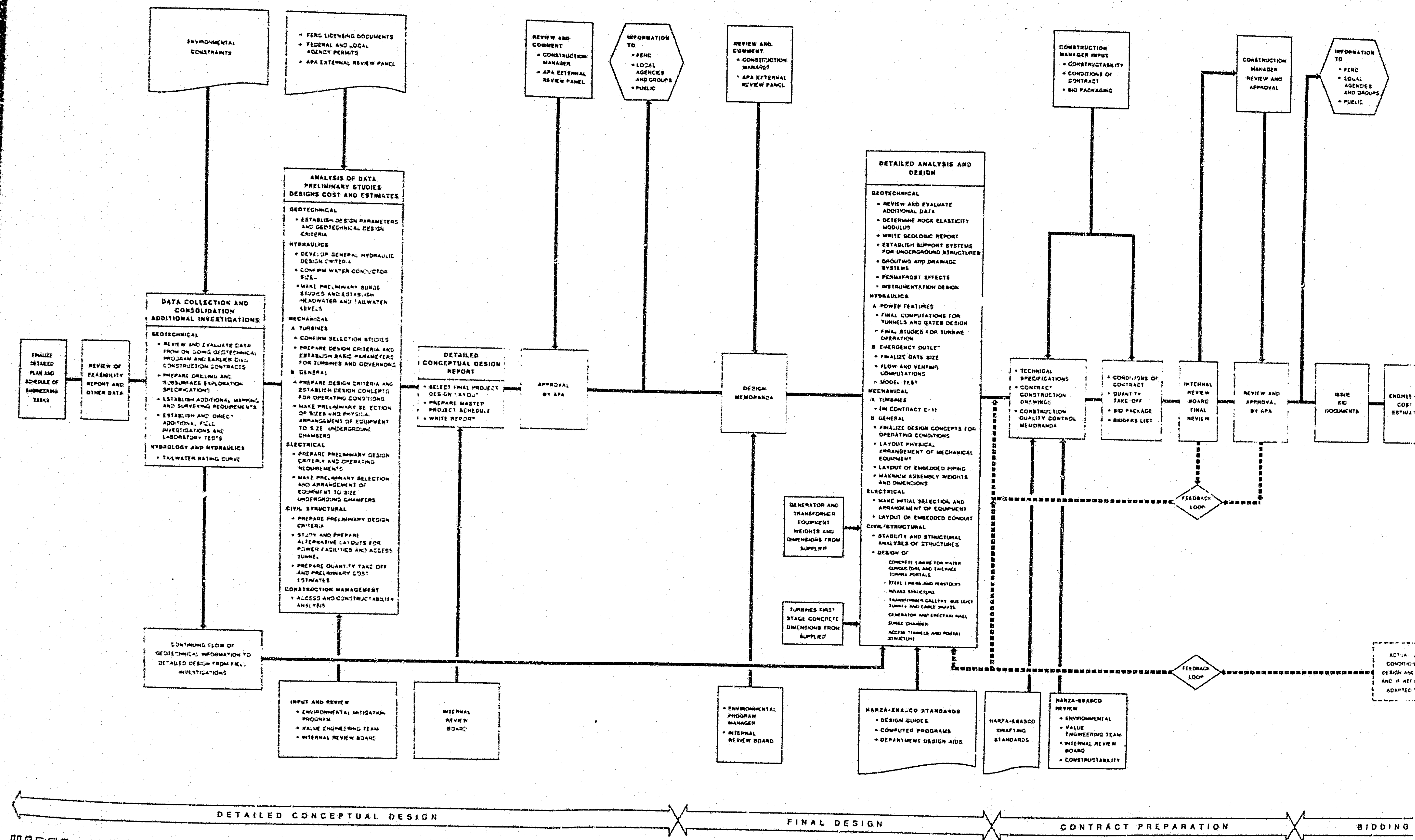

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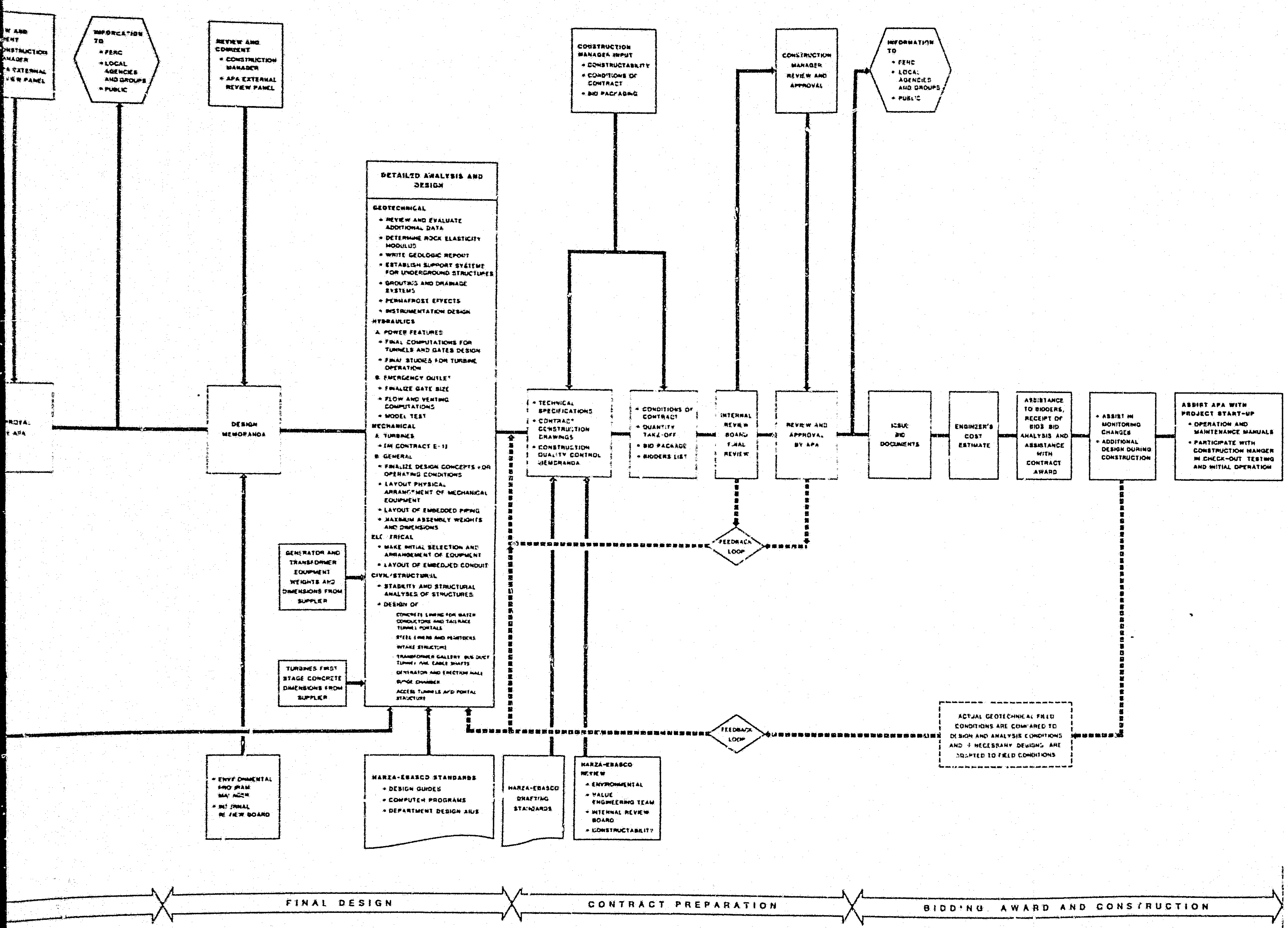

SUSITNA HYDROELECTRIC PROJECT

WORK FLOW DIAGRAM
POWER STATION – FIRST STAGE
Contract C–5

continued

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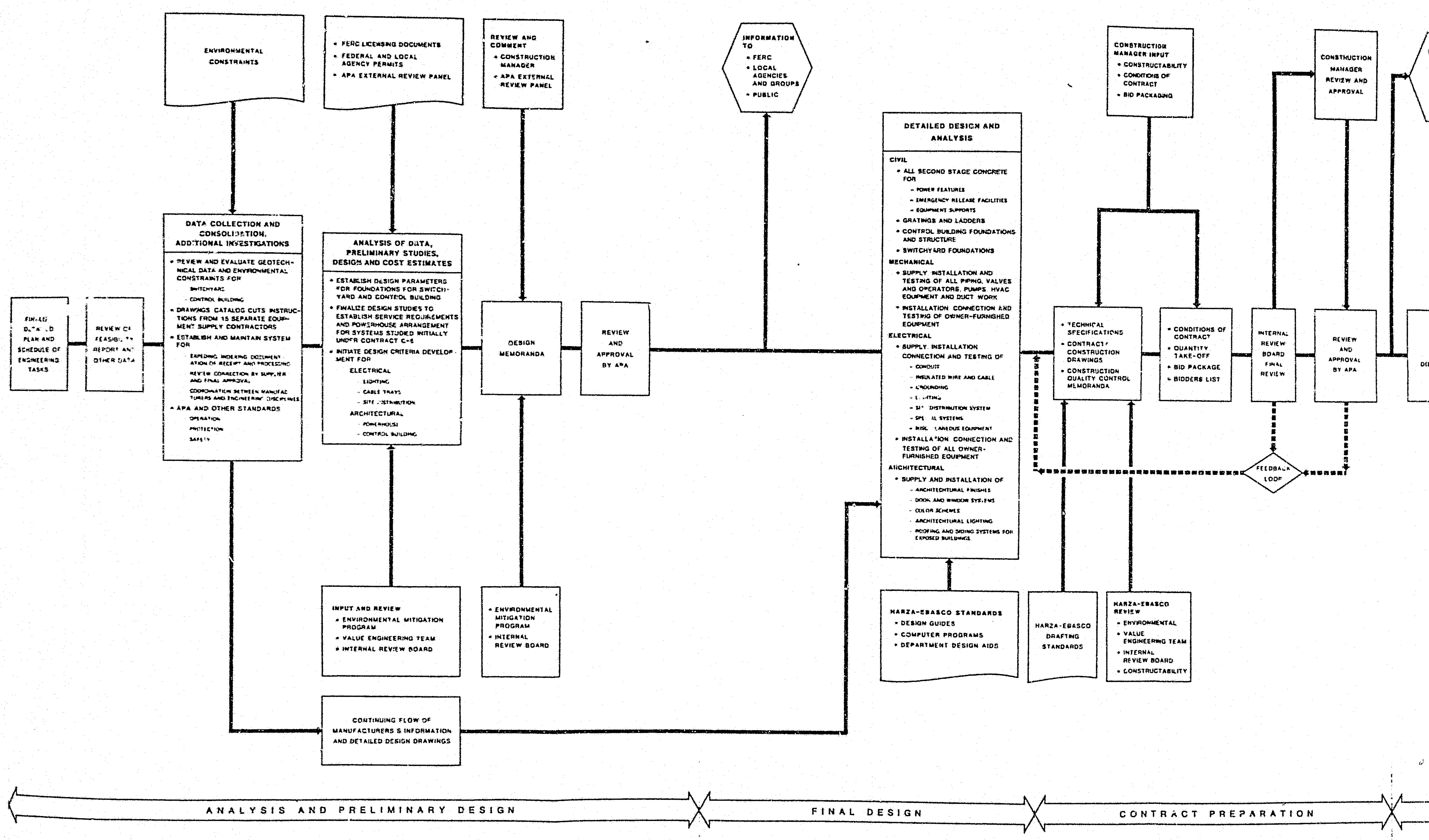

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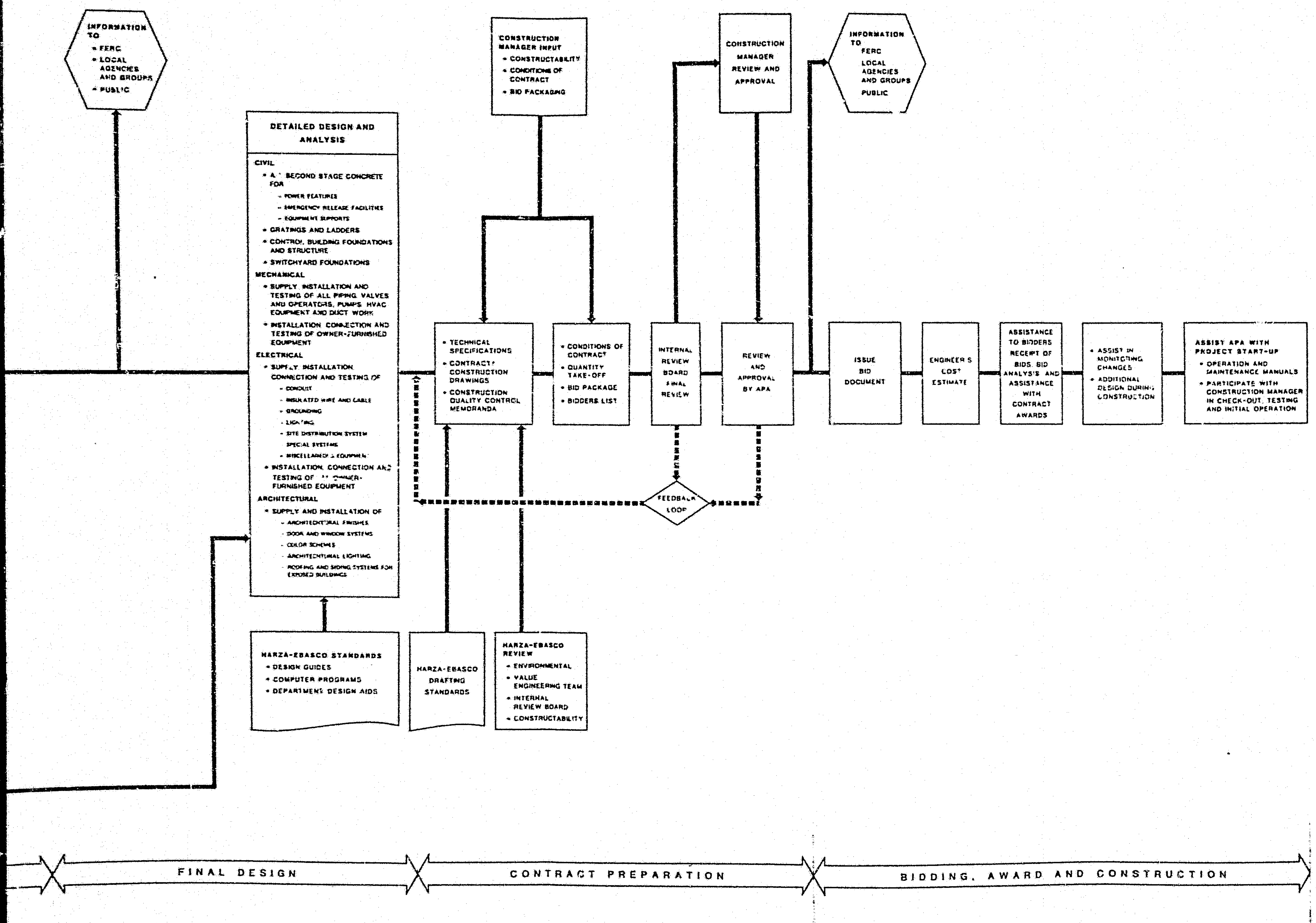
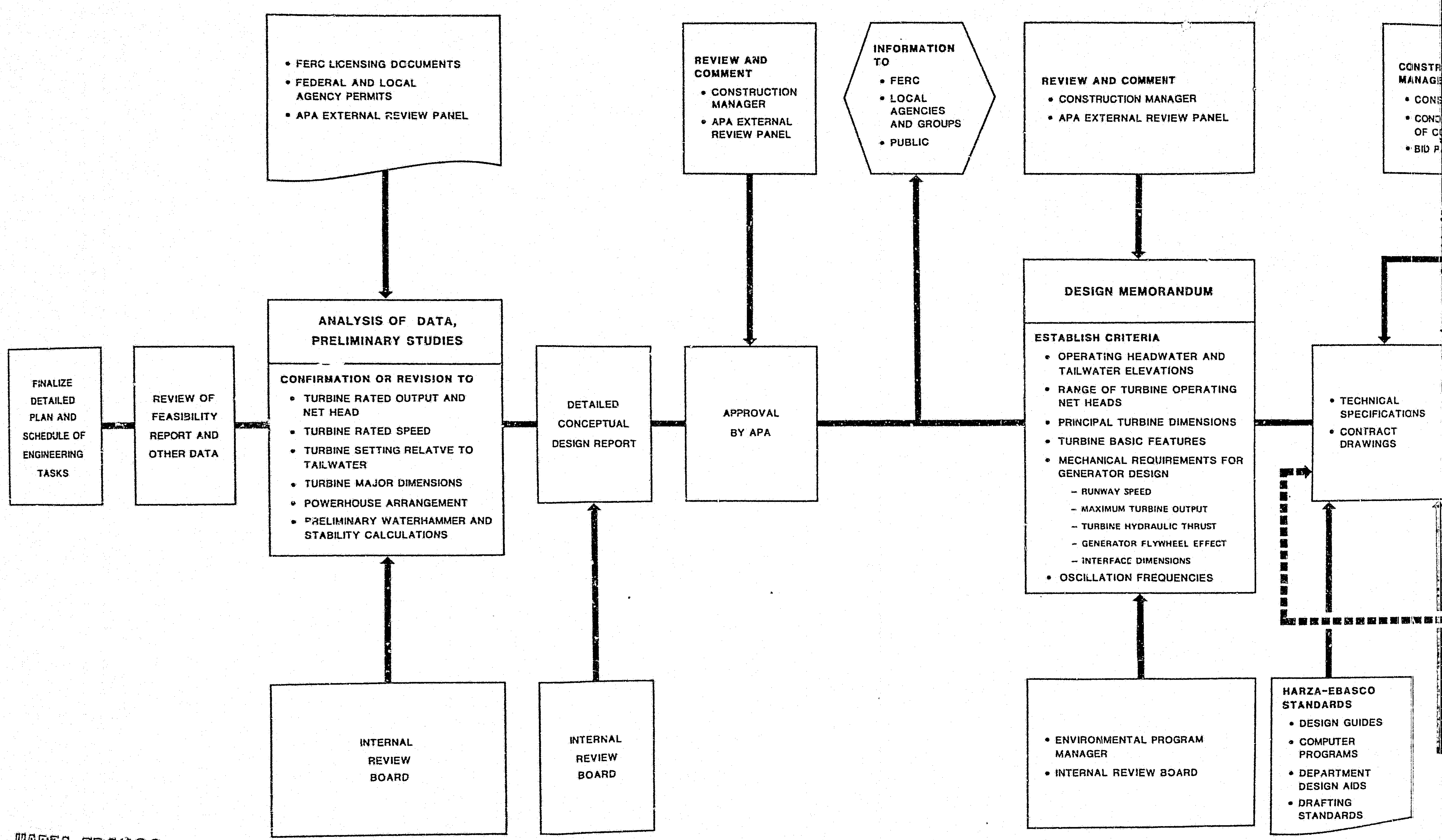


