

Mesquite Group, Inc.

P.O. Box 1283
221 North Harbor Blvd., Suite K
Fullerton, California 92632
(714) 738-8224

April 24, 1991

Mr. Murray E. Towill, Director
STATE OF HAWAII
Department of Business,
Economic Development & Tourism
Attention: Energy Division
335 Merchant Street, Room 110
Honolulu, HI 96813

DIV. OF WATER &
LAND DEVELOPMENT

91 APR 30 8:41

RECEIVED

Subject: Your March 29, 1991, Request for Proposal for Technical
Advisory Services Relating to Geothermal Resource Assessment

Dear Mr. Towill:

Mesquite Group, Inc. is pleased to submit the attached proposal in response to the subject RFP. In order to provide the services needed by the DBED and DLNR, Mesquite has assembled a team of Mainland and Hawaiian organizations which bring to the project extensive experience in all aspects of geothermal exploration, development, transmission facilities/power plant design and construction, environmental impact analysis, and operations. These organizations are:

- Mesquite Group, Inc. - Geothermal resource exploration/development/operations consultants
- POWER Engineers, Inc. - Power transmission/plant engineering consultants
- Edward K. Noda and Associates, Inc. - Environmental and ocean engineering consultants

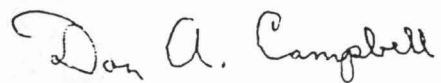
Most of the key technical members of the proposed team have specific Hawaiian experience, including resource assessment/development/operations consulting related to KERZ development and planning/design consulting for the geothermal/cable project. We believe this team to be exceptionally well qualified to perform the desired scope of work. The individual team members

Mr. Murray E. Towill
April 24, 1991
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are practically oriented, but innovative. All enjoy sharing their knowledge and experience, and have a sincere desire to provide the consulting services DBED seeks.

If you have any questions or wish more detail on any aspect of this proposal, please contact me at (714) 738-8224 (FAX {714} 525-2852).

Sincerely,

A handwritten signature in cursive script that reads "Don A. Campbell".

Don A. Campbell
President

DAC:lwp

Attachment

**PROPOSAL FOR TECHNICAL ADVISORY SERVICES
RELATING TO GEOTHERMAL RESOURCE
ASSESSMENT**

Submitted to

**STATE OF HAWAII DEPARTMENT OF BUSINESS,
ECONOMIC DEVELOPMENT & TOURISM,
ENERGY DIVISION**

by

MESQUITE GROUP, INC.
221 North Harbor Boulevard
Suite "K"
Fullerton, California 92632

POWER ENGINEERS, INC.
3940 Glenbrook Drive
Hailey, Idaho 83333

**EDWARD K. NODA
AND ASSOCIATES, INC.**
615 Piikai Street
Suite #1000
Honolulu, Hawaii 96814

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**PROPOSAL TO THE STATE OF HAWAII DEPARTMENT OF BUSINESS,
ECONOMIC DEVELOPMENT & TOURISM
FOR
TECHNICAL ADVISORY SERVICES RELATING TO
GEOTHERMAL RESOURCE ASSESSMENT**

1.0 INTRODUCTION

This proposal has been prepared in response to the Department of Business, Economic Development & Tourism's (DBED's) Request for Proposal (RFP) dated March 29, 1991, to provide Technical Advisory Services Relating to Geothermal Resource Assessment. The proposal is submitted by the following group of companies:

Mesquite Group, Inc.
221 North Harbor Blvd., Suite "K"
P. O. Box 1283
Fullerton, CA 92632
(714) 738-8224
FAX (714) 525-2852

Edward K. Noda and Associates, Inc.
615 Piikai St., Suite #1000
Honolulu, HI 96814
(808) 533-0553
FAX (808) 524-1126

POWER Engineers, Inc.
3940 Glenbrook Drive
P. O. Box 1066
Hailey, ID 83333
(208) 788-3456
FAX (208) 788-2082

The firms comprising the group combine the talents of geothermal exploration and development geologists and engineers, power transmission engineering-constructors, and environmental/geotechnical engineering specialists. In addition to an extensive geothermal technology background, most members of the team have specific knowledge of Hawaii geothermal resource development activities and/or the geothermal/cable project. The team was carefully selected to encompass the diverse experience and knowledge needed to provide a comprehensive evaluation of the geothermal resource characteristics and potential within the State of Hawaii. We believe that this versatile group is exceptionally well qualified to advise the DBED and Department of Land and Natural Resources (DLNR).