SUSITNA HYDROELECTRIC PROJECT

WORK FLOW DIAGRAM
COMPLETION CONTRACT
(Second Stage Concrete and Equipment Installation)
Contract C-10

continued



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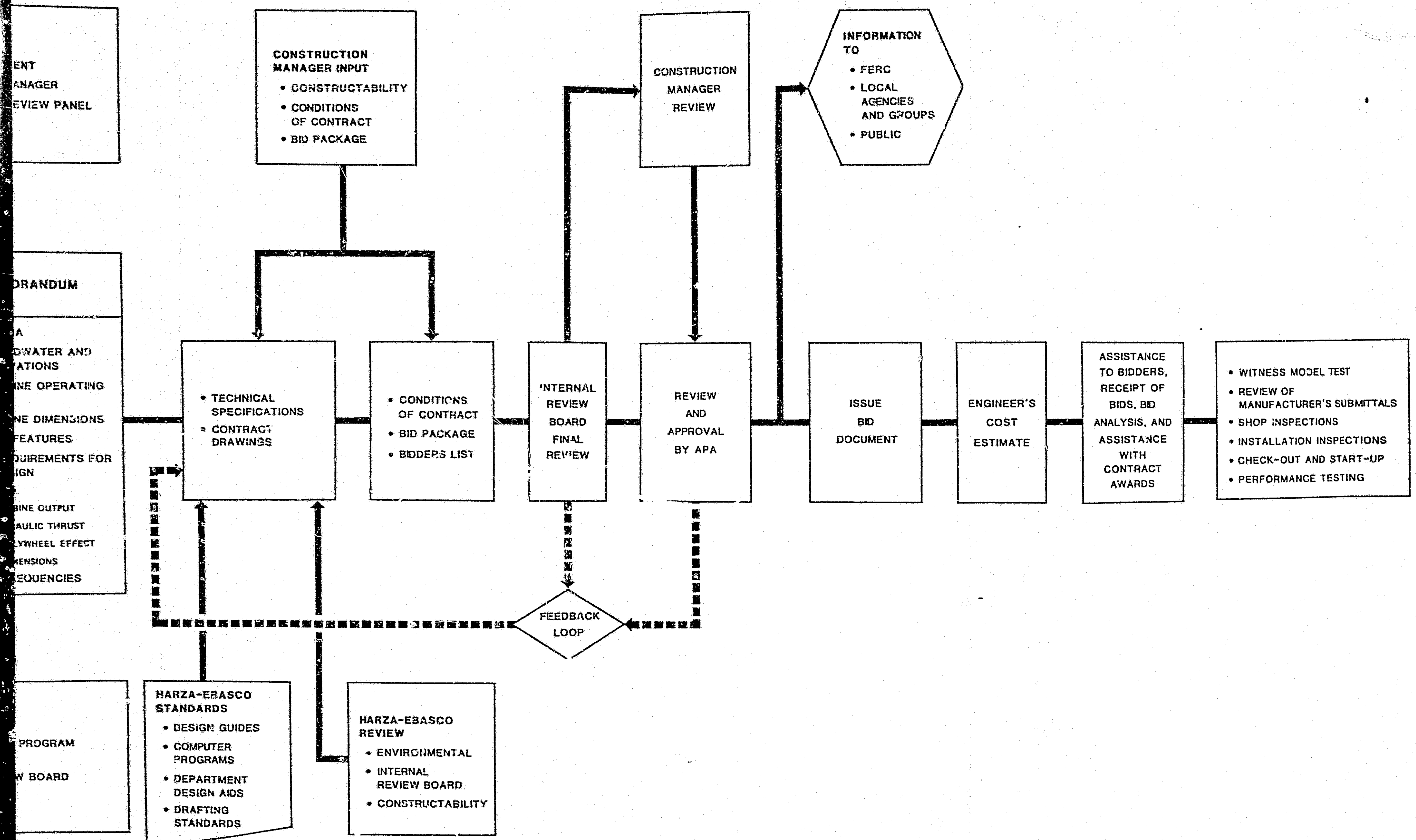

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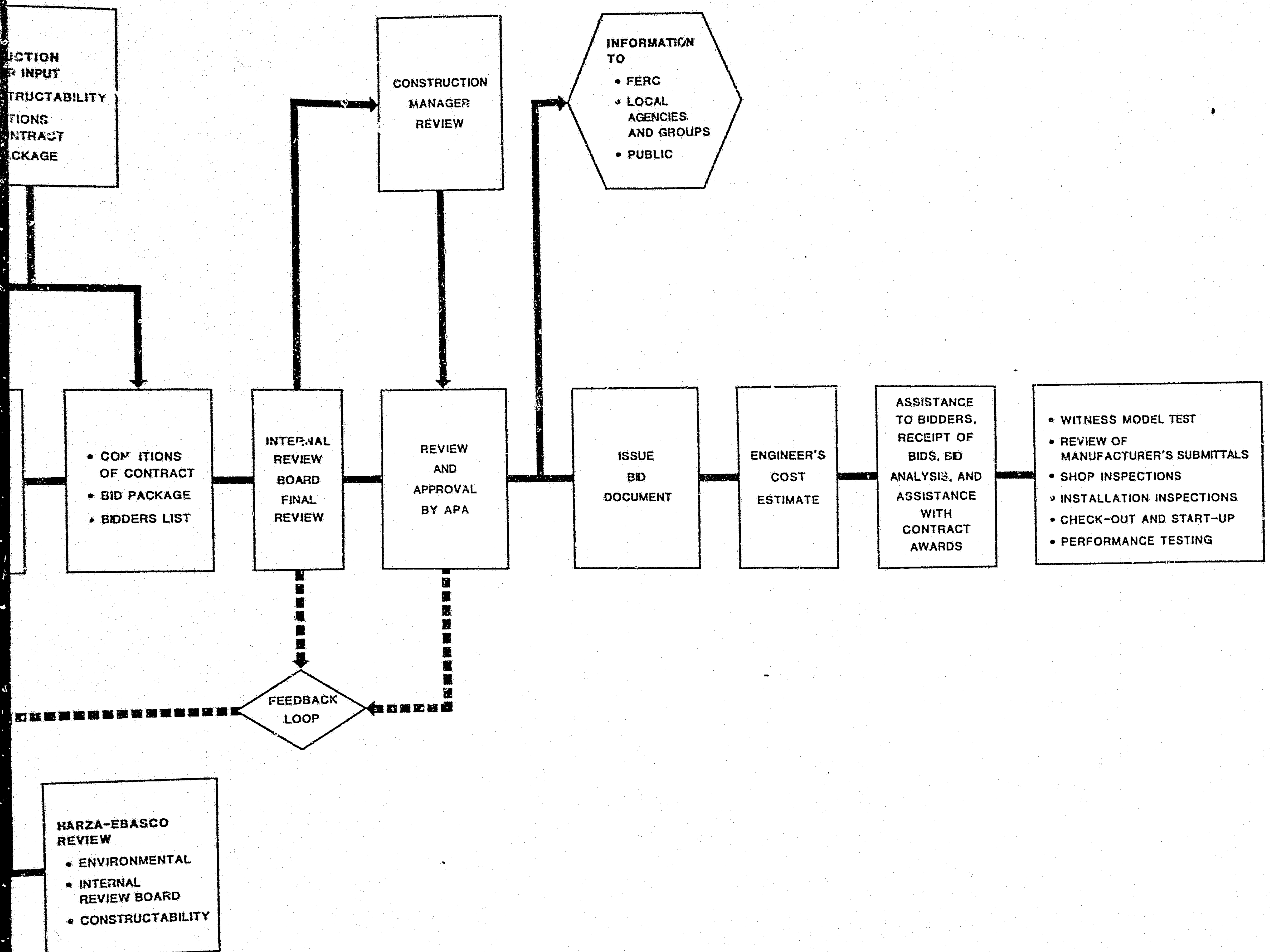
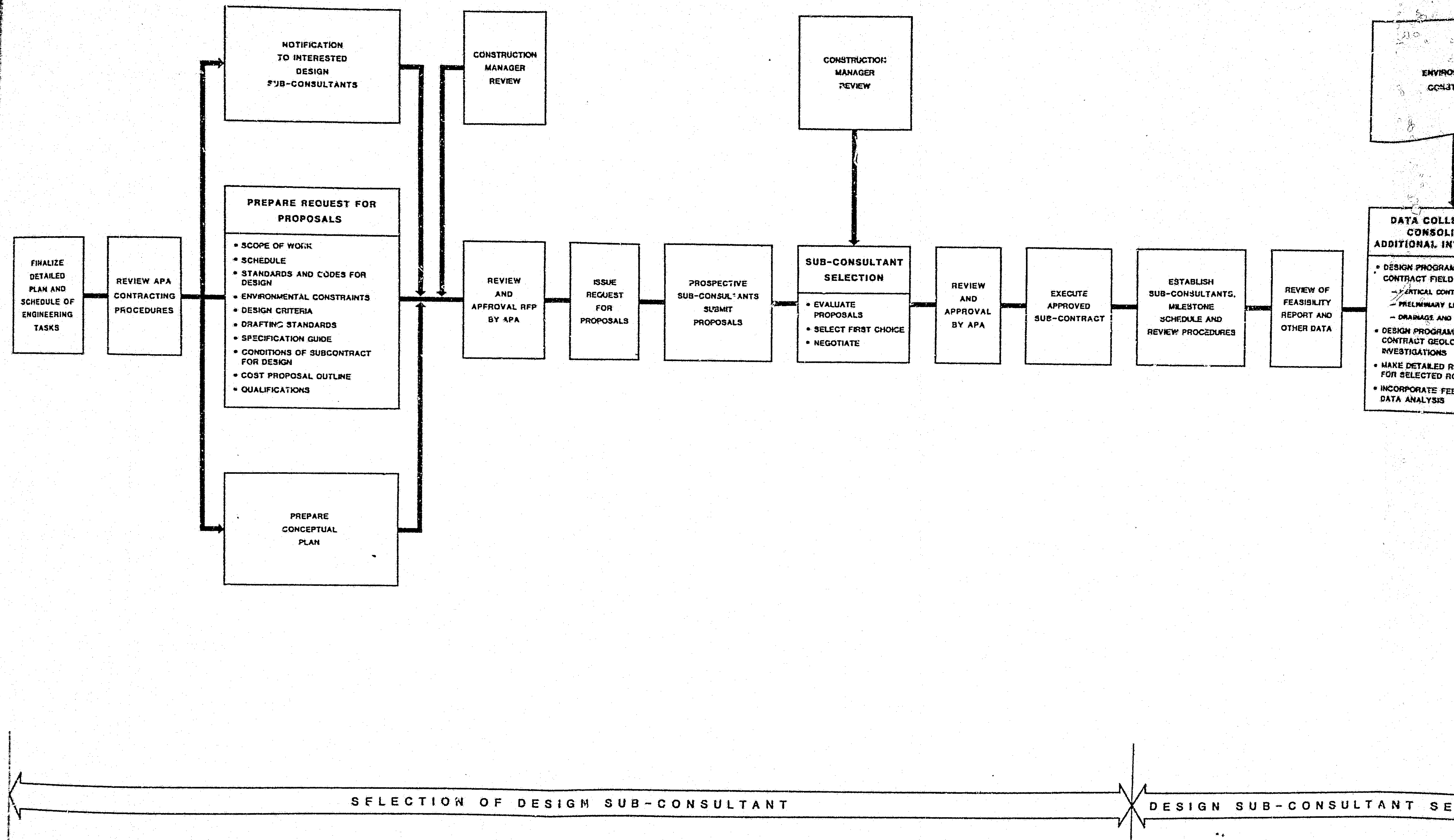


SUSITNA HYDROELECTRIC PROJECT

WORK FLOW DIAGRAM
HYDRAULIC TURBINE PROCUREMENT

continued



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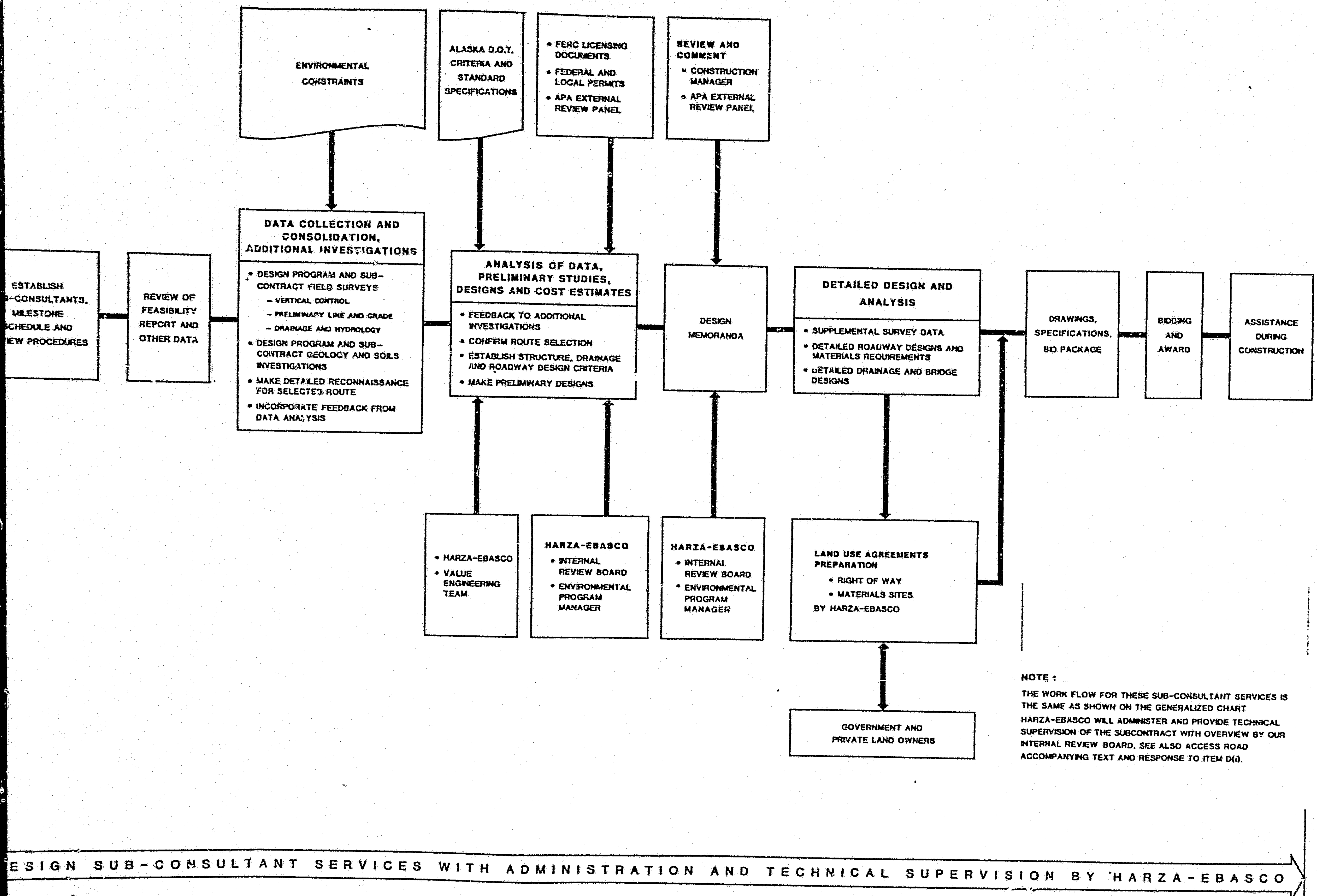

SUSITNA HYDROELECTRIC PROJECT

WORK FLOW DIAGRAM
ACCESS ROAD
(With Sub–Contracted Engineering)

continued

TASKS

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DETAILS OF THE TASKS

The total engineering effort for the Susitna Hydroelectric Project has been separated by the Joint Venture into 38 tasks. Each will have a number of sub-tasks. This section of our proposal presents, by discipline, the detailed content of the 38 tasks and their sub-tasks. The deliverables - reports, memoranda, contract/contract documents and drawings - are shown under the OUTPUT heading of each task. These deliverables are summarized in the table that follows.

The manpower budget for each task is shown in the Cost Proposal. The schedules for the tasks are shown on Exhibits D(b)-1, D(b)-2 and D(b)-3.

LIST OF DELIVERABLES

Work Task No.	Description of Task	Reports	Memos	Contracts/Contract Documents	Drawings					
					Arch	Civil	Elect	Geot	Mech	Total
1.	Project Management	150(E)	–	–	–	–	–	–	–	–
2.	Project Support Services	60(E)	–	–	–	–	–	–	–	–
3.	Review Prior Studies and Project Conceptual Design	1	8	–	–	20	4	9	–	31
4.	Environmental Studies	100(E)	As Required	–	–	–	–	–	–	–
5.	Geotechnical Studies	15	11	–	–	–	–	60	–	60
6.	FERC License Support	As Required	As Required	–	As Required					
7.	Electric Power System Studies	1	1	–	–	–	–	–	–	–
8.	Public Participation Meetings Support	As Required	As Required	–	As Required					
9.	External Review Panel Meetings	As Required	As Required	–	As Required					
10.	C-1 Diversion Tunnel & Facilities	1	3	1	–	38	2	2	2	–
11.	C-2 Main Dam, Excavation & Foundations	3	5	1	–	–	–	20	–	20
12.	C-3 Main Dam, Cofferdams-Fill to 1400	1	6	1	–	–	–	10	–	10
13.	C-4 Main Spillway Excavation	1	5	1	–	–	–	6	–	6
14.	C-5 Outlet Facilities	1	3	1	1	31	2	2	2	38
15.	C-6 Power Facilities - 1st Stage	4	5	1	9	111	9	9	32	170
16.	C-7 Main Dam to 2210	–	–	1	–	2	–	25	–	27
17.	C-8 Aggregate to Concrete Production	1	3	1	–	–	–	3	–	3
18.	C-9 Main Spillway, Outlet Works Valve House Concrete	2	3	1	–	–	2	–	2	4
19.	C-10 Power Facilities Completion	1	9	1	9	63	431	1	100	604
20.	C-11 Willow Control Center	1	3	1	10	3	23	1	–	37
21.	E-1 Turbines and Governors	1	1	1	–	1	–	–	2	3
22.	E-2 Generator and Excitation	1	1	1	–	1	2	–	–	3
23.	E-3 Microwave System	1	1	1	–	–	37	–	–	37
24.	E-4 Willow Control Equipment	1	2	1	–	–	9	–	16	25
25.	E-5 Trashracks, Gates & Hoists	1	5	1	–	–	–	–	17	17
26.	E-6 Cranes & Hoists	1	4	1	–	–	–	–	5	5
27.	E-7 Outlet Works Valves & Gates	1	2	1	–	–	–	–	4	4
28.	E-8 Transformers	1	1	1	–	2	1	–	–	3
29.	E-9 Control Switchboards	1	2	1	–	2	1	–	–	3
30.	E-10 HV-Switchgear	1	–	1	–	2	1	–	–	3
31.	E-11 Generator Voltage Switchgear	1	–	1	–	–	1	–	–	1
32.	E-12 Station Service Switchgear	1	2	1	–	–	1	–	–	1
33.	E-13 Computer Control	1	1	1	–	2	50	–	–	52
34.	E-14 345kV Power Cables	1	1	1	–	2	1	–	–	3
35.	E-15 Switchyard Structures & Busses	1	1	1	–	1	–	–	–	1
36.	E-16 Home Office Specialist Support to Field	40(E)	–	–	–	–	–	–	–	–
37.	E-17 Field Support	100(E)	–	–	–	–	–	–	–	–
38.	E-18 Management of Design Subcontracts	75(E)	30(E)	Minimum of 6 Subcontracts	–	–	–	–	–	–

(E) - Estimated Number

Task Number: 1

Task: Project Management

SUBTASKS

Project Management Subtasks

Review proposed Work Plan with Power Authority

Assemble project team leaders in Anchorage for review of previous studies and to establish Project Conceptual Design

Develop detailed Work Plan Task schedule Establish manpower budgets for all tasks and their subtasks

Staff Anchorage and field offices

Direct and control the staffing of Bellevue office

Maintain liaison with Power Authority and its External Review Panel

Plan, support and participate in Power Authority's public information meetings.

Support Power Authority in coordination and responses to regulatory agencies.

Monitor Work Plan cost and schedule performance and take corrective action as required to maintain goals

Control technical disciplines in the project design work

Submit progress reports to Power Authority

Schedule Internal Review Board participation in the project design work

Schedule Value Engineering Team participation in the project design work

Coordinate Construction Manager interaction with design work

Task Number: 2

Task: Project Support Services

SUBTASKS

Project Management Subtasks

Coordinate and collect monthly progress reports information from Engineering Operations, Project Control and Environmental and Regulatory Programs

Direct preparation of monthly JV progress reports

Support Services Subtasks

Implement "EPICS System" to control work

Finalize Tasks with subtask lists and establish "Description of Technical Service"

Develop Project Work Breakdown Schedule and CPM

Using updated monthly Task progress reports generate Monthly Project Progress Report

Generate Monthly Variance Analysis Report

Generate "Budget Baseline Project Estimate"

Generate study estimates as required

Generate Monthly Potential Cost/Schedule Report

Generate Engineers Estimates for each construction and equipment supply contract

Generate "Preliminary Project Estimate"

Generate "Definitive Project Estimate"

Develop Standard Conditions of Contract - revise them on subsequent contracts to fit the Contract

Prepare drafts and final Contract Documents for issue to Bidder

Task Number: 1

Task: Project Management

OUTPUT

Project Work Plan and Schedule

Monthly Progress Reports showing design work completed, work in progress and fiscal status of the JV contracted work

Agenda for and reports on decisions made at conferences and meetings

Project Cost Estimates and Updated Estimates

Coordinated Contract Documents for the equipment supply and construction contracts of the Watana Project

Contract awards in accordance with APA directives and procedures

Coordination of Home Office support and field support to APA's Construction Manager.

Task Number: 2

Task: Project Support Services

SUBTASKS

Project Management Subtasks

Coordinate and collect monthly progress reports information from Engineering Operations, Project Control and Environmental and Regulatory Programs

Direct preparation of monthly JV progress reports

Support Services Subtasks

Implement "EPICS System" to control work

Finalize Tasks with subtask lists and establish "Description of Technical Service"

Develop Project Work Breakdown Schedule and CPM

Using updated monthly Task progress reports generate Monthly Project Progress Report

Generate Monthly Variance Analysis Report

Generate "Budget Baseline Project Estimate"

Generate study estimates as required

Generate Monthly Potential Cost/Schedule Report

Generate Engineers Estimates for each construction and equipment supply contract

Generate "Preliminary Project Estimate"

Generate "Definitive Project Estimate"

Develop Standard Conditions of Contract - revise them on subsequent contracts to fit the Contract

Prepare drafts and final Contract Documents for issue to Bidder

Task Number: 2
SUBTASKS
Page 2

Prepare Notice to Bidders for Power Authority approval

Issue Addenda to Contract Documents to Bidder as required

Receive bids

Participate in evaluation of contractual terms of Bids

Prepare Recommendation of Award for Approval of Power Authority

Assist Power Authority in Contract Negotiations

Prepare and update Project Construction Schedule

Coordinate with Vendor and participate in Vendor QA inspections

Task Number: 2

Task: Project Support Services

OUTPUT

Support Services Output

"EPICS" control system applied to JV work program

Description of Technical Services for the JV work

Project CPM

Monthly Progress Reports for Power Authority submitted to Project Manager for

Baseline Project Estimate

Study Estimates

Engineers Estimates

Preliminary Project Estimate

Definitive Project Estimate

Standard Conditions of Contract

Contract Documents, prepared, assembled and issued

Notices to Bidders

Addenda to Contract Documents issued to Bidder

Receipt and Evaluation of Contractual Terms of Bids

Letters of Recommendation of Award of Contract

Contract Negotiation Support to Power Authority

Project Construction Schedule and Updates

Vendor QA inspections

Task Number: 3

Task: Review Prior Studies, Develop Conceptual Design and Master Project Schedule

SUBTASKS

Management Subtasks

Issue and control manpower schedule and budget for Tasks and Subtasks

Assemble Transition Team, establish work plan and schedule

Control and direct team

Initiate work

Transition Team-Review of Feasibility Report Subtasks

Hydrology

Review hydrology aspects of Feasibility Report and data collected to date.

Confirm or propose modifications to
Probable Maximum Flood (PMF)
Project Design Flood
Project Diversion Flood considerations

Geotechnical Engineering and Geology

Gather and collate all pertinent data, topographic and geologic maps, geologic field and laboratory data repots, and seismic studies

Summarize prior work

Identify additional field investigations and materials and laboratory studies needed

Prepare plan and estimate costs to complete additional geotechnical field and laboratory investigations.

Civil Engineerg

Review civil/structural aspects of Feasibility Report

Confirm or propose and justify modifications to
- Number and size of Generating Units proposed
- Power Intakes and Tunnels
- Generator Hall/Erection Bay size
- Transformer gallery size
- Surge chamber and tail tunnel sizes and shapes
- Access tunnel

Hydraulic Engineering

Review hydraulic aspects of Feasibility Report

Confirm to propose modifications to
- Diversion tunnel alignment, size, intake, outlet and hydraulics
- Main spillway/emergency spillway flood passing capacity
- Main spillway alignment, profile, flip bucket location and geometry
- Main spillway plunge pool location and geometry
- Main spillway gates
- Emergency spillway location and geometry
- Outlet facilities location, tunnel size, capacity, operation
- Emergency outlet operation, gate arrangement, configuration and outlet structure
- Power Intake hydraulics, multiple level withdrawal ports and gates
- Power tunnels alignment and size
- Tail tunnel Surge Chamber size
- Tail tunnels size and alignment

Electrical Engineering

Review electrical aspects of Feasibility Report

Review control protection and instrumentation features

Review auxiliary electrical and miscellaneous system features.

Mechanical Engineering

Review mechanical aspects of Feasibility Report

Confirm or propose and justify a different selection of
- Turbines and Governors
- Diversion Tunnels and Emergency Outlet Gates and Hoists
- Outlet Facilities Gates & Hoists and Valves
- Power Intake Gates and Hoists
- Main Spillway Gates and Hoists
- Draft Tube Gates and Hoists
- Mechanical systems

Environmental

Review environmental aspects of Feasibility Reports, environmental agencies correspondence, etc.

Transition Team Subtasks in Project Conceptual Design

Conceptual Design Criteria

Main Dam Development Criteria
- Establish alignment of main dam
- Establish crest width and the outer slopes of the main dam
- Establish the location and alignment of cofferdams
- Establish scope of foundation treatment
- Direct layout studies for grouting, drainage and access galleries
- Initiate and direct alternate layout studies

Develop Relict Channel Criteria
- Initiate and direct alternative conceptual layouts for relict channel treatment using a range of assumptions
- Determine the data requirements to establish the need for and scope of treatment

Diversion Tunnel Development Criteria
- Establish hydraulic design criteria
- Establish structural design criteria
- Geotechnical input for tunnel and portal location
- Initiate and direct alternate layout studies with flood routings

Task Number: 3
SUBTASKS
Page 4

Power Facilities Development Criteria
- Establish generating unit size and number of units
- Establish size of power for tailrace tunnels
- Establish power tunnel c to c spacing
- Establish underground chamber pillar distances
- Establish height and width of generator/erection bay chamber
- Establish height and width of surge chamber and transformer chamber
- Establish access tunnel dimensions
- Establish desired tunnel and chamber orientation
- Establish dimensions of main cable and access shafts
- Initiate and direct alternate layout studies

Main Spillway and Emergency Spillway Development Criteria
- Confirm PMF and design flood for each spillway
- Establish geotechnical criteria for spillways layouts
- Initiate and direct alternate layouts and considering various main spillway control structures, spillway alignments and bucket configurations

Mid Level Outlet Facilities Development Criteria
- Confirm discharge requirement
- Establish hdyraulic design criteria
- Establish structural design criteria
- Establish geotechnical criteria for intake, tunnel orientation, outlet manifold and outlet location
- Initiate and direct alternate outlet layouts

Screen Layouts and Costs
- Optimize selected layouts
- Present to Internal Review Board for comment
- Modify selected layout(s) in accordance with internal review board decisions
- Present recommended layout(s) to Power Authority and its External Review Panel for approval

Prepare Project Schedule
Prepare Final Conceptual Design Report
Respond to FERC review comments on Conceptual Design Report

Civil Engineering Subtasks

For diversion tunnel, power facilities, main spillway and outlet structure participate in preparation of the design criteria and in development of alternate layouts.

Electrical Engineering Subtasks

Provide Equipment Layouts and Dimensional Data

Provide Cost Comparisons and Cost Estimates

Provide input to other disciplines studies for electrical features and constraints

Mechanical Engineering Subtasks

Provide support to develop project design layouts
Scheduling and estimates for civil contract & the separate supply contracts

Hydraulic Engineering Subtasks

Power intake
- Head Loss and revenue loss for alternatives
- Comparison with gate and concrete costs
- Determination of optimum intake

Power Tunnels
- Head Loss and revenue loss for alternatives
- Compare with excavation and lining costs
- Determination of optimum size

Tail-Tunnels
- Head Loss and revenue loss for alternatives
- Compare with excavation and lining costs
- Determination of optimum size

Tail-Tunnel Surge Chamber
- Comparison of several alternatives based on maximum and minimum surge levels during load change
- Comparison of alternative costs
- Selection of optimum size

Outlet Works
- Compare head losses for various tunnel sizes
- Determine valve sizes for each alternate tunnel size
- Select optimum tunnel-valve combination

Emergency Outlet
- Study double head-break scheme
  - Study alternative combinations of gates
  - Study alternative gate costs
  - Select optimum

- Study Single Head-Break Scheme
  - Study alternative combinations of gates
  - Study alternative gate costs
  - Select optimum

Service Spillway
- Determine costs of various spillway sizes
- Compare with costs of dam for spillway size alternatives
- Select optimum spillway size

Emergency Spillway
- Width of channel based on geology and topography and fuse plug height

Diversion
- Determine HW for several tunnel sizes (Assume Concrete lined)
- Compare tunnel costs and cofferdam costs for alternatives
- Select preliminary economic optimum tunnels

Geotechnical Engineering Subtasks

For main dam, relict channel, main spillway, emergency spillway and underground structures, participate in layout studies and support to Civil discipline in alternate-layouts for Project Conceptual Design

Environmental Subtasks

Input environmental considerations to project conceptual design studies

Support Services Subtasks

Prepare comparative cost estimates as required
Prepare comparative construction schedules
Constructability reviews
Prepare Project Base Line Estimate

Task Number: 3

Task: Review Prior Studies, Develop Conceptual Design and Master Project Schedule

OUTPUT

Management Output

Input to Monthly Progress Report on status of Task, with respect to schedule and budget

Coordinated Project Conceptual Design Report

Civil Engineering Output

Civil/structural assistance to other disciplines as required

Sketches/layouts as required

Input to Project Conceptual Design Report in form of Drawings, quantity estimates and text on Civil/Structural aspects of Project Conceptual Design

Hydrology Output

Hydrology input to other disciplines' subtasks in form of PMF, PDF, diversion flood frequency study, sedimentation study and environmental aspects

Texts and graphs for Project Conceptual Design Report

Hydraulic Engineering Output

Hydraulics input to other disciplines' subtasks in form of preliminary surge chamber level, flood routing results etc.

Input to Project Conceptual Design Report in form of text and drawings

Geotechnical Engineering Output

Geotechnical input to other disciplines in form of criteria for location, orientation and support requirements for underground structures; cut slopes and support requirements for surface features

OUTPUT

Input to Project Conceptual Design Report in form of text, drawings of Main Dam and material quantity estimates

Mechanical Engineering Output

Mechanical input and coordination to subtasks of other disciplines

Input to Project Conceptual Design Report in form of text, drawings, and materials and equipment cost estimates

Electrical Engineering Output

Electrical input and coordination to subtasks of other disciplines

Input to Project Conceptual Design Report in form of text, drawings, and materials and equipment cost estimates

Environmental Output

Input of environmental considerations and guidance to other disciplines in accomplishing work of their subtasks

Text describing mitigation measurs in Conceptual Design Report

Support Services Output

Project Conceptual Design Layout construction schedule

Input to Project Conceptual Design Report in form of text describing considerations in developing construction schedule and procedures used in estimating costs

Note: Management Subtasks budget is included with Task Number 1 Project Management

Task Number: 4

Task: Environmental Studies

SUBTASKS

Management Subtasks

Issue and control manpower schedule and budget for Task and Subtasks

Geotechnical Engineering and Geology Subtasks

Study of Geotechnical and Geologic aspects in support of Environmental studies

Hydraulic Engineering Subtasks

Power Intake
- Temperature Control
- Ice Control

River Studies
- Downstream River Ice
- Upstream Reservoir Ice

Diversion
- Effects on Fish
- Effects on River Ice

Environmental Science Subtasks

Environmental Studies

Water Use and Quality Studies
Fish, Wildlife and Botanic Resources Studies

Aquatic Ecosystems
Terrestrial Resources

Historic and Archeological Resources
Socioeconomic Studies
Soils and Geology Studies
Recreation Studies
Aesthetics Studies
Land Use Studies
Project Alternatives
Post License Environmental Program

Design of Monitoring Program

Hydrology Subtasks

Hydrologic Studies

Review and Evaluate Previous Studies

Continue Hydrologic and Meteorological Data Monitoring

River Sedimentation Modeling Studies

River - Reservoir Water Quality

Update and/or Upgrade River - Reservoir Ice Cover Duration and Thickness Studies at Selected Locations

Support Services Subtask

Coordinate the technical and contractual portions of the specifications for construction to support the requirements of the environmental studies

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 4

Task: Environmental Studies

OUTPUT

Management Output

Input to Monthly Progress Report on status of Task with respect to schedule and budget

Coordinated effort for studies

Civil Engineering Output

Layout sketches as required

Geotechnical Engineering and Geology Output

Sections of the Environmental Report as required

Hydraulic Engineering Output

Parts of environmental report or letters answering FERC questions.

Environmental Science Output

Final Environmental Report

Hydrology Output

Periodic Data Documentation

Report on River - Reservoir Flow, Depth, and Velocity Studies

Report on River - Reservoir Temperature Studies

Report on Sedimentation Modeling Studies

Report on Water Quality Modeling Studies

Report on Ice Cover Studies

Support Services Output

Environmental Protection Provisions in contract specifications

Task Number: 5

Task: Geotechnical and Geological Field Studies

SUBTASKS

Management Subtasks

Issue and control manpower schedule and budgets for task and subtasks
Control field investigation subcontracts
Coordinate field works and environmental requirements for the work

Civil Engineering Subtasks

For mapping and surveying programs determine scales, locations and size of mapping areas required.

For design of structures, determine what geotechnical data is required.