The proposal which follows responds to the complete range of the RFP requirements. It first provides a description of the qualifications and experience of the firms and individuals involved. This is followed by a discussion of how the team will work towards accomplishing the defined project objectives in terms of organization, management, and responsibilities relative to the specified scope of work and desired products. The accessibility and responsiveness of the team is then discussed, followed by short discussions of billing rates/expenses and conflict of interest status. Appendices contain detailed resumes for key technical personnel and detailed experience listings.

2.0 QUALIFICATIONS AND EXPERIENCE

The qualifications and experience of the firms and individuals proposed for work on this project are summarized below. Detailed experience summaries and resumes for the personnel proposed to work on this project are contained in Appendices A and B.

2.1 FIRM DESCRIPTIONS AND GENERAL EXPERIENCE

- MESQUITE GROUP, INC.

Mesquite Group, Inc. (Mesquite) is a California corporation formed in October 1985, for the purpose of providing exploration and development consulting and operating services to the geothermal and petroleum industries. The company is based in Fullerton, California, and maintains an operations office in Bakersfield, California. Mesquite personnel are mainly derived from the group of technical geothermal experts formerly with Republic Geothermal, Inc.

Each of the three officers of the company has over 20 years of natural resource development experience in engineering and/or operations management. They possess specialized skills in management, reservoir engineering, production engineering and field operations supervision. Five other professional employees or associates are currently available with expertise in exploration and production geology, geochemistry, drilling engineering and supervision, production operations, well logging, and reservoir engineering. While most of these professionals had their early experience in the petroleum industry, each has specialized for a number of years in geothermal exploration and development.

Mesquite provides comprehensive geothermal resource expertise, but emphasizes high-quality, cost-effective resource evaluation and development because of the extensive "hands on" experience of its staff. Using its own personnel and equipment or supervising well-qualified subcontractors, the company provides the following services:

- Exploration program management, surveys (geothermal, geoelectrical, seismic, gravimetric, magnetic, temperature gradient) and data interpretation
- Prospect identification, geologic mapping, and well siting
- Well drilling management, engineering, on-site supervision and well-site geology

- Open and cased-hole logging supervision and interpretation
- Well completion, stimulation, pump installation, workover engineering and on-site supervision
- Design of well, reservoir and fluid testing programs and facilities
- Installation and operation of well testing and water treating facilities
- Sampling, analysis and interpretation of fluid chemistry
- Numerical wellbore flow simulation
- Numerical reservoir simulation (thermal and isothermal)
- Well and reservoir forecasts and reserve estimates
- Project evaluation and planning (technical and economic)
- Project engineering and management for field development and operations
- Automated data gathering, software development and data management
- Financial feasibility analysis and reporting
- Expert testimony and presentations for court and regulatory hearings

Past geothermal efforts of Mesquite (or Mesquite staff members while at Republic) have involved exploration, drilling, testing and evaluations in more than 60 different geothermal fields. Most of these resources have been located in the western United States, (i.e., California, Nevada, Alaska, Idaho, New Mexico and Oregon). The staff also has extensive experience in Japan and the Philippines, and lesser experience in Central America and the Caribbean. Overall, the personnel at Mesquite have been responsible for numerous exploration surveys, discovery of seven new geothermal fields, over 250 gradient holes, 66 full-size exploration or development wells, nearly 200 well tests, 50 well workovers (repairs), pump installations, or stimulation jobs, and over 200 special studies or evaluations. Geothermal resources encountered have been virtually all types and have ranged from moderate temperature, fresh waters in sandstones and fractured volcanics to ultrahigh-temperature, hypersaline-corrosive brines in deep, fractured metasediments and volcanics. Mesquite has successfully drilled and tested geothermal wells in some of the most environmentally sensitive areas of the world, including urban environments, as well as in areas that are extremely remote and/or subject to very hostile weather conditions. A summary tabulation of most of Mesquite's major geothermal project experience is provided in Appendix B.