Geotechnical Engineering and Geology Subtasks

Management Functions - Geotechnical Field Investigations
- Planning - Coordination
- Quality Control
  - Surveillance (Rock Exploration)
  - Monitoring (Soils Exploration)
  - Direct Responsibility
    - Mapping
    - Surface Geophysics
    - Instrumentation
    - Hydrogeology
- Data Compilation
  - Standard Format - forms, reporting mode
  - Standard Sampling - sample preparation
  - Standard Procedures/Methods
- Data Presentation/Documentation/Storage
  - Maps, Sections - Standard Graphics
  - Field Data
  - Lab Test Data
  - File System - Computer Storage - Retrieval
- Data Transfer and Scheduling - in
- Data Request - action/scheduling - in

Task Number: 5
SUBTASKS
Page 2

Staffing - scheduling
Safety Assurance - Personnel

Rock Exploration
- Core Drilling
  - Main Dam and Cutoff
  - Cofferdams
  - Diversion Tunnels
  - Underground Structures
  - Spillways
  - Quarry Evaluation
- Test Grouting - Cutoff
- In-Situ Testing
  - Adit Excavation
  - Rock Mechanics Instrumentation
  - Borehole Geophysics
  - Borehole Imagery
- Laboratory Testing (Anchorage/Stateside)
  - Petrographic Studies
  - Strength Property Parametric-cores
  - Strength Property - Discontinuities
  - Aggregate Acceptance

Soil Exploration
- Hammer Drilling
  - Borrow Areas
  - River Channel
  - Relict Channels
- Auger/Rotary Drilling
  - Borrow Areas
  - Relict Channels
- Trench and Test Pits
  - Borrow Areas
  - Relict Channels
- Soil Testing
  - In-Situ
  - Laboratories
    - Site
    - Anchorage
    - Stateside

Support Exploration Services
- Geologic Mapping
  - Main Dam Area
  - Borrow & Quarry Areas
  - Relict Channels
  - Reservoir
- Geophysical Exploration (Surface)
  - Main Dam Area
  - Borrow & Quarry Areas
  - Relict Channels
  - Reservoir
- Instrumentation
  - Temperature (Thermistors)
  - Groundwater (Piezometers)
- Hydrogeology
  - Main Dam
  - Relict Channels
  - Borrow Areas
  - Reservoir

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 5

Task: Geotechnical and Geological Field Studies

OUTPUT

Civil Engineering Output

Sketches of mapping and surveying areas

Memo on geotechnical data for structures required

Geotechnical Engineering and Geology Output

Geologic Borehole Logs

Report of Test Grouting

Adit Geologic Maps

Petrographic Report

Rock Core Tests - Report

Aggregate Suitability - Report

Report-Becker Drill Data and Boring Logs for
F.Y. 83 and F.Y. 84

Boring Logs and Drill Hole Data for
F.Y. 83,
F.Y. 84, and
F.Y. 85

Exploration Logs for
F.Y. 83,
F.Y. 84, and
F.Y. 85

Report - In-situ Soil Tests

Soils Testing Reports
F.Y. 83,
F.Y. 84, and
F.Y. 85

Task Number: 5
OUTPUT
Page 2

Main Dam Area - Geologic Maps
Borrow & Quarry Areas - Geologic Maps
Relict Channels - Geologic Maps
Reservoir - Geologic Maps

Plans of Geophysical Traverses
Report of Geophysical Exploration
including Velocity Sections along each Traverse

Report of Ground Temperature Surveys
Report of Ground W ter Data

Hydrogeology Report including chapters on
- Main Site Area
- Relict Channels
- Borrow Areas
- Reservoir Area

Annual Reports of Geotechnical Investigations
- FY 83,
- FY 84, and
- FY 85

Final Geotechnical Report of Investigations for Design

Field Data Volume - Surface Geophysical Surveys
Lab Test Data Volume - Subsurface Geophysical Surveys

Contract Documents Volume - Boring Logs Rock
Boring Logs Soil
Volume - Lab Test Data Rock
Lab Test Data Soils
Volume - Logs, Test pits, Trenches
Volume - In-situ Tests, Rock, Soils
Volume - Reservoir Maps
Volume - Instrumentation Data

Drawings-Geotechnical

1. Subsurface Exploration Plan - Damsite
2. Subsurface Exploration Plan - Watana Channel
3. Subsurface Exploration Plan - Fog Lakes Channel
4. Borrow Areas - Location and Exploration

Task Number: 6

Task: FERC License Support

SUBTASKS

Management Subtasks

Coordinate with Power Authority in JV support efforts for license application

Expedite JV work to respond to license questions by FERC and other agencies

Envir( )mental Engineering Subtasks

FERC License Support

Review
- Environmental Studies
- Project Design and Operation
- FERC Request for Supplemental Information, List of Deficiencies

Assist in Preparation of Response to FERC for Supplemental Information

Assist Power Authority in the review Agency/Public Comments on License Application and prepare responses

Modify Environmental Programs, Project Concepts as necessary

Review Draft EIS

Prepare Comments
- On Draft EIS
- On Agency/Public Review of Draft EIS

Review Final EIS

- On Draft EIS
- On Agency/Public Review of Draft EIS

Review FERC Proposed General and Special Conditions to License for Project

Assist Power Authority in Discussions with FERC/Agencies on General and Special License Conditions

Develop Final Project Monitoring and Mitigation/Enhancement Programs

Geotechnical Engineering Subtasks

FERC License Support

Prepare studies and analyses to support license Application

Dam and Foundation Treatment

Relict Channel Treatment

Prepare Exhibits for Presentations at FERC Hearings, other agency and Public Meetings.

Water and Energy Planning Resource Subtasks

FERC License Support

Review License Application and prepare responses to FERC supplemental information requests on project economics

Prepare Exhibits for presentation at FERC Hearings

Task Number: 6

Task: FERC License Support

OUTPUT

Management Output

Coordinate responses and support to Power Authority during FERC License Review Period

Environmental, Geotechnical and Energy Planning Output

Memos, Exhibits, and presentations as required to support Power Authority during FERC License Review

Task Number: 7

Task: Electric Power Systems Studies

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule for Tasks and Subtasks

Initiate work

Electrical Engineering Subtasks

To carry out complete electric power system studies including; load flow, transient stability, fault current (i.e. short circuit), and transient network analysis (TNA). Work will assure that the initial Watana project and later Devel's Canyon Projects will be compatible with the operation of the projects together with the initial planned Anchorage-Fairbanks transmission interconnection as well as other planned power system facilities in the Rail belt area.

Prepare Data Base for Electric Power System
Make Load Flow Calculations
Make Transient Stability Calculations
Calculate System Impedance Equivalents for use with TNA Study
Carry out TNA Studies
Short Circuit Calculations
Prepare Report of Electrical Power System Studies

Mechanical Engineering Subtasks

Assemble information on turbine and governor characteristics at other generating facilities in the system as well as at Watana and Devil's Canyon

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 7

Task: Electric Power Systems Studies

OUTPUT

Management Output

Input to Monthly Progress Report on status of Task with respect to schedule and budget

Electrical Engineering Output

A report that includes results and recommendations with respect to
Transient Network Analysis Studies (TNA)
- Set Basic Impulse Insulation Level (BIL)
- Set Basic Switching Surge Level (BSL)
- Insulation Coordination
- Determine Surge Arrester Rating
- Determine Transient and sustained voltage conditions at power plant substations
- Investigate Ferro Resonance Conditions taking into account saturation characteristics of Generator Step-up Transformers
- Verify need for resistors in high voltage circuit breakers for opening and closing operation
- Analysis of switching surge levels and transient voltage conditions for underground powerhouse high voltage cables.

Transient Stability Studies
- Determine limits of machine inertia relative to power system stability
- Verify generator and generator step-up transformer reactance limits.
- Verify application of generator excitation and speed governor characteristics
- Provide input to hydraulic studies relative to power system
- Determine circuit breaker reclosing requirements

Short Circuit Studies
- Provide equivalent impedance values for TNA studies
- Determine circuit breaker interrupting ratings
- Provide data base to calculate fault current levels required to determine relay requirements

Load Flow Studies

Determine power flow levels and plant voltage regulation requirements

Verify selection of machine power factor

Establish generator step-up transformer tap setting requirements

Provide data base for stability and TNA studies. In conjunction with reservoir operations studies, determine power system losses, and feasibility of various modes of hydro-thermal generation dispatch.

Mechanical Engineering Output

A memorandum that lists the turbine and governor characteristics of the generating plants included in the system studies

Task Number: 8

Task: Preparation and Participation in Power Authority's Public Information Meetings

SUBTASKS

Management Subtasks

Jointly with Power Authority schedule series of Public Information Meetings

Prepare plan of meetings, agenda of meetings and recommend participants for Power Authority Approval

Coordinate the preparation of necessary graphics, visual aids as well as participation of JV personnel, subcontractor personnel and outside consultants

Architectural, Civil, Electrical, Environmental, Geotechnical, Hydraulic, Hydrology, Mechanical disciplines of JV participate as required and prepare material for presentation to by Power Authority public in meetings

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 8

Task: Preparation and Participation in Power Authority's Public Information Meetings

OUTPUT

Exhibits, memos, brochures and reports to Public

Task Number: 9

Task: Preparation and Participation in Power Authority's External Review Panel Meetings and Governmental Agency Review Meetings

SUBTASKS

Management Subtasks

Jointly with Power Authority schedule meeting with Power Authority's External Review Panel.

Prepare agenda, collect supply necessary information in advance of meeting for dissemination by participants

Prepare Minutes of the meeting

Coordinate the preparation of necessary graphics, visual aids as well as participation of JV personnel, subcontractor personnel and outside consultants

Internal Review Panel

Preparation and participation in meetings as required.

Architectural, Civil, Electrical, Environmental Geotechnical, Hydraulic, Hydrology, Mechanical Disciplines Disciplines - preparation, participation and support to APA and JV Management as required for meetings.

Prepare material for support of JV Management and Internal Review Panel in meetings with Power Authority's External Review Panel

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 9

Task: Preparation and Participation in Power Authority's External Review Panel Meetings and Governmental Agency Review Meetings Review Panel Meetings

OUTPUT

Management Output

Exhibits, memos and reports

Task Number: 10

Task: Contract Document C-1
Diversion Tunnel and Facilities

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule for Task and Subtasks
Initiate work

Civil Engineering Subtasks

Prepare design memo
Prepare technical specifications
Perform structural analysis and design of all project features
Prepare contract/construction drawings
Coordinate and review drawings from other disciplines
Prepare quantity take offs for the engineers estimate
Review manufacturers drawings and computations

Electrical Engineering Subtasks

Prepare drawings of embedded electrical work features
Prepare technical specification
Prepare cost estimate

Geotechnical Engineering and Geology Subtasks

Study geotechnical data pertinent to the tunnels and tunnel portals
Select design criteria
Establish portal geometry and support
Determine tunnel support requirements
Establish instrumentation system
Prepare design memo on excavation and support
Prepare contract documents
- Collate and index geotechnical data
- Prepare data volume
- Prepare boring location map
- Prepare contract drawings
  - Portals, 2 sheets
  - Tunnel, 1 sheet
- Prepare technical specification sections

Prepare procedures for inspection

Task Number: 10
SUBTASKS
Page 2

Mechanical Engineering Subtasks

Provisions for diversion gate hoist
Embedded portions of diversion gate (include associated details for installation) Dwg. preparation
Preliminary studies for emergency release gates (including associated details for release/hydraulic studies/operation)
Provisions for mechanical equipment and operators and associated space allocations
Preparation of specifications for embedded components

Hydraulic Engineering Subtasks

Diversion
Prepare hydraulic design memo
Compute tailwater at tunnel outlets
Consider ice passage and ice control requirement during diversion
Compare relative costs for alternatives
Select optimum
Finalize tunnel setting and design water profiles, and pressures.
Finalize intake structure water passage dimensions
Finalize outlet structure water passage dimensions

Support Services Subtasks

Develop standard conditions of bidding and construction contracts to carry through remainder of C-contracts
Make quantity take-off, develop detailed bases for cost estimating and prepare engineer's estimate
Prepare construction schedule for Contract C-1
Edit, word process and revise, as necessary specification technical sections and bid forms; reproduce and bind
Provide constructability review of technical specifications witten by the design department
Assist with bidding and award: bidder prequalification, isue of documents, jobsite pre-bid meeting, bid receipt and recording, bid evaluation and letter of recommendation
Prepare addenda as necessary

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 10

Task: Contract Document C-1
Diversion Tunnel and Facilities

OUTPUT

Management Output

Contract Document C-1
Contract Award

Civil Engineering Output

Design memo diversion tunnel structural design
Technical specifications
Steel liner
Metalwork
Civil/structural computations
Contract/construction drawings
Quantity take off of civil items
Review of manufacturers drawings and computations for steel liner and metalwork
Drawings
Index
Project Location Map
Vicinity Plan
General Project Layout
Climatological Data
Hydrological information
Standard Details - Sheets 1-5
Diversion Tunnel - Sheets 1-4
Emergency Releases Features - Sheets 1-4
Access Tunnel and Portal - Conc. and Reinf. - Sheets 1 and 2
Intake Excavation - Sheets 1 and 2
Intake No. 1 & 2 - Geometry - Sheets 1 and 2
Intake No. 1 & 2 - Conc. & Reinf. - Sheets 1-5
Intake Hoist Structure Housing - Sheets 1 and 2
Diversion Intake Yard
Diversion Outlet Portal Excavation
Diversion Outlet Portal - Tunnel No. 1 & 2 - Conc. & Reinf. - Sheets 1-3
Diversion Portal Yard

Electrical Engineering Output

Drawings
Conduit and Grounding Sheets 1 and 2

Specification text sections
- Conduit
- Grounding
- Miscellaneous Work

Cost estimate

Geotechnical Engineering and Geology Output

Design Memos
- Diversion Tunnel Excavation and Support

Contract Documents
- Technical Specifications Sections on
  - Diversion and Care of Water
  - Clearing, Grubbing and Stripping
  - Open Excavation
  - Restoration
  - Underground Excavation
  - Excavation Support
  - Drilling and Grouting
  - Instrumentation
- Geotechnical Data Volume
- Contract Drawings

Manual of Inspection Procedures

Mechanical Engineering Output

Two contract/construction drawings for embedded items
One general section of specification for embedded materials

Hydraulic Engineering Output

Hydraulic design memo
Memos
Hydraulic Geometry
Headwater and Tailwater Rating Curves for documents

Support Services Output

Contract Documents C-1
Engineer's estimate
Letter of recommendation for award

Task Number: 11

Task: Contract Document C-2 - Main Dam I Excavation of Abutments, Drainage and Grouting Access Tunnels; Drilling and Grouting Inside Galleries

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedules for Task and subtasks

Initiate Work

Civil Engineering Subtasks

Provide assistance as required to geotechnical

Geotechnical Engineering Subtasks

Study and evaluate pertinent geotechnical data

Select geotechnical design parameters

Establish criteria for abutment excavation
under shells
under core and filters

Establish criteria for the grout curtain

Establish criteria for the drainage curtain

Study and select the layout for grouting, drainage, and access galleries

Analyze the methods and procedures to thaw ground ice in advance of grouting

Model the effects of the reservoir on the permafrost in the dam abutments and foundation

Establish the foundation instrumentation system

Prepare reports
Methods and procedure to thaw ground ice in advance of grouting
Reservoir effects on the permafrost in the dam abutments and foundation

Prepare Design Memo
Dam, Foundation Treatment

Prepare Contract Document
collate and index geotechnical data

prepare data volume

prepare data location map

prepare contract drawings

prepare technical specs.

Prepare construction inspection procedures

Mechanical Engineering Subtasks

Review and coordinate civil contract for associated mechanical equipment sizing/layout/arrangement

Provisions for gallery drainage (including associated details necessary during preparation of civil drawings)

Provisions for gallery ventilation (including associated details necessary during preparation of civil drawings)

Prepare Design memos covering drainage and grouting access tunnel ventilation and drainage pumping system

Support Services Subtasks

Revise conditions of contract to fit specific contact

Make quantity take-off develop detailed bases for cost estimating, prepare engineer's estimate

Prepare detailed construction schedule

Prepare drafts and final documents for issue, prepare agenda

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 11

Task: Contract Document C-2 - Main Dam I Excavation of Abutments, Drainage and Grouting Access Tunnels; Drilling and Grouting Inside Galleries

OUTPUT

Management Output

- Contract document C-2
- Contract Award

Civil Engineering Output

- Sketches of pumping stations and portal structures

Geotechnical Engineering Output

- Report on Methods and Procedure to Thaw Ground Ice in Advance of Grouting
- Report on Reservoir Effects on the Permafrost in the Dam, Abutments and Foundation
- Design Memo on Dam Foundation Treatment
- Contract Documents
  - Technical Specifications Sections on
    - Open Excavation
    - Underground Excavation
    - Excavation Support
    - Drilling and Grouting
    - Instrumentation
  - Geotechnical Data Volume
  - Contract Drawings
    - Index
    - Project Location Map
    - Vicinity Plan
    - General Project Layout
    - Climatological Data
    - Hydrological Information
    - Foundation Excavation Sheets 1 and 2
    - Galleries Sheets 1-4
    - Grouting and Drainage Sheets 1-4
    - Instrumentation Sheets 1-4
- Construction Control Memos on
  - Foundation Treatment
  - Instrumentation
  - Excavation and Support

Task Number: 11
<u>OUTPUT</u>
Page 2

Mechanical Engineering Output

Prepare Design memos covering drainage and ventilation for Main Dam grouting and drainage tunnel

Provide sketches for use in preparation of civil/geotechnical drawings.

Review civil/geotechnical drawings for mechanical equipment and specifications

Support Services Output

Contract Documents
Engineer's Estimate

Task Number: 12

Task: Contract Document C-3 - Main Dam II

SUBTASKS

Management Subtasks

Issue and control manpower budgets and scheduling for Task and subtasks

Initiate work

Geotechnical Engineering and Geology Subtasks

Study and evaluate pertinent geotechnical data
Select geotechnical design parameters
Establish criteria for cofferdams
- sources and characteristics of materials
- internal and external geometry
- seepage control and dewatering
- stability
- constructability

Establish criteria for dam excavation in valley floor
Establish criteria for rock treatment
- in contact with dam shells
- in contact with core and filters

Finalize dam geometry
- core
- filter zones
- shells

Evaluate material sources and characteristics
- volume available
- homogeneity
- properties

Select material parameters for design

- Design filter and drain gradations
- Determine placement, moisture and compaction requirements for materials
- Establish the instrumentation system
- Prepare design memos
  - cofferdam
  - dam, excavation and foundation treatment
- Prepare Contract Document
  - collate and index geotechnical data
  - prepare data volume
  - prepare data loc. map

Task Number: 12
SUBTASKS
Page 2

prepare contract drawings
prepare technical specs
Prepare construction inspection procedures

Hydraulic Engineering Subtasks

Alternative Dam Cross-Sections
Pore Pressure Gradients
Alternative Foundation Treatment
Foundation Pressure Gradients

Support Services Subtasks

Revise conditions of contract to fit specific contract
Make quantity take-off, develop detailed bases for cost estimating, prepare engineer's estimate
Prepare detailed construction schedule
Prepare drafts and final documents for issue
Prepare addenda

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

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Task Number: 12

Task: Contract Document C-3 - Main Dam II

OUTPUT

Management Output

Contract Documents C-3
Contract Award

Geotechnical Engineering and Geology Output

Design Memos
- Dam Excavation and Rock Surface Treatment
- Cofferdams
- Dam, Material Characteristics
- Dam, Cross Section, Zoning and Details

Contract Documents
- Technical Specification Sections on
  - Diversion and Care of Water
  - Clearing, Grubbing and Stripping
  - Open Excavation
  - Restoration
  - Excavation Support
  - Drilling and Grouting Fills
  - Instrumentation
- Geotechnical Data Volume
- Contract Drawings
  - Cofferdams Sheets 1-3
  - Excavation and Foundation Treatment Sheets 1 and 2
  - Dam Sheets 1-3
  - Instrumentation Sheets 1 and 2
- Construction Control Memos on
  - Foundation Treatment
  - Fills
  - Instrumentation

Hydraulic Engineering Output

Memo and sketches

Support Services

Contract Documents
Engineer's Estimate
Letter of Recommendation Award

Task Number: 13

Task: Contract Document C-4, Main Spillway Excavation Foundation Treatment, Drainage Gallery

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedules for Task and subtasks

Initiate work

Civil Engineering Subtasks

Coordinate work between preparation of concrete outline drawings and excavation drawings
Interface with Contract C-9

Assist in drainage gallery location design

Geotechnical Engineering and Geology Subtasks

- Study and evaluate pertinent geotechnical data
- Select geotechnical design parameters
- Finalize excavation geometry
  - approach channel
  - spillway headworks and chute
  - tailrace channel
- Establish cut slopes
  - temporary
  - permanent
- Establish criteria for cut slope support
- Establish criteria for foundation treatment
  - galleries
  - grouting
  - drainage
- Establish the instrumentation system
- Prepare design memos
  - Main Spillway, Excavation and Foundation Support
- Prepare Contract Document
  - collate and index geotechnical data
  - prepare data volume
  - prepare data loc. map
  - prepare contract drawings
- Prepare construction inspection procedures

Task Number: 13
SUBTASKS
Page 2

Hydraulic Engineering Subtasks

Begin Hydraulic Design Memo
Establish alignment with downstream plunge pool
Develop spillway profile considering geology and topography
Develop approach channel alignment and dimensions
Begin Model Test Program

Support Services Subtasks

Revise conditions of contract to fit specific contract
Make quantity take-off develop detailed bases for cost estimating, prepare engineer's estimate
Prepare detailed construction schedule
Prepare drafts and final documents for issue
Prepare Addenda

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 13

Task: Contract Document C-4, Main Spillway Excavation, Foundation Treatment, Drainage Gallery

OUTPUT

Management Output

- Contract Document C-4
- Contract Award

Civil Engineering Output

- Review of excavation drawings, sketches and design computations for drainage gallery location and interface with Contract C-9

Geotechnical Engineering and Geology Output

- Design Memos
  - Main Spillway, Excavation and Foundation Treatment
- Contract Documents
  - Technical Specifications on
    - Diversion and Care of Water
    - Clearing Grubbing and Stripping
    - Open Excavation
    - Underground Excavation
    - Excavation Support
    - Drilling and Grouting
    - Instrumentation
  - Geotechnical Data Volume
  - Contract Drawings
    - Spillway Excavation Sheets 1-3
    - Spillway Foundation Treatment Sheets 1-3
- Construction Control Memos on
  - Excavation and Support
  - Foundation Treatment
  - Instrumentation

Hydraulic Engineering Output

- Hydraulic Design Memo
- Model Program
- Alignment and Profile for Contract Documents

Task Number: 14

Task: Contract Document C-5 Outlet Facilities.
Outlet Facilities: Tunnel Excavation, Concrete and Furnish and Install Steel Tunnel Liner (only up to the point where conduits enter the Discharge Valve House)

SUBTASKS

Management Subtask

Issue and control manpower budgets and schedule for Task and subtasks

Civil Engineering Subtasks

Prepare design memos

Prepare technical specifications

Perform structural analysis and design of all project features

Prepare contract/construction drawings

Coordinate and review drawings from other disciplines

Prepare quantity take-offs for the engineer's estimate

Review manufacturers' drawings and computations

Electrical Engineering Subtasks

Prepare drawings of embedded electrical work features
Prepare technical specification
Prepare cost estimate

Geotechnical Engineering and Geology Subtasks

Study and evaluate geotechnical data
Select geotechnical design parameters
Establish portal geometry and support
Determine tunnel support requirements
Establish criteria for tunnel grouting
Establish the instrumentation system
Prepare design memo
Outlet facilities, Excavation and Support

Task Number: 14
SUBTASKS
Page 2

Prepare contract documents
- collate and index geotechnical data
- prepare data volume
- prepare contract drawings
- prepare technical specifications

Mechanical Engineering Subtasks

Studies for provisions for Outlet Facilities Intake Gate Hoist Structure and Equipment

Drawing preparation of Outlet Facilities Intake Gates Embedded portions including associated details for installation

Coordination of Hydraulic studies for Outlet Facilities conduit sizing and Hydraulic studies for Outlet Facilities Intake Gate and Discharge Valve sizing (Preliminary Studies)

Hydraulic Engineering Subtasks

Prepare Hydraulic Design Memo
Compute Head Losses
Compute Discharge Ratings for Valves
Check Tailrace Protective Works for Valve Discharge
Transient Tunnel Pressures Based on Valve Operation
Tunnel Pressure and Gate Loading for Emergency Closure of Intake Gate

Support Services Subtasks

Revise conditions of contract to fit specific contract

Make quantity take-off, develop detailed bases for cost estimating, prepare engineer's estimate

Prepare detailed construction schedule

Prepare drafts and final documents for issue, prepare agenda

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 14

Task: Contract Document C-5 Outlet Facilities.
Outlet Facilities: Tunnel Excavation, Concrete and Furnish and Install Steel Tunnel Liner (only up to the point where conduits enter the Discharge Valve House)

OUTPUT

Management Output

Contract Document C-5
Contract Award

Civil Engineering Output

Design Memo
Outlet Facilities structural design

Technical Specifications
Steel liner
Metalwork
Architectural

Civil/Structural computations

Quantity take-off of civil and architectural items

Review of manufacturers' drawings and computations

Contract Construction Drawings

Index
Project Location Map
Vicinity Plan
General Project Layout
Climatological Data
Hydrological Information
Standard Details Sheets 1-5
Outlet Facilities - General Layout
Outlet Facilities - Concrete and Reinforcement Sheets 1-3
Gate Structure - Excavation Sheets 1 and 2
Gate Structure Yard
Gate Structure - Conc. & Reinf. Sheets 1-7
Gate Hoist Tower Structure Sheets 1 and 2
Outlet Manifold & Valve
Chambers - General Layout

Task Number: 14

Task: Contract Document C-5 Outlet Facilities.
Outlet Facilities: Tunnel Excavation, Concrete and Furnish and Install Steel Tunnel Liner (only up to the point where conduits enter the Discharge Valve House)

OUTPUT

Management Output

Contract Document C-5
Contract Award

Civil Engineering Output

Design Memo
Outlet Facilities structural design

Technical Specifications
Steel liner
Metalwork
Architectural

Civil/Structural computations

Quantity take-off of civil and architectural items

Review of manufacturers' drawings and computations

Contract Construction Drawings

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Project Location Map
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General Project Layout
Climatological Data
Hydrological Information
Standard Details Sheets 1-5
Outlet Facilities - General Layout
Outlet Facilities - Concrete and Reinforcement Sheets 1-3
Gate Structure - Excavation Sheets 1 and 2
Gate Structure Yard
Gate Structure - Conc. & Reinf. Sheets 1-7
Gate Hoist Tower Structure Sheets 1 and 2
Outlet Manifold & Valve
Chambers - General Layout

- Outlet Manifold & Valve Chambers - General Layout
- Details - Conc. & Reinf. Sheets 1-3
- Architectural Enclosure Plan Elevation & Details

Electrical Engineering Output

- Conduit and grounding drawings Sheets 1 and 2
- Specification text sections on conduit, grounding and miscellaneous work
- Cost estimate

Geotechnical Engineering and Geology Output

- <u>Design Memo</u>
  - Outlet Facilities, Excavation and Support
- <u>Contract Documents</u>
  - <u>Technical Specifications</u>
  - Clearing, Grubbing and Stripping
  - Open Excavation
  - Underground Excavation
  - Excavation Support
  - Concrete Reinforcement
  - Instrumentation
  - <u>Geotechnical Data Volume</u>
  - Contract Construction Drawings
    - Portal Excavation
    - Tunnel Excavation
- Construction Control Memos on
  - Excavation and Support
  - Instrumentation

Mechanical Engineering Output

- Two Contract/Construction Drawings for Embedded Components:
  - Drawing List - Mechanical
  - M1 Outlet Facilities Intake Gates Embedded Parts: Plan & Sections
  - M2 Outlet Facilities Intake Gates Embedded Parts: Details
- One general section of specifications for embedded items

Hydraulic Engineering Output

Hydraulic Design Memo
Hydraulic Geometry

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation of Award
Expedite contractor shop drawings
Expedite design department's review and approval of Contractor's submittals
Prepare regular status report of all contractors submittals

Task Number: 15

Task: Contract Document C-6 - Power Facilities & Access Tunnels to Power Facilities, Excavation and Concrete Structures, Diversion Tunnel Plugs, Furnish and Install Steel Penstock Liners and Steel Conduits in Tunnel No. 1 Plugs, Mass Concrete in Powerhouse, Transformer Gallery, and Surge Chamber

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule for Task and subtasks

Initiate work

Civil Engineering Subtasks

Prepare design memos
Prepare technical specifications
Perform structural analysis and design of all project features
Prepare contract/construction drawings
Coordinate and review drawings from other disciplines
Prepare quantity take-offs for the engineer's estimate
Review manufacturers' drawings and computations

Electrical Engineering Subtasks

Provide equipment layouts
Prepare drawings of embedded elec. work features
Prepare technical specification
Prepare cost estimate
Perform technical and economic evaluation of SF-6 bus configuration compared with oil pipe type cable for powerhouse-to-switchyard high voltage connections

Geotechnical Engineering and Geology Subtasks

Study and evaluate geotechnical data
Select geotechnical design parameters
Evaluate chamber/tunnel orientation and geometry
Study stress and deformation in rock surrounding main chambers
Study pillar requirements between draft tube excavations
Study stress patterns in rock surrounding main intersections

- Evaluate support systems for chambers and tunnels
- Evaluate effects of permafrost if present
- Establish grouting and drainage systems
- Establish the instrumentation system
- Prepare Contract Document
  - collate and index geotechnical data
  - prepare data volume
  - prepare data loc. maps
  - prepare contract drawings
- Prepare technical specs.
- Prepare report on "Anticipated deformations of Rock during Excavation"
- Prepare construction inspection procedures

Mechanical Engineering Subtasks

- Review and coordinate civil contract for associated mechanical equipment size/layout/arrangement
- Drawing preparation for embedded portions of Power Intake Gates (including associated details for installation)
- Studies for provisions for Power Intake Gate Crane structure and equipment
- Powerhouse Mechanical system Studies
- Surge chamber mechanical system studies
- Drawing preparation for embedded portions of major piping (included associated details for installation)
- Coordination for work done under Task 21
- Drawing preparation for embedded portions of Emergency Release Gates (including details for installation)
- Prepare mechanical system design memos from which drawings and specs will be prepared from under Task 21

Hydraulic Engineering Subtasks

Hydraulic Design Memo for power operation
Hydraulic Design Memo for emergency outlet
Maximum and Minimum internal tunnel pressures for range of specified governor times
Detail head loss computations
Input turbine characteristics for computer turbine operation transients
Final tailwater studies for unit setting
Determine final tail-tunnel surge levels
Intake gate closure for gate loads and tunnel pressures
Finalize Emergency Outlet gate sizes
Compute final Emergency Outlet discharge ratings
Compute Emergency Outlet water profiles in tunnel
Compute Emergency Outlet air vent requirements
Finalize Emergency Outlet structure
Prepare Emergency Outlet Model Program
Monitor Emergency Outlet Model Program
Coordinate required revision to design
Review model report

Support Services Subtasks

Revise conditions of contract to fit specific contract
Make quantity take-off, develop detailed bases for cost estimating, prepare engineer's estimate
Prepare detailed construction schedule
Prepare drafts and final documents for issue
Prepare Addenda

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 15

Task: Contract Document C-6 - Power Facilities & Access Tunnels to Power Facilities, Excavation and Concrete Structures, Diversion Tunnel Plugs, Furnish and Install Steel Penstock Liners and Steel Conduits in Tunnel No. 1 Plugs, Mass Concrete in Powerhouse, Transformer Gallery, and Surge Chamber

OUTPUT

Management Output

Contract Document C-6

Contract Award

Civil Engineering Output

Design Memos
General Design Criteria
Powerhouse General Arrangement and Structural Design
Power Intake, Tunnel, Tailrace and Surge Chamber Structural Design
Penstock and Steel Liner
Power Facilities Architectural Design
Technical Specifications
- Penstock and Steel Liners
- Metalwork
- Architectural

Civil/Structural computations
Contract/Construction drawings (see attached drawing list)
Quantity take-off of civil and architectural items
Review of manufacturers' drawings and computations

Civil/Structural Drawings
Index
Project Location Map
Vicinity Plan
General Project Layout
Climatological Data
Hydrological Information
Standard Details, Sheets 1-5
General Layout and Power Tunnel Details, Sheets 1-4
Intake General Arrangement, Sheets 1-3
Intake - Cond. & Reinforcement, Sheets 1-9
Intake - Superstructure, Sheets 1-4
Power Facilities General Layout, Sheets 1 and 2
Powerhouse General Arrangement, Sheets 1-5

Task Number: 15
OUTPUT
Page 2

Powerhouse Excavation, Sheets 1 and 2
Powerhouse - Layout, Sheets 1-6
Powerhouse - Concrete (Plans, Sections & Details from Draft Tube to El. 1463.0), Sheets 1-20
Powerhouse - Reinforcement (Overlay to Concrete Dwg.), Sheets 1-20
Service Bay & Battery Room Gallery - Concrete & Reinforcement, Sheets 1-5
Access Shaft Conc. & Reinforcement, Sheets 1 and 2
Powerhouse Access Tunnel & Portal, Sheets 1-3
Transformer Gallery - Concrete & Reinforcement, Sheets 1-6
Tailrace Tunnels - Concrete & Reinforcement, Sheets 1-4
Surge Chamber - Concrete & Reinforcement Sheets 1-5

Architectural

Intake Enclosure, Sheets 1 and 2
Powerhouse, Sheets 1-7

Electrical Engineering Output

Electrical Drawings
Conduit and Grounding: Intake - Sheets 1 and 2
Conduit and Grounding: Powerhouse Sheets 1 and 2
Conduit and Grounding: Generator/Erection Bay Gallery
Conduit and Grounding: Transformer Gallery Sheets 1 and 2
Conduit and Grounding: Surge Chamber Sheets 1 and 2

Specification text sections: Conduit
Grounding
Miscellaneous

Summary report - SF-6 Bus Versus
Oil-Pipe-Type Cable

Geotechnical Engineering and Geology Output

Design Memo
Power Facilities and Access, Excavation and Support

Contract Documents
- Technical Specifications
- Diversion and Care of Water
- Clearing, Grubbing and Stripping
- Open Excavation
- Underground Excavation
- Restoration
- Excavation Support
- Drilling and Grouting
- Instrumentation
- Geotechnical Data Volume
- Contract Drawings
  - Powerhouse Excavation Sheets 1 and 2
  - Powerhouse Access Tunnel Excavation
  - Tailrace Tunnels
  - Surge Chamber Excavation
  - Powerhouse Excavation Support Sheets 1 and 2
  - Tunnel Excavation Support
  - Surge Chamber Excavation Support

Construction Control Memos
- Excavation and Support
- Instrumentation
- Foundation Treatment

Report on "Anticipated deformations of rock during Excavations"

Mechanical Engineering Output

Provide sketches of embedded piping for use in preparation of civil drawings

Mechanical system design memoranda & studies

List of Mechanical Drawings
- General Mechanical (Piping Standards)
- Draft Tube Depression System
- Unit Unwatering and Filling System
- Station Drainage
- Sewage Treatment
- Raw and Cooling Water Systems
- Treated Water System
- Oil Systems
- Fire Protection Systems
- Penstock Filling System
- Machine Shop Equipment
- Piezometers and Water Level Gauges
- Heating, Ventilating and Air Conditioning Systems
- Compressed Air Systems
- Powerhouse Crane

Task Number: 15
OUTPUT
Page 4

Intake Crane
Draft Tube Crane
Intake Gates and Hoists
Draft Tube Gates
Trashracks

12 contract/construction drawings for embedded items (for gate equipment)

List of Mechanical Embedded Items Drawings

Intake Gates and Hoists, Sheets 1 and 2
Intake Bulkhead
Intake Shutter Gate
Intake Trashracks
Intake Ice Boom
Power Intake Cranes
Diversion Closure Gate Hoists and Sheets 1 and 2
Emergency Release Facilities Trashrack
Emergency Release Gates & Hoists, Sheets 1 and 2

3 general sections of specifications for embedded items:

List of Specifications

Intake Gates, Bulkhead, Trashrack and Ice Boom
Diversion Closure Gate and Emergency Release Equipment
Embedded Piping

Hydraulic Engineering Output

Hydraulic Design
Model Program for emergency release
Model Report
Hydraulic Geometry

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation for Award
Report of Status of Contractors Drawing Submittal

Task Number: 16

Task: Contract Document C-7 Main Dam III
Embankment to Elevation 2210, Plus Relict Channel
Excavation and Embankment, Emergency Spillway Excavation,
Fuse Plug and Switchyard Excavation

SUBTASKS

Civil Engineering Subtasks of Spillway, Intakes (Power and Outlet Facilities)
- Coordinate Work with dam embankment design

Geotechnical Engineering and Geology Subtasks

- Study and evaluate pertinent geotechnical data

- Select geotechnical design parameters

- Evaluate material sources and characteristics
  - lessons learned from Contract C-3
  - volume available
  - homogeneity
  - properties

- Select material parameters

- Perform seepage analyses
  - dam
  - foundations

- Perform stress, deformation and stability analyses
  - during construction
  - with full pool
  - during flood
  - during drawdown

- Perform dynamic stress, deformation and stability analyses
  - select seismic design parameters
  - select dynamic soil properties
  - input static stress conditions
  - perform dynamic response analysis

Determine the earthquake effects on the dam

Establish the defense measures to mitigate the effects of earthquake

Evaluate constructability of the dam
- Evaluate use of material from various borrow or quarry sources
- Evaluate use of required excavations
- Evaluate schedule for construction

Finalize crest details, freeboard and slope protection

Finalize internal geometry and zoning

Review placement, moisture and compactions requirements for materials based on Contract C-3 experience

Review selection of filter and drain gradation

Establish the instrumentation system

Determine bedrock configuration in relict channels
- Watana channels
- Fog Lakes

Identify geologic processes and study

Establish hydrogeologic regime and estimate permeability of strata

Estimate strength characteristics of relict channel materials based on standard penetration and core penetrometer tests

Determine the extent of permafrost and temperature regime and relict channels

Perform seepage analyses
- Develop computer and hand models
- Perform parametric analysis
- Determine need for treatment

Perform stability analysis of relict channels for
- upstream slopes
  - reservoir fill
  - reservoir drawdown
  - under earthquakes (liquefaction analysis)
- downstream slopes