- **POWER ENGINEERS, INC.**

POWER Engineers, Inc. (POWER) is an employee-owned engineering consulting firm specializing in design and construction management services for:

- Power Transmission and distribution lines
- Geothermal generating systems
- Industrial plant facilities
- Co-generation facilities
- Substations
- Telephone/data transmission lines

In only 14 years, POWER has grown from a two-engineer firm to its present prominence as a utility engineer with more than 250 employees. This growth is testimony to POWER's high quality of workmanship and the ability of its staff to provide clients with needed services within their schedules and budgets.

POWER's staff consists of professional engineers, surveyors, designers, managers and support staff experienced in all phases of project development, including conceptual design, feasibility studies, capital estimating, detailed design, siting and permitting, contract preparation, equipment selection and procurement, construction management, startup, commissioning, and performance testing.

POWER is one of the most experienced geothermal system engineers in the U.S. POWER's personnel have carried out pioneer work in specialized designs for handling scale-prone resources, and have been involved in the design of most of the major fluid-dominated gathering systems developed in North America. A detailed listing of POWER's geothermal related experience is contained in Appendix B.

POWER personnel are familiar with fluid-dominated, two-phase, dry steam, flashed steam, binary cycle, hybrid system and modular (wellhead) technologies. POWER is particularly skilled in the following specialty areas of geothermal system design and development:

- Feasibility Studies and Coast Estimates
- Pilot Plant Design for Scale Testing and Resource Evaluation
- Pipeline Route Selection and Field Surveys
- Two-Phase Gathering Systems
- Injection Systems

- Piping Supports and Structure Design
- Plant Troubleshooting and Optimization
- Engineering for Control systems and Wellhead Electrics
- Scale and Corrosion Control
- Noncondensable Gas Removal
- Hydrogen Sulfide Abatement
- Conceptual Designs and Estimating
- Environmental and Regulatory Services

POWER Field Services is a recently formed subsidiary of **POWER Engineers** which offers construction management and inspection services, furnishes field services for turnkey projects, and provides actual project construction. **POWER Field Services** was developed to meet the changing needs of its clients and is dedicated to construction and field activities. The company has already developed an impressive list of clients and projects throughout the country.

- **EDWARD K. NODA AND ASSOCIATES, INC.**

Edward K. Noda and Associates, Inc. (EKNA) is a Hawaiian-based company specializing in coastal and ocean engineering in the Pacific Basin. The company has extensive experience and capabilities in all the fundamental areas of coastal and ocean engineering including the following:

- Oceanographic design criteria evaluation including deep-water tropical cyclone and hurricane generated wave hindcasting, analytical transformation to nearshore locations using processes of wave refraction, diffraction, shoaling and breaking, storm surge numerical modeling, wave setup processes, overland flooding processes, analysis of forces and loads on structures and breakwaters, marina and harbor planning and design, and littoral drift and coastal erosion processes.
- Computer modeling of ocean processes including circulation flows driven by tides and winds, effluent plume models for ocean outfall discharges of both wastewater and heated water from power plants, turbidity dispersion models for such processes as manganese crust and nodules mining and discharges, dumping of dredged spoils from harbor dredging operations, stormwater discharges and turbidity generated by offshore construction activities.
- Extensive field data acquisition capabilities including bathymetry and sub-bottom seismic surveys, current and wave measurement programs,

oceanographic and water quality field measurement surveys, and diving and underwater inspection services.

- Environmental Assessment and Environmental Impact Statement development combining the evaluations and results of the above technical areas.

A detailed listing of EKNA's underwater cable and related oceanographic information systems experience is included in Appendix B.

2.2 EXPERIENCE SPECIFICALLY RELEVANT TO HAWAII

- Mesquite Group, Inc.

Mesquite is currently employed as a consultant for Constellation Energy, Inc. (CEI), the equity partner of Ormat Energy Systems, Inc. (OESI) in the Puna Geothermal Venture. OESI, as the partnership operator, is currently developing a 25 MW_e project in the Puna area of the Kilauea East Rift Zone (KERZ). As CEI's consultant, it is Mesquite's job to review and comment on OESI's resource evaluations and field development plans, monitor field development operations, and evaluate results. Mesquite has also been instrumental in analyzing and making recommendations to eliminate or minimize a number of problems experienced by OESI in their initial phases of development. In performing this function, Mesquite has become very familiar with most of the published and proprietary reports and well data dealing with the KERZ, the HGPA project, and the SOH drilling and testing project, as well as the PGV project.