Perform thermal analysis of relict channel materials to determine
- thaw effects of the reservoir
- thaw - settlement

Develop design concepts to mitigate the effects of seepage, earthquake and thaw
- establish use of filter blanket
- cutoffs
- drain curtains
- underground dam

Establish design criteria for the freeboard dike

Verify previously established design criteria and material requirements

Finalize excavation geometry for the emergency spillway
- approach channel
- spillway

Establish criteria for cut slopes and support

Establish criteria for foundation treatment, emergency spillway
- grouting
- drainage

Analysis of Reservoir Slopes
- Determine composition and competence of reservoir slopes
- Evaluate exostomg stability of slopes
- Determine the effects of the reservoir under a full pool and under drawdown
- Determine the effects of earthquakes
- Estimate the volume of potential slides
- Determine the size of waves generated by reservoir slides

- Determine the effects of reservoir slides on the dam, spillways, and intakes
- Establish design criteria and concepts to mitigate the effects of reservoir slides
- Establish design criteria for fuse plug

Prepare reports

- Seepage through the dam and its foundation
- Static stresses and deformations within the dam during construction and project operation
- Seismic design parameters
- Dynamic stresses and deformations during earthquake
- Hydrology and Potential for Leakage through Relict Channels
- Stability of Relict Channel slopes

- Thaw of permafrost in Relict Channels and Resulting Effects
- Design Concepts for Relict Channel Treatment
- Reservoir Slides, Size, Effects and Mitigating Features

Prepare design memos

- Relict Channels, Characteristics of Glacial De_ -sits
- Relict Channel Treatment
- Freeboard Dike
- Emergency Spillway, Foundation Treatment
- Fuse Plug

Prepare contract, documents

- Collate and index geotechnical data
- Prepare data volume
- Prepare data location maps, 4 sheets

Prepare contract drawings

Dam, zoning and details,	7 sheets
Foundation treatment,	3 sheets
Instrumentation,	4 sheets

Prepare technical specifications

Relict channel treatment	6 sheets
Freeboard dike	1 sheet
Emergency Spillway foundation treatment and excavation	3 sheets
Fuse plug	1 sheet

Task Number: 16
SUBTASKS
Page 5

Prepare construction inspection procedures

Hydraulic Engineering Subtasks

Freeboard Design Memo
Freeboard Design Studies

Support Services Subtasks

Make quantity take-off, develop detailed bases for cost estimating, prepare engineer's estimate

Prepare detailed construction schedule

Prepare drafts and final documents for issue, prepare agenda

Environmental Science Subtasks

NOTE: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 16

Task: Contract Document C-7 Main Dam III
Embankment to Elevation 2210, Plus Relict Channel
Excavation and Embankment, Emergency Spillway Excavation,
Fuse Plug and Switchyard Excavation

<u>OUTPUT</u>

Civil Engineering Output

Coordination of Main Dam with Spillway, Intake, and Emergency Spillway Interfaces.

Geotechnical Engineering and Geology Output

<u>Design Memos</u>

Relict Channels, Characteristics of Glacial Deposits
Relict Channel Treatment
Freeboard Dike
Emergency Spillway, Foundation Treatment
Fuse Plug

<u>Contract Documents</u>
<u>Technical Specifications</u>

Diversion and Care of Water
Clearing, Grubbing and Stripping
Open Excavation
Excavation Support
Drilling and Grouting
Fills
Instrumentation

<u>Geotechnical Data Volume</u>
<u>Contract Drawings</u>

Dam	Sheets 1-7
Foundation Treatment	Sheets 1-3
Instrumentation	Sheets 1-4
Relict Channel Treatment	Sheets 1-6
Emergency spillway foundation treatment and excavation	Sheets 1-3
Fuse Plug	

Construction Control Memos

Excavation and Support
Foundation Treatment
Fills
Instrumentation

Reports

Seepage through the dam and its foundation
Static stresses and deformations within the dam during construction and project operation
Seismic design parameters
Dynamic stresses and deformations during earthquake
Hydrology and potential for leakage through relict channels
Stability of relict channel slopes
Thaw of permafrost in relict channel treatment
Reservoir slides, size, effects and mitigating features

Hydraulic Engineering Output

Freeboard Design Memo
Memo and Sketches

Support Services Output

Contract Documents
Engineers Estimate

Environmental Science Output

Environmental input to Specifications

Task Number: 17

Task: Contract Document C-8 - Aggregates & Concrete Production

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Establish concrete strength requirements

Geotechnical Engineering and Geology Subtasks

Study and evaluate pertinent geotechnical data regarding the use of various borrow or quarry sources for aggregate
Design Memo
    Aggregate for Concrete
Prepare Contract Document
    Collate and index geotechnical data
    Prepare data volume
    Prepare data location maps, 3 sheets
Prepare construction control procedures

Support Services Subtasks

Establish production rates for aggregates and concrete production
Revise conditions of contract to fit specific contract
Make quantity take-off, develop detailed bases for cost estimating, prepare engineer's estimate
Prepare drafts and final documents for issue
Prepare addenda

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 17

Task: Contract Document C-8 - Aggregates & Concrete Production

OUTPUT

Management Output

Contract Document E-8

Contract Award

Civil Engineering Output

Memo on concrete strength requirements

Geotechnical Engineering and Geology Output

Design Memo
Aggregates for Concrete, Filters and Drains

Contract Documents
Technical Specification on
Aggregates
Geotechnical Data Volume
Contract Drawings
Data location Plan Sheets 1-3
Construction Control Memo on
Aggregates for Concrete,
Filters and Drains

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation for Award

Task Number: 18

Task: Contract Document C-9
Main Spillway, Concrete
Structures including Outlet
Works Discharge Valve House

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Prepare design memos

Prepare technical specifications

Perform structural analysis and design of all project features

Prepare contract/construction drawings

Coordinate and review drawings from other disciplines

Prepare quantity take-offs for the engineers estimate

Review manufacturers' drawings and computations

Electrical Engineering Subtasks

Prepare drawings of embedded electrical work features
Prepare technical specification
Prepare cost estimate

Geotechnical Engineering and Geology Subtasks

Review, drainage, grouting and anchorage details prepared by others

Review design memos, drawings and specifications

Mechanical Engineering Subtasks

Review and coordinate civil contract for associated mechanical equipment size/layout/arrangement

Prepare mechanical system design studies and memos for Outlet Facilities Valve House

Confirm Discharge Valve size

Prepare drawings for related mechanical equipment embedded items

Hydraulic Engineering Subtasks

Finish Hydraulic Design Memo on Spillway
Extend Tailwater to PMF Flow
Final Water and Pressure Profile
Cavitation Number Profile to Determine Aeration Requirements
Design Air Ramps
Prepare Model Program
Monitor Model Program
Co-ordinate Revision to Design Based on Model Results
Review Model Reports

Support Services Subtasks

Revise conditions of contract to fit specific contract

Make quantity take-off, develop detailed bases for cost estimating, prepare engineer's estimate

Prepare detailed construction schedule

Prepare drafts and final documents for issue, prepare agenda

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 18

Task: Contract Document C-9
Main Spillway, Concrete
Structures including Outlet
Works Discharge Valve House

OUTPUT

Management Output

Contract Document E-9

Contract Award

Civil Engineering Output

Design Memo
Spillway Structural Design
(Including Architectural portion of the Spillway
Control Structure)

Technical Specifications
Structural Steel
Metalwork
Architectural

Civil/Structural computations

Contract/Construction drawings

Index
Project Location Map
Vicinity Plan
General Project Layout
Climatological Data
Hydrological Information
Standard Details Sheets 1-5
Main Spillway (Plan & Profile)
Approach Wall & Apron - Concrete & Reinforcement
Spillway Ogee - Concrete & Reinforcement Sheets 1-7
Spillway Chute - Concrete & Reinforcement Sheets 1-15
Flip Bucket - Concrete & Reinforcement Sheets 1-5
Aeration Details Sheets 1 and 2
Spillway Hoist Housing Sheets 1 and 2
Architectural Enclosure Plan, Elevations & Data

Quantity take-off of civil and architectural items

Review of manufacturers' drawings and computations

Electrical Engineering Output

Drawings
Conduit and Groundings - Sheets 1 and 2
Text sections on conduit, grounding and miscellaneous work
Specification
Cost estimate

Mechanical Engineering Output

Preliminary Outlet Facilities Valve House Design Memo
One Contract/Construction Drawing for Embedded mechanical equipment Components related to Valve House
One General piping section of specifications for related embedded items

Hydraulic Engineering Output

Hydraulic Design Memo on Spillway
Memos
Model Program
Model Report
Hydraulic Geometry, Hydraulic Loads

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation for Award

Task Number: 19

Task: Contract Document C-10 - Completion Contract
(1) Second-stage concrete, all structures
(2) Supply and installation of Lighting, Heating, Ventilating and General Electrical Systems, including Switchyard and Emergency Diesel Generators
(3) Supply and installation of Piping and General Mechanical Systems and Gate Operator and Hoist Structures
(4) Supply and installation of Architectural Items
(5) Installation and testing of all Owner supplied Equipment
(6) Constructing Civil Works in Switchyard
(7) Painting and Other Surface Treatments
(8) Landscaping, Fencing, Project Cleanup
(9) Control Building

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Prepare design memos
Prepare technical specifications
Perform structural analysis and design of all project features
Prepare contract/construction drawings
Coordinate and review drawings from other disciplines
Prepare quantity take-offs for the engineer's estimate
Review manufacturers' drawings and computations
Prepare supplementary construction drawings for installation of owner furnished equipment in computer Contracts C-1, C-5, C-6, and C-10
Input to O&M manuals
Provide office assistance to field

Electrical Engineering Subtasks

Prepare General Electrical Design
Prepare Design Memoranda

Review design memoranda of other disciplines
Prepare Technical Specifications and Bid Forms
Prepare Electrical Drawings
Review Specifications of other disciplines
Review Drawings of other disciplines
Prepare cost estimate
Assist in bidding and Bid Evaluation
Review Shop drawings
Provide Office Assistance to Field
Provide Scheduling Assistance

Geotechnical Engineering and Geology Subtasks

Study and evaluate geotechnical data pertinent to switchyard foundation design
Select geotechnical design parameters
Establish foundation design
Prepare Design Memo
- Switchyard Foundation Design

Prepare Contract Document
- collate and index geotechnical data
- prepare data volume
- prepare data location map
- review drawings and specs

Mechanical Engineering Subtasks

C-10 (1)

Review and coordinate civil contract for associated mechanical equipment size/layout/arrangement
Review 2nd stage concrete civil drawings for turbine embedded components
Review 2nd stage concrete civil drawings for gate embedded components
Review 2nd stage concrete civil drawings for Miscellaneous Mechanical embedded items

C-10 (2)

Prepare HVAC contract/construction drawings for all project features
Prepare HVAC supply and installation specification for all project features
Prepare Diesel-Electric generator, contract/construction specifications

Prepare Diesel - Electric generator supply and installation specifications
Assist in bid evaluation
Review of manufacture prints/Prepare O&M Manual
Inspection and testing:Reports and trips

C-10 (3)

Prepare piping, general mechanical system, gate operator and gate hoist structures, contract/construction drawings for all project features

Prepare piping, general mechanical system, gate operator and gate hoist structures, supply and installation specification for all project features
Assist in bid evaluation
Review manufactures' prints/Prepare O&M Manual
Inspection and testing: Reports and trips

C-10 (4)

Review and coordinate architectural features as related to mechanical equipment
Review architectural supply and installation specs

C-10 (5)

Review and coordinate civil features as related to mechanical equipment
Prepare installation specifications for owner furnished mechanical equipment prepared under "E" contracts
Review other disciplines installation specification for owner furnished equipment as related to mechanical items
Supervision of testing of owner furnished installed mechanical equipment

C 10 (7)

Prepare paint specifications for mechanical equipment
Review manufacturer shop paint schedules

C-10 (9)

Evaluate and establish control building requirement as related to mechanical equipment (includes preliminary equipment sizing)

Task Number: 19
SUBTASKS
Page 4

Coordinate with other disciplines control building layout and arrangement as related to mechanical equipment
Prepare design memo outlining control building's mechanical systems and the basis of their design
Perform design studies to establish type and size of mechanical systems
Prepare mechanical equipment specifications and contract/construction drawings
Assist in bid evaluation
Review manufacture prints/Prepare O&M Manual
Inspection and testing: Trips and Reports

Support Services Subtasks

Revise conditions of contract to fit specific contract
Make quantity take-off, develop detailed bases for cost estimating, prepare engineer's estimate
Prepare detailed construction schedule
Prepare drafts and final documents for issue
Prepare addenda

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 19

Task: Contract Document C-10 Completion Contract

OUTPUT

Management Output

- Contract Document C-10
- Contract Award

Civil Engineering Output

- Design Memo
  - Second Stage Concrete
  - Switchyard Structures
- Technical Specifications
  - Metalwork
  - Architectural
- Civil/Structural computations
- Quantity take-off of civil and architectural items
- Review of manufacturers' drawings and computations
- Civil/Structural Contract/Construction Drawings
  - Index
  - Project Location Map
  - Vicinity Plan
  - General Project Layout
  - Climatological Data
  - Standard Details, Sheets 1-5
  - Second Stage Concrete - Concrete, Sheets 1-5
  - Second Stage Concrete - Reinforcement, Sheets 1-5
  - Switchyard - Concrete & Reinforcement, Sheets 1-4
  - Control Building - Concrete & Reinforcement, Sheets 1-7
  - Emergency Spillway Bridge -Concrete & Reinforcement, Sheets 1-4
  - Supplementary Drawings
  - Diversion Tunnels (4 estimated)
  - Outlet Facilities (5 estimated)
  - Powerhouse (15 estimated)
  - Switchyard (4 estimated)

Architectural Output

Architictural Treatment Memo

Task Number: 19
OUTPUT
Page 2

Arthitectural Contract Construction Drawings

- Control Building - Elevations
- Control Building - Floor
- Control Building - Ceiling
- Control Building - Sections & Elevations
- Control Building - Sections & Details
- Control Building - Sections & Details
- Control Building - Framing Plan
- Elevator & Stairs - Sheets 1 and 2
- Emergency Diesel Generator

Electrical Engineering Output

- Design memos
- Lighting Design Memo
- Cable Tray Design Memo
- Grounding Design Memo
- Site Distribution Design Memo
- Plant Communication System Design Memo
- Computations
- Specification text section
- General Electrical Work includes finishing and installing and testing conduit, grounding, insulated wire and cable, lighting, cable tray, etc. communication equipment; distribution equipment; miscellaneous equipment
- Installation of Owner Furnished Equipment includes the installation and field testing of the equipment specified in the following contracts:
    - Generator, E-2;
    - Transformer, E-8;
    - Control Switchboard Equipment, E-9;
    - High-Voltage Switchgear, E-10;
    - Generator Voltage Switchgear, E-11;
    - Station Service Switchgear, E-12;
    - Powerhouse Computer Control Equipment specified in E-13;
    - Switchyard Structures and Buses, E-37

Drawings

9	I-L Diagrams
6	Load Tabulation and Panel Schedules
5	Abbreviations, Symbols and Designations
76	Physical Drawings (conduit, arrangement details)
10	Grounding Drawing
47	Lighting Drawing
33	Schematic Diagram
148	Interconnection Diagram
92	Conduit and Cable Schedules
5	Communication Drawings
431	

Cost estimates
Computations
Reviewed shop drawings

Geotechnical Engineering and Geology Output

Design Memo
Switchyard Foundations
Contract Documents Technical Specifications
Open Excavation
Drawings
Data Location Map
Geotechnical Data Volume

Mechanical Engineering Output

C-10 (1)

Intra office review and coordination

C-10 (2)

35 contract/construction drawings
List of Drawings - HVAC/D-E Generator
Symbols & Abbreviations
Standard Details
HVAC Diagrammatical Sheets 1 and 2 - Powerhouse
HVAC Diagrammatical Sheet 1 of 1 - Transf. Vault & Cable Ways
HVAC Diagrammatical Sheet 1 of 1 - Surge Chamb./Tunnels & Shafts
HVAC El 1406 Sheets 1 and 2 - Powerhouse
HVAC El 1422 Sheet 1 of 1 - Powerhouse
HVAC El 1433 Sheets 1 and 2 - Powerhouse
HVAC El 1444 Sheets 1-3 - Powerhouse
HVAC El 1463 Sheets 1-3 - Powerhouse
HVAC Access Shaft Sheets 1 and 2
HVAC Surge Chamber Sheet 1 of 1
HVAC Tunnels Sheet 1 of 1
HVAC Transformer Vault Sheets 1 and 2
HVAC Bus Gallery Sheets 1 and 2
HVAC Cable Way Shaft Plan
HVAC Cable Way Shaft Elevation
HVAC Cable Way Shaft Sections
HVAC Cable Way Shaft Details

HVAC Outlet Facilities
HVAC HVAC Equipment for Miscellaneous Structures Sheets 1 and 2
Diesel-Electric Generator Sheets 1 and 2
Diesel-Electric Generator Piping Schedule/Fuel Storage System/Details
Prepare 5 general sections of specifications as follows:
- General
- HVAC Equipment
- Diesel-Electric Equipment
- Installation
- Testing

Bid analysis recommendation
Review Manufacture drawings
Inspection and Testing:Reports and Trips
Prepare 51 Mechanical Piping contract/construction drawings
- Drawing List - Mechanical Piping
  - Symbols & Abbreviations (Piping)
  - Standard Details
  - Unwatering & Sta. Drainage Diagrammatical PH
  - PH Drainage Diagrammatical PH
  - Raw & Cool Water Supply Diagrammatical PH
  - Raw Water Dist. Diagrammatical PH
  - Lub & Governor Oil System Diagrammatrical PH
  - Compressed Air Systems Diagrammatical PH
  - Treated Water Dist. Diagrammatical PH
  - Sanitary Drainage System Diagrammatical PH
  - Pumps & Control Diagrammatical PH
  - Fire Protection Diagrammatical
  - Water Dist./Drainage/Oil Sump/Storage/Handling Diagrammatical Transf. Vault
  - Piping Diagrammatical Outlet Facilities
  - Deicing & Misc. Systems for Remaining Misc. Structures Diagrammatical Sheets 1 and 2
  - Piping (Schedule) Valves
  - Piping (Schedule) Piping
  - Piping Plan El 1406 Sheet 1 of 4 Gallery & Unit 1
  - Piping Plan El 1406 Sheet 2 of 4 Unit 2 & 3
  - Piping Plan El 1406 Sheet 3 of 4 Unit 4 & 5
  - Piping Plan El 1406 Sheet 4 of 4 Unit 6 & Gallery
  - Piping Plan El 1422 Sheets 1 and 2
  - Piping Plan El 1444 Sheet 1 of 4 Access Shaft & PH Personnel Area
  - Piping Plan El 1444 Sheet 2 of 4 Unit 1 & 2

Task Number: 19
OUTPUT
Page 5

Piping Plan El 1444 Sheet 3 of 4 Unit 3 & 4
Piping Plan El 1444 Sheet 4 of 4 Unit 5 & 6
Piping Plan El 1463 Sheets 1-3
Piping Plan El 1463 1 of 1 Section
Piping PH Oil Storage Sheet 1 of 2 Enlarged Plan
Piping PH Oil Storage Sheet 2 of 2 Enlarged Section
Piping Fire Protection for Oil Room Enlarge Plan/Section
Piping - Plumbing Sheets 1 and 2 Details
Piping - Supports Sheets 1-3 Details
Piping Sections/Details Sheets 1 and 2
Piping Transformer Vault Sheets 1-3
Piping Transformer Vault Section General Sheets 1 and 2
Piping Outlet Facilities Sheets 1 and 2
Piping & Mechanical Equipment Systems for Remaining Miscellaneous Structures Sheets 1-4

C-10 (3)

Prepare 15 general sections of specifications for mechanical equipment and systems

Mechanical Equipment Specification List
General
Piping
Valves
Plumbing
Sewage Treatment System
Treated Water System
Fire Protection Systems
Machine Shop Equipment
Compressed Air Systems
Elevators
Pumps and Controls
Gate operating Equipment
Gate Hoist Structures
Installation of Equipment
Testing of Equipment

Bid analysis recommendation
Review of manufacturers' prints
Inspection and testing: Reports and trips

C-10 (4)

Intra office review/coordination

C-10 (5)

Prepare 4 general sections of Installation and Testing Specifications of Owner Furnished Equipment as follows:
- General
- Details
- Installation
- Testing

Field Test Reports/Field Inspection Reports

C-10 (9)

Prepare Design Memo and 14 contract-construction drawings
Specifications for Control Building
Design Memo - Mechanical Features for the Control Building features
- HVAC (general)
- HVAC (special)
- Piping
- Plumbing
- Maintenance facilities
  - Specialties as related to Building necessities

List of Drawings - Mechanical Features for Control Building
- Abbreviation/Symbols and Piping Schedule
- Piping systems - Isometric
- Piping - Plan sheets 1 and 2
- Piping - Sections
- Piping - Details
- Piping - Plumbing & Drainage Details Sheets 1 and 2
- HVAC - Abbreviation and symbols
- HVAC - Plan Sheets 1 and 2
- HVAC - Sections & Details Sheets 1 and 2
- Miscellaneous Mechanical Equipment System Details

General Sections of Specifications as follows:
- General/Piping/Plumbing/HVAC (general)/HVAC (special)/Misc. Mech. Systems/Installation/Testing

Support Services Output

Contract Documents
Engineers Estimate
Letter of Recommendation of Award
Report of Status of Contractor Equipment Drawing Submittal

Task Number: 20

Task: Contract Document C-11 Willow Control Center & Microwave Site Facilities

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Prepare design memo

Prepare technical specifications

Perform structural analysis and design of the Energy Management Building and Microwave Tower foundations

Prepare contract/construction drawings

Coordinate and review drawings from other disciplines

Prepare quantity takeoffs for the engineers estimate

Review manufacturers' drawings and computations

Provide office assistance to the field

Electrical Engineering Subtasks

Prepare functional design memos.

Review Building Layout and Arrangement

Prepare electrical design

Prepare technical specifications

Prepare drawings

Coordinate and review drawings from other disciplines

Review manufacturers' drawings and computations

Provide office assistance to the field

Provide coordination and assistance in commissioning

Geotechnical Engineering and Geology Subtasks

Study and evaluate pertinent geotechnical data

Select geotechnical design parameters

Establish foundation designs

Mechanical Engineering Subtasks

Review Bldg. layout and arrangement

Perform Preliminary studies to establish Bldg. requirements as related to mechanical systems

Perform preliminary studies for Bldg. mechanical system size/layout/arrangements

Support Services Subtasks

Contract Preparation Phase Services

Revise conditions of contract to fit specific contract

Make Quantity take-off develop detailed bases for cost estimating, prepare engineer's estimate

Prepare drafts and final documents for issue, prepare addenda.

Assist with bidding and award

Construction Phase Services

Expedite submittals of Contractor's drawings, catalog cuts, instructions

Expdite design department's review and approval of Contractor's submittal

Task Number: 20
<u>SUBTASKS</u>
Page 3

Prepare regular status report of all equipment Contractors drawing submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 20

Task: Contract Document C-11 Willow Control Center & Microwave Bldg.

OUTPUT

Civil Engineering Output

- Microwave Building Structural and Architectural Design
- Control Center and Design Memo
- Technical Specifications
  - Architectural
  - Metalwork
- Civil/Structural computations
- Contract/construction drawings - Civil/Structural Drawings
- Civil/Structural Drawings
  - Plan & Sections Sheets 1 and 2
  - Foundations
- Quantity takeoff of civil and architectural items.
- Review of manufacturers' drawings and computations

Architectural
- Elevations
- Roof Plan & Details
- Floor Plan
- Reflected Ceiling - Plan & Details
- Sections & Interior Elevations
- Sections & Details Sheets 1 and 2
- Emergency Diesel/Generator House
- Door & Finish Schedule
- Roof Framing Plan and Details

Mechanical Engineering Output
- Intra-office review and coordination
- Preliminary Design Memo as related to Building Mechanical Systems

Electrical Engineering Output

Design memo sections and design drawings

Specification sections

General Electrical Work includes furnishing, installing, and testing; building service and distribution equipment; conduit, grounding; lighting; insulated wire and conductors, and miscellaneous equipment

Installation of Owner-Furnished Equipment includes installing and testing: building communication equipment; Energy Management System computer control equipment and accessories specified in Contract E-13; all microwave and related equipment specified in Contract E-3; all Willow support equipment specified in Contract E-4.

Review Shop Drawings
Contract/Construction Drawings
- 1 - I-L Diagram
- 1 - Panel Tabulations
- 1 - Symbols and Designations
- 2 - Lighting
- 2 - Conduit and Cable Schedules
- 1 - Grounding
- 5 - Physical drawings (Arrangement)
- 5 - Schematic diagrams and Details
- 5 - Interconnection diagrams

Cost Estimates
Computations

Mechanical Engineering Output

Intra-office review/coordination

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation for Award
Report of Status of Contractors Submittals

Task Number: 21

Task: Contract Document E-1 Turbines & Governors

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Provide the powerhouse contract/construction "base" drawings, prepared under Task No. 15, to show the Turbine & Governor equipment locations

Coordinate, assist and review all interface work between civil and mechanical disciplines

Electrical Engineering Subtasks

Review Turbine/Governor Design Memo
Review Turbine/Governor Specs for elec. features
Assist in Bidding and Bid Evaluation (see below)

Mechanical Engineering Subtasks

Prepare Turbine Selection Studies
Prepare Turbine Design Memo
Prepare separate supply specifications for turbines and governors
Prepare & coordinate contract/construction drawings with civil drawings prepared under Task No. 15
Assist in Bid Evaluation
Review of Manufacture Prints
Inspection & Testing: Reports and Trips

Support Service Subtasks

Contract Preparation Phase Services

Develop Standard Conditions of Bidding Equipment Contracts for Susitna

Prepare contract documents from design department's drafts: review copies, final preparation

Review and process engineers estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of Bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 21

Task: Contract Document E-1 Turbines & Governors

OUTPUT

Management Output

Contract Document E-1

Contract Award

Civil Engineering Output

Powerhouse outline "base" drawings from Task No. 15

Review comments

Electrical Engineering Output

Reviewed design memo and specification
Reviewed shop drawings
Shop inspection reports, Governor

Mechanical Engineering Output

Prepare Turbine Design Memo & separate supply specification for Turbine & Governor
Prepare Turbine Bid Recommendation
Assist During Negotiations for Bid Award
Review Mfr. Prints
Conduct Shop Inspection/Testing: Prepare associated Reports

Support Services Output

Contract Documents
Engineers Estimate
Letter for Recommendation of Award
Report of Status of Equipment Contract Submittals

Task Number: 22

Task: Contract Document E-2 Generator & Excitation Equipment

SUBTASKS

Management Subtasks

- Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Provide powerhouse contract/construction "base" drawings, prepared under Task No. 15, to show Generator & Excitation Equipment

Coordinate, assist and review all interface work between civil and electrical disciplines

Electrical Engineering Subtasks

Assist in unit selection
Prepare design memorandum
Prepare specifications and bid form
Prepare cost estimate
Assist in bidding
Prepare bid evaluation
Assist in Contract award
Review shop drawings
Review inspection reports
Conduct shop inspection

Mechanical Engineering Subtasks

Coordinate with other disciplines as related to turbine equipment interfacing with generator supply and civil work

Support Services Subtasks

Contract Preparation Phase Services

Contract Award conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Task Number: 22
SUBTASKS
Page 2

Review and process engineer's estimate

Coordinate equipment contract and delivery schedule with project construction schedule

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 22

Task: Contract Document E-2 Generators and Excitation Equipment

OUTPUT

Civil Engineering Output

Powerhouse outline "base" drawings from Task No. 15 Review comments

Electrical Engineering Output

Design Memorandum (Generator)
Specification and Bid Form
Cost Estimate Assistance
Bid Evaluation
Review Shop Drawing
Review Insp. Reports
Participation in Shop Inspection Reports

Mechanical Engineering Output

Intra-office review/coordinate

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation for Award
Input to Report of Status of Equipment Contract Submittals

Task Number: 23

Task: Contract Document E-3 - Microwave System & Towers

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Review manufacturer's drawings and computations for towers

Electrical Engineering Subtasks

Design memos and preliminary design, evaluating alternative communications
Equipment specifications
Cost estimate Assistance
Assistance in bidding
Bid evaluation and recommendation
Manufacturer's drawing review
Shop inspection and meetings
Preparation of drawings

Support Services Subtasks

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Coordinate equipment contract fabrication and delivery dates with project construction schedule

Task Number: 23
SUBTASKS
Page 2

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 23

Task: Contract Document E-3 - Microwave System & Towers

OUTPUT

Management Output

Contract Document E-3

Award & Contract

Electrical Engineering Output

Design Memorandum
Contract document technical specifications section
Drawings:
- 10 - physical
- 17 - path profile
- 5 - schematic
- 5 - interface

Bid Evaluation
O&M manual
Inspection reports
Reviewed shop drawings

Support Services Output

Contract Documents
Engineer's Estimate
Letter Of Recommendation For Award
Input to Report of Status of Equipment Contract Submittals

Task Number: 24

Task: Contract Document E-4 - Willow Support Equipment

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Coordinate, assist and review all interface work between civil electrical and mechanical disciplines

Electrical Engineering Subtasks

Prepare design memorandum
Prepare technical specifications
Prepare drawings
Cost estimate assistance
Provide assistance in bidding
Provide Bid Evaluation and Recommendation
Provide shop inspection

Support Services Subtasks

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Task Number: 24
SUBTASKS
Page 2

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 24

Task: Contract Document E-4 - Willow Support Equipment

OUTPUT

Management Output

Contract Document E-4

Contract Award

Civil Engineering Output

Review comments and prepare layout drawing for building

Electrical Engineering Output

Design Memorandum
Contract document technical specification section
Drawings:
3 - physical
3 - schematic
3 - interface
Bid Evaluation Input
Inspection reports
Reviewed shop drawings

Mechanical Engineering Output

Prepare Design Memo/16 contract-construction drawings/specifications

Design Memo - Mechanical Features for Willow Control Building HVAC (general)/ HVAC (special)/ Piping/ Plumbing maintenance facilities/ specialties as related to Building necessities

Drawing List - Mechanical Features for Willow Control Building
Abbreviations/symbols and piping schedule
Piping systems - Isometric
Piping - Plan Sheets 1 and 2
Piping - Section
Piping - Details
Piping - Plumbing & Drainage Details Sheets 1 and 2
HVAC - Abbreviations and symbols

Task Number: 24
OUTPUT
Page 2

HVAC - Plan Sheets 1 and 2
HVAC - Sections & Details Sheets 1 and 2
Diesel - Electric Generator Plan
Diesel - Electric Generator Section & Details
Miscellaneous Mechanical Equipment System Details

List of General Sections of Specification - Mechanical Features for Willow Control Building:
General/ Piping/ Plumbing/ HVAC (general)/ HVAC (special)/ Miscellaneous Mechanical Systems/ Diesel-Electric Generator/ Installation/ Testing

Assist in bid analysis recommendation
Review manufacturers' prints
Inspection & Testing: Reports and Trips

Support Services Output

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Task Number: 25

Task: Contract Document E-5 Trashracks, Gates & Hoists - Including Structures

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Coordinate, assist and review all interface work between civil and mechanical disciplines

Electrical Engineering Subtasks

Review mechanical design memo
Review specifications
Assist in bid evaluation
Review elec. shop drawings and inspection reports

Mechanical Engineering Subtasks

Prepare Design studies and design memo for related mechanical equipment
Prepare separate supply specifications for trashracks, gate & hoists
Prepare & coordinate contract/construction drawing with civil drawings
Assist in Bid Evaluation
Review of Manufacture Prints
Inspection & Testing: Reports and Trips

Support Services Subtasks

<u>Contract Preparation Phase Services</u>

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 25

Task: Contract Document E-5 Trashracks, Gates & Hoists - Including Structures

OUTPUT

Management Output

Contract Document E-5

Contract Award

Civil Engineering Output

Review comments

Electrical Engineering Output

Reviewed design memo and specification
Reviewed elec. shop drawings
Reviewed elec. inspection reports

Mechanical Engineering Output

Prepare Design Memos/ 17 Contract-Construction drawings/specifications

Design Memos - Mechanical Features
- Diversion Gate & Equipment
- Spillway Gate & Equipment
- Outlet Intake Gate & Equipment
- Power Intake Gates & Equipment
- Draft Tube Gates & Tailrace Bulkhead Equipment

Drawing List - Mechnical Features
Diversion Closure Gate & Hoist Sheet 1 of 2
Diversion Closure Gate & Hoist Sheet 2 of 2
Spillway Gate & Hoist Sheet 1 of 2
Spillway Gate & Hoist Sheet 2 of 2
Spillway Stoplogs
Outlet Intake Gate & Hoist Sheet 1 of 2
Outlet Intake Gate & Hoist Sheet 2 of 2
Outlet Intake Bulkhead
Outlet Intake Trashracks
Power Intake Gates & Hoist Sheet 1 of 2
Power Intake Gates & Hoist Sheet 2 of 2
Power Intake Bulkhead
Power Intake Shutter Gate

Task Number: 25
OUTPUT
Page 2

Power Intake Trashracks
Power Intake Ice Boom
Draft Tube Gate
Tailrace Bulkhead

General sections of specification - Mechanical Features
General/ Details/ Design Standards/ Diversion Gate & Equipment/ Spillway Gate & Equipment/ Outlet Intake Gate & Equipment/ Power Intake Gate & Equipment/ Draft Tube Gate & Tailrace Bulkhead

Prepare Bid Analysis Recommendation
Review Manufacturers' Prints
Inspect & Test: reports and trips
Prepare O&M manual

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation for Award
Report of Status of Equipment Contract Submittals

Task Number: 26

Task: Contract Document E-6 - Cranes and Hoists

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Provide powerhouse contract/construction "base" drawings prepared under Task No. 15, to show Crane & Hoist Equipment. Coordinate, assist and review all interface work between civil and mechanical disciplines

Electrical Engineering Subtasks

Review mechanical design memo
Review specifications
Assist in bid evaluation
Review elec. shop drawings and inspection reports

Mechanical Engineering Subtasks

Prepare Design Studies
Prepare Design Memos
Prepare separate supply specifications for Cranes & Hoists
Prepare and coordinate contract/construction drawings with civil drawings
Assist in Bid Evaluation
Review Manufacture Prints
Inspection and Testing: Reports and Trips

Support Services Subtasks

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Task Number: 26
SUBTASKS
Page 2

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 26

Task: Contract Document E-6 - Cranes & Hoists

OUTPUT

Management Output

Contract Document E-6

Contract Award

Civil Engineering Output

Powerhouse outline "base" drawings from Task No. 15 Review Comments

Electrical Engineering Output

Reviewed design memo and specification
Reviewed elec. shop drawings
Reviewed elec. inspection reports and O/M manuals

Mechanical Engineering Output

Prepare Design Memo/5 Contract-Construction drawings/specifications (see Memo/Drawing/Specification List)

Design Memos - Mechanical Features
- Valve House Crane & Hoist Equipment
- Power Intake Crane
- Surge Chamber Bridge Crane
- Powerhouse Crane

Drawing List - Mechanical Features
- Valve House Service Crane
- Valve House Monorail Hoist & Trolley
- Power Intake Crane
- Surge Chamber Bridge Crane
- Powerhouse Crane

General Sections of Specifications - Mechanical Features
General
Details
Design Standards
Valve House Monorail Hoist
Valve House Service Crane

Task Number: 26
OUTPUT
Page 2

Power Intake Crane
Surge Chamber Bridge Crane
Powerhouse Crane

Prepare Bid Analysis Recommendation
Review Manufacturers' Prints
Inspection & Test: Reports and Trips
Prepare O&M manual

Support Services Output

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Task Number: 27

Task: Contract Document E-7 Outlet Works Valves Including High Pressure Slide Gates for Emergency Release

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule for Task and subtasks

Initiate work

Civil Engineering Subtasks

Provide outlet works concrete outline drawings prepared under Task No. 14

Coordinate, assist and review all interface work between civil and mechanical disciplines

Electrical Engineering Subtasks

Review mechanical design memo
Review specifications
Assist in bid evaluation
Review elec. shop drawings and inspection reports

Mechanical Engineering Subtasks

Prepare separate supply specifications for outlet facilities valves & associated guard gate
Prepare separate supply specification for Emergency Release Gates
Prepare & coordinate contract/construction drawing with civil drawings
Assist in Bid Evaluation
Review of Manufacture Prints/Prepare O&M manual
Inspection & Testing
Prepare Design Studies
Prepare Design Memo

Support Services Subtask

<u>Contract Preparation Phase Services</u>

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 27

Task: Contract Document E-7 Outlet Works Valves Including High Pressure Slide Gates for Emergency Release

OUTPUT

Management Subtasks

Contract Documents
Contract Award

Civil Engineering Output

Outlet Works concrete outline drawings prepared under Task No. 14

Review comments

Electrical Engineering Output

Reviewed design memo and specification
Reviewed elec. shop drawings
Reviewed elec. inspection reports and O/M manuals.