Mesquite is also currently the prime contractor for an eleven prospect geothermal resource assessment review project in the Philippines. This project is analogous to the Hawaii project in terms of its geologic setting in that all the prospects are located on the flanks of volcanic islands. It is also similar in that it involves regional exploration and assessment, as well as prospect specific evaluations and provision of state-of-the-art guidance to upgrade the Philippines evaluation technology and operating practices. The client in this case is the Philippine National Oil Company (PNOC), a quasi-government agency. Mesquite reports will serve as the third-party review required for PNOC to receive several hundred million dollars in loans from the World Bank for development of over 1000 MW_e of geothermally generated power by the year 2000.

In the past, Mesquite personnel have also conducted exploration programs in Alaska and Japan in geologic settings analogous to Hawaii's. Both programs resulted in geothermal field discoveries. Of particular note was the work in Japan, wherein Mesquite personnel were the principal consultant's to the Japanese Government (MITI) for a program of nationwide

geothermal exploration. In addition to providing oversight of a multitude of contractors employing virtually every exploration technique known, Mesquite personnel integrated all the gathered data into regional models which identified 21 major prospect areas.

- **POWER ENGINEERS, INC.**

Mr. David O'Day, POWER's Geotechnical Services Manager, has been directly involved in a number of projects in the Hawaiian-Islands for prior employers. Most important with respect to this project was his work as Test Director for the Hawaii Deep Water Cable Program during 1988 and 1989 for Hawaiian Dredging and Construction Company. This was, of course, the \$22 million demonstration project to test the feasibility of installing a 500 MW direct current transmission system between the island of Hawaii and Oahu, a prerequisite to the extensive development of the geothermal potential of Hawaii. The project's principal challenge was the installation of the cable system across the Alenuihaha Channel -- 6,500 feet deep, rocky, and very steep. Previously, the deepest cable installation was 1,800 feet deep. Mr. O'Day was responsible for planning scheduling and monitoring vendor and subcontractor performance, project administration and management, review of progress, supervision of designs, details, and reports, and preparation of reports to the clients.

Other Hawaiian and related projects Mr. O'Day has been involved in include: geotechnical engineering for numerous building projects in Honolulu; project manager/engineer for the design and construction of the AFDM berthing wharf at Pearl Harbor; project manager/engineer for the Kaneohe-Kailua Flood Control project on Oahu; project manager/engineer for transmission line reconstruction on Guam; and foundation engineering for the Koolau Ridgeline project transmission line, the Kahe Power Plant and the Kahului Power Plant.

POWER, as a company, also has some related Hawaiian experience involving determination of the structural integrity of a 46-year old 57 kV transmission line and design of a new 69 kV transmission line for Kauai Electric. In addition, the transmission-distribution engineer, electrical engineer and senior systems engineer proposed for work on this project by POWER have extensive experience in all aspects of power transmission line design and construction for systems throughout most of the western U.S.

- EDWARD K. NODA AND ASSOCIATES, INC.

EKNA was a significant participant in the Hawaii Deep Water Cable Program completed last year. They had a number of major task responsibilities, including extensive field measurements of waves and near-surface currents (2 years) and near-bottom currents along both the Hawaii and Maui slopes of the channel (2 years), the development of the oceanographic and environmental design criteria for the at-sea operations, the design, fabrication and operation of a high-resolution bottom roughness measuring system which obtained excellent bottom roughness data with operational resolutions of 4-6 inches in water depth of 6,000 ft and the design, fabrication and operation of the entire data acquisition system during the At-Sea Test including wind, waves and current data and all technical parameters associated with the cable laying operation. EKNA was also responsible for the analysis of oceanographic data from the At-Sea Test Program and assisted in the development of the Final Report dated September 1990. In addition to the Final Report preparation, EKNA also performed many additional final tasks, including the feasibility and cost estimates for the trenching and burial of the power cable along the coastal and nearshore areas.