Mechanical Engineering Output

Prepare Design Memo/4 Contract-Construction drawings/specifications (see Memo/Drawing/Specification List)

Design Memos - Mechanical Features
Emergency Release Gate Equipment
Outlet Facilities Gates & Valves
Drawing List - Mechnical
Emergency Release Trashracks
Emergency Release Gate & Hoist Sheet 1 of 2
Emergency Release Gate & Hoist Sheet 2 of 2
Ring follower Gate & Outlet Facilities Discharge Valve

General Sections of Specifications - Mechanical Features
General
Details
Design Standards
High Pressure Emergency Gate & Equipment
Low Pressure Emergency Gate & Equipment

Task Number: 27
<u>OUTPUT</u>
Page 2

Outlet Facilities Ring Follower Guard Gate & Equipment
Outlet Facilities Free Discharge Valve & Equipment

Prepare Bid Analysis Recommendation
Review Manufacture Prints
Inspection & Test: Reports and Trips
Prepare O&M manual

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation for Award
Report of Status of Equipment Contract Submittals

Task Number: 28

Task: Contract Document E-8 Transformers

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Provide powerhouse contract/construction "base" drawings, prepared under Task No. 15 to show Transformer Equipment

Coordinate, assist and review all interface work between civil and electrical disciplines

Electrical Engineering Subtasks

Prepare design memorandum
Prepare technical specification and bid form
Prepare cost estimate
Assist in bidding
Prepare bid evaluation
Assist in Contract award
Review shop drawings
Provide shop inspection

Support Services Subtasks

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Task Number: 28
SUBTASKS
Page 2

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 28

Task: Contract Document E-8 Transformers

OUTPUT

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Output

Powerhouse outline "base" drawings from Task No. 15

Review comments

Electrical Engineering Output

Design memorandum Transformers
Specification and Bid Form
Cost Estimate
Bid Evaluation
Reviewed Shop Drawing
Inspection Reports
O/M Manuals

Support Services Output

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Task Number: 28
OUTPUT
Page 2

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Task Number: 29

Task: Contract Document E-9, Control Switchboard Equipment

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Provide powerhouse contract/construction "base" drawings, prepared under Task No. 15 to show Control Switchboard Equipment

Coordinate, assist and review all interface work between civil and electrical disciplines

Electrical Engineering Subtasks

Design station controls and protection
Prepare Design Memos
Prepare technical specifications and bid form
Prepare cost estimate
Assist in Bidding
Prepare Bid Evaluation
Assist in Contract Award
Review Shop Drawings
Review Inspection Reports
Conduct Shop inspection

Support Services Subtasks

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit

Task Number: 29
SUBTASKS
Page 2

Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 29

Task: Contract Document E-9, Control Switchboard Equipment

OUTPUT

Management Output

Contract Document E-9

Contract Award

Civil Engineering Output

Powerhouse outline "base" drawings from Task No. 15

Review comments

Electrical Engineering Output

Design Memo, Station Controls
Design Memo, Protective Relaying
Specification and Bid Form
Cost Estimate
Bid Evaluation
Reviewed shop drawing
Inspection reports
O/M Manuals

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation for Award
Report of Status of Equipment Contract Submittals

Task Number: 30

Task: Contract Document E-10 Hv Switchgear

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Provide powerhouse contract/construction "base" drawings, prepared under Task No. 15 to show HV Switchgear Equipment

Coordinate, assist and review all interface work between civil and electrical disciplines

Electrical Engineering Subtasks

Prepare technical specifications and bid forms
Prepare cost estimate
Assist in bidding
Prepare bid evaluation
Assist in contract award
Review Shop Drawings
Provide shop inspection
Provide office assistance to field

Support Services Subtasks

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Task Number: 30
SUBTASKS
Page 2

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 30

Task: Contract Document E-10 Hv Switchgear

OUTPUTS

Management Output

Contract Document E-10

Contract Award

Civil Engineering Subtasks

Powerhouse outline "base" drawings from Task No. 15

Review comments

Electrical Engineering Output

Specification and bid form
Cost estimate
Bid evaluation
Reviewed shop drawings
Inspection reports

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation for Award
Report of Status of Equipment Contract Submittals

Task Number: 31

Task: Contract Document E-11 Generator Voltage Switchgear

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Provide powerhouse contract/construction "base" drawings, prepared under Task No. 15 to show Generator Voltage, Switchyard equipment

Coordinate, assist and review all interface work between civil and electrical disciplines

Electrical Engineering Subtasks

Prepare specifications and bid forms
Prepare cost estimate
Assist in bidding
Prepare Bid Evaluation
Assist in Contract award
Review Shop Drawings
Perform shop inspection
Provide office assistance to field

Support Services Subtasks

Construction Phase Services

Revise standard conditions to fit specific contract
Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Task Number: 31
SUBTASKS
Page 2

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 31

Task: Contract Document E-11 Generator Voltage Switchgear

OUTPUT

Management Output

Contract Document E-11

Contract Award

Civil Engineering Output

Powerhouse outline "base" drawings from Task No. 15

Review comments

Electrical Engineering Output

Specification and Bid Form
Cost Estimate
Bid Evaluation
Reviewed Shop Drawing
Inspection Reports

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation for Award
Report of Status of Equipment Contract Submittals

Task Number: 32

Task: Contract Document E-12, Station Service Switchgear

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule or task and subtasks

Initiate work

Civil Engineering Subtasks

Provide powerhouse contract/construction "base" drawings, prepared under Task No. 15 to show Station Service Switchgear Equipment

Coordinate, assist and review all interface work between civil and electrical disciplines

Electrical Engineering Subtasks

Prepare Design Memos
Prepare specifications and bid form
Prepare cost estimate
Assist in Bidding
Prepare Bid Evaluation
Assist in Contract Award
Review Shop Drawings
Provide shop inspection

Support Service Subtasks

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification, Document Issue and Follow-up, Receipt and Recording of bids, Edit Technical Evaluation of Bids by Design Departments, Commercial Evaluation of Bids, Prepare Letter of Recommendation for Award, Contract/Purchase Order Negotiation.

Task Number: 32
SUBTASKS
Page 2

Construction Phase Services

Expedite submittals of manufacturers' drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 32

Task: Contract Document E-12, Station Service Switchgear

OUTPUT

Management Output

Contract Document E-12

Contract Award

Civil Engineering Output

Powerhouse outline "base" drawings from Task No. 15

Review comments

Electrical Engineering Output

Prepare Design Memo on Station Service System
Prepare Design Memo on Diesel Generator
Specification and Bid Form
Cost Estimate
Bid Evaluation
Reviewed shop drawing
Inspection reports

Support Services Output

Contract Documents
Engineer's Estimate
Letter of Recommendation for Award
Report of Status of Equipment Contract Submittals

Task Number: 33

Task: Contract Document E-13
Computer Control for the Susitna Powerhouse and the Willow Control Center

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule for Task and subtasks

Initiate work

Civil Engineering Subtasks

Provide powerhouse contract/construction "base" drawings, prepared for Contract C-6 to show Computer Control Equipment location

Coordinate, assist and review all interface work between civil and electrical disciplines

Electrical Engineering Subtasks

Prepare design memo and preliminary design
Prepare technical specifications
Provide assistance during Bidding
Provide Bid review and recommendation
Provide cost estimate
Review manufacturer's drawings
Provide shop inspection and attend meetings
Prepare drawings

Support Services Subtasks

Contract Preparation Phase Equipment

Revise standard conditions

Prepare contract documents from design dept's drafts: review copies, final reproduction

Review and process engineer's estimate

Task Number: 33

Task: Contract Document E-13
Computer Control for the Susitna Powerhouse and the Willow Control Center

OUTPUT

Management Output

Contract Document E-13
Contract Award

Civil Engineering Output

Powerhouse outline "base" drawings from Contract C-6

Review comments

Electrical Engineering Output

Susitna Plant Computer Control Design Memo
Energy Management System Computer Control (Willow) Design Memo

Technical specifications for Susitna and Willow Computer Systems and all Accessories

Drawings
- 20 - Interface drawings
- 10 - Schematic diagrams

Cost Estimate
Bid Evaluation
Reviewed Shop drawings

Support Services Output

<u>Contract Preparation Phase Services</u>

Contract Documents
Engineer's Estimate
Letter of Recommendation for award

<u>Construction Phase Services</u>

Report of status of equipment contract submittals

Task Number: 34

Task: Contract Document E-14 Pipe-Type Cables - Furnish and Install

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule for Task and subtasks

Initiate work

Civil Engineering Subtasks

Coordinate, assist and review all interface work between civil and electrical disciplines. Provide civil "base" drawing from C-6 contract to electricals for E-14 contract drawing.

Electrical Engineering Subtasks

Prepare design memorandum
Prepare specification and bid form
Prepare cost estimate (see attached)
Assist in bidding
Prepare bid evaluation
Assist in contract award
Review shop drawings
Provide shop inspection

Support Services Subtasks

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification document issue and follow-up, receipt and recording of bids, edit technical evaluation of bids by design departments, commercial evaluation of bids

Task Number: 34
SUBTASKS
Page 2

Prepare letter of recommendation for award, contract/ purchase order negotiation

Construction Phase Services

Expedite submittals of manufacturer's drawings, catalog cuts, instructions

Expedite design department's review and approval of manufacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 34

Task: Contract Document E-14 Pipe-Type Cables - Furnish and Install

OUTPUT

Management Output

Contract Document E-16
Contract Award

Civil Engineering Output

Review comments

Electrical Engineering Output

Design memorandum
Specification and bid form
Cost estimate
Bid evaluation

Reviewed shop drawings
Inspection reports
O/M Manuals

Support Services Output

Contract Preparation Phase Services

Contract Documents
Engineer's estimate
Letter of recommendation for award

Construction Phase Services

Report of status of equipment contract submittals

Task Number: 35

Task: Contract Document E-15
Switchyard Structures - Busses & Acc.

SUBTASKS

Management Subtasks

Issue and control manpower budgets and schedule for Task and subtasks

Initiate work

Civil Engineering Subtasks

Coordinate, assist and review all interface work between civil and electrical disciplines. Prepare base drawing to Electricals

Electrical Engineering Subtasks

Prepare design memorandum
Prepare Specification and bid form
Prepare cost estimate (see attached)
Assist in bidding
Prepare Bid evaluation
Assist in contract award
Review shop drawings
Conduct shop inspection

Support Services Subtasks

Contract Preparation Phase Services

Revise standard conditions to fit specific contract

Prepare contract documents from design department's drafts: review copies, final reproduction

Review and process engineer's estimate

Assist with bidding and award: Prequalification document issue and follow-up, receipt and recording of bids, edit technical evaluation of bids by design departments, commercial evaluation of bids

Task Number: 35
SUBTASKS
Page 2

Prepare letter of recommendation for award, contract/ purchase order negotiation

Construction Phase Services

Expedite submittals of manufacturer's drawings, catalog cuts, instructions

Expedite design department's review and approval of manifacturers' submittals

Prepare regular status report of all equipment contract submittals

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 35

Task: Contract Document E-15
Switchyard Structures - Busses & Acc.

OUTPUT

Management Subtasks

Issue and control manpower budgets and schedule for Task and subtasks

Initiate work

Civil Engineering Output

Review comments

Electrical Engineering Output

Design memorandum, Switchyard
Specification and bid form
Cost estimate
Bid evaluation
Reviewed shop drawings
Inspection reports

Support Services Output

Contract Preparation Phase Services

Contract Documents
Engineer's estimate
Letter of recommendation for award

Construction Phase Services

Report of status of equipment contract submittals

Task Number: 36

Task: Home Office Specialists Support to Field During Construction

SUBTASKS

Management Subtasks

Intiate, contral and coordinate home office specialist support to field with Construction Manager and JV Resident Field personnel

Civil Engineering Subtasks

Assist and advise field personnel on civil/structural matters

Geotechnical Engineering and Geology Subtasks

Home Office Specialists Support to Field During Construction

Confirm design concepts as excavation, foundation treatment, and fill work proceeds by reviewing field reports, correspondence and field trips

Drilling and grouting results review
Embankment quality control test results review
Observation of instrumentation results

Revise and update construction inspection procedures as required

Review and Evaluate the results of geologic mapping of excavations, tunnels, shafts, galleries and chambers

Develop a monitoring plan for reservoir filling

Provide assistance in field and advice to field staff during construction

Mechanical Engineering Subtasks

Confirm that general construction contractor supplied equipment conforms with specification
Respond to manufacturers inquires
Intra office coordination

Task Number: 36
SUBTASKS
Page 2

Support Services Subtasks

Concrete mix design review and quality control

Constructability review and estimating concerned with field initiated design revisions

Input to check-out and start-up of generating units and station systems

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 36

Task: Home Office Specialists Support to Field During Construction

OUTPUT

Management Outputs

Expediting response to field support requests

Civil Engineering Output

Trip memos, reports and sketches

Geotechnical Engineering and Geology Output

Trip memos, reports, sketches and construction evaluation reports as required

Mechanical Engineering Output

General correspondence, special instructions, miscellaneous memos/studies/sketches advising field as associated with mechanical equipment and systems

Support Services Output

Studies and reports

Task Number: 37

Task: Engineers Field Support

During construction, the Joint Venture will post to the Project Site a staff of experienced Support Services engineers who will assure, on-site, that our construction-related design responsibilities to APA are met. Members of this staff will be intimately familiar with project designs, having participated in their development and their definition in the drawings and specifications. They will be competent to deal with most questions without reference to the Joint Venture Control or Production offices, but will keep these offices informed through regular reports.

Staffing

The Joint Venture proposal is based on staffing the Field Support Services function with the following positions:

- Resident Engineer
- Engineering Geologist
- Soils Engineer
- Construction/Civil Engineer
- Mechanical Engineer - Gates
- Mechanical Engineer - Power Plant
- Electrical Engineer
- Draftsmen

The proposed service schedule for the Field Support Services staff is shown in the Cost Proposal.

SUBTASKS

Responsibilities of Field Support Services Engineers are described in the following Sub-tasks:

- Geotechnical review of actual field conditions as they are exposed, assessment of their impact on designs, and modifications to design; drawings and specifications if necessary.

- Interpretations of the drawings and specifications for the Construction Manager and the contractors.

Task Number: 37
<u>SUBTASKS</u>
Page 2

- Quality assurance monitoring of all construction operations, and inspections thereof, to assess adherence to the Engineer's quality control memoranda.

- Documentation of all project construction activities and events that impact on the execution of the design

- Regular reporting to the Joint Venture project control and design production offices of the progress of construction and important matters related to the design.

- Assistance to the project control and design production offices with information collection, studies, designs and sketches necessary to the solution of problems arising during construction.

- Assist in developing the Joint Venture's input to the assessment and resolution of contractor's claims.

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 37

Task: Engineers Field Support

OUTPUT

Output:

- Diaries of each staff member
- Weekly reports of construction activities and significant design-related events and activities
- Reports of drawings and specifications interpretations to the Construction Manager
- Reports of drawing or specification changes to the Construction Manager
- Special reports or memoranda to project control and design production offices concerning necessary studies and design, drawings and specification changes, or claims assessment and resolution.

Task Number: 38

Task: Management of Design Subcontracts
Access Road
Railroad Extension
Airfield
Sewage Treatment and Water Treatment Systems
Camp Facilities
Reservoir Clearing

SUBTASKS

Management Subtasks (F.A. Moolin & Associates)

Design Subcontracts - For each design subcontracts
- Prepare RFQ and after APA approval send to local Alaskan consultants (optional)
- Receive, evaluate qualifications, and present list of qualified consultants to APA for acceptance (optional)
- Prepare draft terms of contract to include in RFP for APA review and approval
- Prepare draft scope of work including technical criteria for RFP for APA review and approval
- Incorporate APA review comments and issue RFP to qualified Alaskan consultants
- Receive and evaluate proposals in accordance with APA evaluation procedure.
- Negotiations leading to award of contract

Control and coordinate design subcontractors
Monitor subcontractor progress with respect to budgets and schedules
Schedule and coordinate technical reviews and V-E reviews
Schedule and coordinate Construction Manager review
Prepare Monthly Progress Report and submit to JV Project Manager
Participate with JV Project Management in meetings with APA; APA's External Review Panel, Alaskan Highway Dept., Alaskan R.R.; environmental agencies, etc.
Participate in identification of project lands, acquisition of land use rights and rights of entry

Task Number: 38
SUBTASKS
Page 2

Civil Engineering Subtasks

Assist management in evaluation of qualifications and establishment of Scope of Work for each subcontract.

Assist F.A. Moolin & Associates in review of Design and Subcontractor prepared Contract Documents

Geotechnical & Geological Engineering Subtasks

Assist management in evaluation of qualifications and establishment of Scope of Work for each subcontract.

Assist F.A. Moolin & Associates in review of Design and Subcontractor prepared Contract Documents

Environmental Sciences Subtasks

Assist management in evaluation of qualifications and establishment of Scope of Work for each subcontract.

Assist F.A. Moolin & Associates in review of Design and Subcontractor prepared Contract Documents

Mechanical Engineering Subtasks

Assist management in evaluation of qualifications and establishment of Scope of Work for each subcontract.

Assist F.A. Moolin & Associates in review of Design and Subcontractor prepared Contract Documents

Electrical Engineering Subtasks

Assist management in evaluation of qualifications and establishment of Scope of Work for each subcontract.

Participate in Review of Design and Subcontractor prepared Contract Documents

Task Number: 38
SUBTASKS
Page 3

Support Services Subtasks

Assist management in evaluation of qualifications and establishment of Scope of Work for each subcontract.

Review of constructibility and Subcontractor prepared Engineers Estimates

Note: Management and Support Services Subtasks budgets are included with Task Number 1 Management and Task Number 2 Support Services.

Task Number: 38

Task: Design Subcontracts through Award
Access Road
Railroad Extension
Airfield
Sewage Treatment and Water Treatment Systems
Camp Facilities
Reservoir Clearing

OUTPUT

Management Output

A minimum of 6RFQ Documents (optional)
A minimum of 6 RFP documents
A minimum of 6 recommendations of award of contract
Award a minimum of six design subcontracts

Monthly Progress Reports on Non-Technical Facilities Design Subcontracts
Reports on decisions taken in meetings with Power Authority and Alaskan agencies
Coordinated and approved Contract Documents for construction of Non-Technical features of Watana project