EKNA is currently working on the Tri-Island Cable project for HECO, and has technical responsibility for:

- Development of the oceanographic design criteria for the underwater cable system, including both the deep water and nearshore areas. This effort includes the hindcasting of hurricane design wave conditions, the transformation of deep-water wave conditions to their shallow-water characteristics, calculation of wave forces, evaluation of scour protection, tsunami wave evaluations, etc.
- Field measurement of ocean currents along 5 potential underwater routes. This program involves the deployment of 12 current meters on 9 individual moorings along 5 proposed underwater routes between the 3 islands.

In addition to these submarine power cable projects, EKNA has performed numerous oceanographic studies in the islands and has developed many related Environmental Assessments and Environmental Impact Statements.

2.3 KEY TECHNICAL PERSONNEL

The experience histories and background of each of the key technical personnel proposed for work on this project are summarized below. Detailed resumes are contained in appendix A.

- Mesquite Group, Inc.

DON A. CAMPBELL (PRESIDENT) - PROJECT MANAGEMENT AND RESERVOIR ENGINEERING

Prior to forming Mesquite, Don was the Vice President at Republic Geothermal in charge of all aspects of geothermal engineering and operations for nine years. He came to Republic from Shell Oil with thirteen years experience in management and reservoir engineering emphasizing supplemental recovery research and operations, reservoir simulation, and evaluation of producing properties and exploration prospects. In addition to project management for clients and administration of the Group, Don provides design and interpretation of well tests, reservoir simulation studies, production/reserve evaluations, field development planning and economic analyses. He holds an MS degree in Oceanography from Scripps Institution of Oceanography, University of California, San Diego.

JOSEPH "SKIP" MATLICK (SENIOR GEOLOGIST - EXPLORATION AND PRODUCTION GEOLOGY

Skip has over fourteen years experience in the exploration and development of geothermal resources throughout the western United States and Japan. During his ten years at Republic Geothermal he participated in the discovery of seven geothermal reservoirs having commercial potential and the development of five of these reservoirs. Skip is a recognized expert in the mercury soil gas exploration method and has supervised and interpreted numerous geophysical, geochemical and aerial exploration surveys. He has also sited and directly supervised the drilling of over 200 temperature gradient holes. His experience in development geology includes well siting, evaluating wells during drilling, and interpreting lithology and electric logs to construct subsurface maps. Skip is a state registered Geologist and a licensed Driller, and holds an MS degree in Geology from Arizona State University.

DONALD E. MICHELS (ASSOCIATE GEOCHEMIST) - GEOCHEMICAL ENGINEERING

Don is the Group's expert on geothermal water, scale and gas chemistry. In eight years with Republic geothermal he made major contributions to the development of geochemical technology in the industry and is a recognized authority on carbonate chemistry. He provides chemical assessments and technical support for investigating

all aspects of geothermal fluid behavior in well bores and surface facilities, including scale deposition and control, two-phase flow modified by gases and dissolved salts, corrosion, brine processing, minerals recovery, brine disposal and environmental impacts. Prior to joining Republic, Don worked in various earth science, materials development and environmental research capacities at INEL, DOW chemical, and the National Academy of Sciences. He holds a DSc from Colorado School of Mines in Chemistry-Geology.

THOMAS L. COOK (ASSOCIATE DRILLING ENGINEER) - DRILLING ENGINEERING AND DRILLING MANAGEMENT

Tom has nearly thirty years of drilling experience with Mobil, Husky, Aminoil, and Republic Geothermal. He has directed drilling and production operations throughout the western United States and Japan, and managed multi-million dollar budgets and staffs as large as 225 employees. For the Group's clients, Tom offers well design and planning, drilling contractor and materials selection, drilling supervision and complete management of drilling operations. He is a state licensed Drilling Contractor and holds a BS degree in Petroleum Engineering from the University of California, Berkeley.

ROBERT V. VERITY (VICE PRESIDENT, ENGINEERING) - PRODUCTION ENGINEERING

Bob provides general engineering management for the Group, specializing in all aspects of well completion, testing and workovers. During nine years with Republic Geothermal he designed and supervised numerous geothermal well test facilities, well tests, stimulation jobs, well workovers and pump installations. Prior to that he had over ten years engineering and research experience with Shell Oil in field facilities construction, well completion design, well workovers, well stimulation and well artificial lift design for conventional and steam-enhanced oil production. Bob is a state registered Mechanical and Petroleum Engineer, and holds an MS degree from Stanford University in Mechanical Engineering.

PAUL B. SPIELMAN (MECHANICAL ENGINEER) - PRODUCTION ENGINEERING AND LOG ANALYSIS

Paul specializes in production engineering and reservoir engineering computer applications, thermodynamic analyses, interpretation of open hole geophysical logs and production logs, and the engineering aspects of field operations. Prior to

joining Mesquite he had two years' experience at Republic Geothermal with similar responsibilities. Paul was a Senior Field Engineer with Schlumberger Well Services for the three years preceding his work at Republic, and was in charge of running and interpreting all types of well logs. He is a state registered Mechanical Engineer, and holds an MS degree in Mechanical Engineering from San Diego State University.

- **POWER Engineers, Inc.**

DAVID O'DAY (MANAGER GEOTECHNICAL SERVICES) - PROJECT MANAGEMENT AND GEOTECHNICAL ENGINEERING

Dave has over 20 years experience managing and conducting geotechnical investigations, construction inspection, contract administration and construction management for a wide variety of projects, including electric power generation, transmission and distribution systems. He worked for Dames & Moore in Hawaii as a Geotechnical Engineer in 1972 and from 1974 to 1981. During these periods, he participated in numerous industrial, defense, government and residential projects on all the principal Hawaiian islands and throughout the Pacific. During 1988 and 1989, he was the Hawaiian Dredging and construction Company's Senior Project Engineer and Test Director for the Hawaii Deep Water Cable Program. Dave is a registered Geotechnical Engineer in California and a registered Civil Engineer in Hawaii, and holds an MS degree in Geotechnical Engineering from the University of California, Berkeley.

DONALD ANGELL (SENIOR SYSTEMS ENGINEER) - SYSTEMS ENGINEERING FOR POWER TRANSMISSION LINES AND FACILITIES

As POWER's Senior Systems Engineer, Don performs the full spectrum of studies and analyses related to electrical system study, design and protection. He has conducted numerous system feasibility and planning studies, work plans, long-range plans, load flow studies, short-circuit and protection analyses, etc., for utility and industrial clients. He has designed sophisticated relaying packages for looped transmission systems, protective schemes for radially fed transmission and distribution lines, and station protective relaying, metering, and control systems. In addition, Don has researched and designed systems to mitigate the effects of switching surges, transient voltages, and lightning strikes on power facilities. Other systems engineering experience includes determination of BIL and insulation coordination requirements for line and station components, large station equipment

specification, RI and TVI studies, SCADA system design, communications system design, and fiber optics analysis. Don has also written and presented technical papers ranging from the effects of large cyclic loads on rural distribution systems to DC excavator impacts. He is a registered engineer in Alaska, California, Idaho, and Nevada, and holds an MS degree in Electrical and Computer Engineering from the University of Idaho.

LESLIE BELL, JR. (ELECTRICAL ENGINEER) - ELECTRICAL ENGINEERING FOR POWER TRANSMISSION AND DISTRIBUTION SYSTEMS

Prior to joining POWER Engineers, Leslie acquired twenty years of electric utility engineering operations and management experience. This experience includes fourteen years with Utah Power & Light Co., a large investor-owned utility headquartered in Salt Lake City, Utah, and six years with Lower Valley Power and Light, a rural electric cooperative headquartered in Afton, Wyoming. His positions in the utility industry have ranged from Junior Engineer to executive level positions.

Specific duties while employed with Utah Power & Light Co. included preparing and supervising the preparation of generic material, construction and application specifications for 7.2/12.47kV and 14.4/24.9kV overhead, and underground distribution systems. Additional duties included project identification, budgeting, engineering design, trouble shooting, construction contract preparation and construction management for the 4.16/7.2kV and 7.2/12.47kV underground distribution and 69kV transmission systems serving the downtown commercial areas of Salt Lake City, Utah, and Ogden, Utah. Leslie holds a BS degree in Electrical Engineering from the University of Utah.

JOHN MCGREW (TRANSMISSION-DISTRIBUTION ENGINEER)

Prior to becoming a Project Engineer for POWER, John acquired valuable practical experience in the electrical engineering field, first as a construction supervisor and then as a transmission/distribution designer. This solid background in construction and design has proven invaluable in the performance of his present duties, which involve the day-to-day coordination and facilitation of all tasks involved in the conduct of a utility project, from conceptual planning through energization of facilities. John's knowledge of the design and construction process allows him to anticipate and address potential problems in those critical project areas, thus

avoiding costly delays and ensuring a project's timely and successful completion. Specific project engineering responsibilities include project scheduling and cost estimating; monitoring and expediting the permitting and right of way acquisition processes; design coordination and final review; interfacing with the client, contractor and other involved agencies; and budget and schedule monitoring. John holds a BS degree in Mechanical Engineering from San Diego State University.

- **Edward K. Noda and Associates, Inc.**

JAMES G. DITTMAR (EXECUTIVE VICE PRESIDENT) - PROJECT MANAGEMENT AND ENVIRONMENTAL ENGINEERING

Jim has twenty-four years experience in the preparation of Planning Studies, and Project Management of Environmental Programs, Alternative Energy Systems Programs, and Transportation and Infrastructure development projects. He has worked in Hawaii since 1974, and became Executive Vice President of EKNA in 1987. He is a member of the Governor's Geothermal Advisory Committee, the Governor's Committee for Hawaii's Economic Future, and the Selection Committee for Fellow in Renewable Energy Engineering, University of Hawaii. Jim was also Chairman of the fund Raising Committee for the 1985 and 1990 International Geothermal Symposium, Kailua-Kona, Hawaii. He holds a B.A. degree in Zoology from the University of Southern California, and has done graduate studies in Oceanography and Marine Biology at the University of Southern California, the University of California at Los Angeles and California State College, Long Beach, California, as well as graduate studies in Business Administration at the University of Hawaii.

ALLAN F. DIVIS (PROJECT MANAGER) - ENVIRONMENTAL AND GEOTECHNICAL ENGINEERING

Allan Divis has over twenty years of diversified experience in geotechnical and environmental studies for hazardous waste, mining, and civil engineering projects. He has an extensive background involving the practical field application of multi-disciplinary analytical techniques in remote site areas in the conterminous U.S., Alaska, South and Central America, and the South Pacific. Allan joined EKNA in 1990 as a Project Manager. He is a registered Geologist in Alaska, Arizona, California and Oregon, and is a registered Engineering Geologist in California. Allan holds a Ph.D. in Earth Sciences from the Scripps Institution of Oceanography, University of California, San Diego.

3.0 APPROACH TO ACHIEVING PROJECT OBJECTIVES

3.1 MANAGEMENT AND ORGANIZATION

The fundamental project objectives as stated in the RFP are: "(1) to determine the extent of geothermal resources within the state; and (2) to learn as much as possible about the characteristics of those resources." Inasmuch as the emphasis is on resource assessment rather than the geothermal/cable project, it is proposed that Mesquite act as the prime contractor for the project, having overall responsibility for management, coordination, and administration. In many respects POWER and EKNA will conduct the required work on the geothermal/cable project separate from Mesquite's resource assessment efforts because of the natural division of technical specialties. However, the three firms and their staffs will work as a team whenever possible, drawing upon and integrating technical resources to achieve the appropriate level of expertise.

Don Campbell, Mesquite's President, will be the overall Project Manager and provide the main interface with the DBED and DLNR, as well as the various other State and Federal agencies, academic institutions, and private developers involved in Hawaii's geothermal activities. He will also, of course, manage Mesquite's resource assessment activities. Dave O'Day, POWER's Geotechnical Services Manager, will act as the manager of POWER's engineering efforts relative to the planning and design of the geothermal/cable project. Jim Dittmar, EKNA's Executive Vice President, will manage EKNA's engineering assessment of the geothermal/cable project master plan and EIS being prepared by ERCE. Jim will also act as the local liaison with the DBED and DLNR, and facilitate communications between all parties. This structure is reflected on the following organization chart along with all the key technical personnel and their respective specialties.

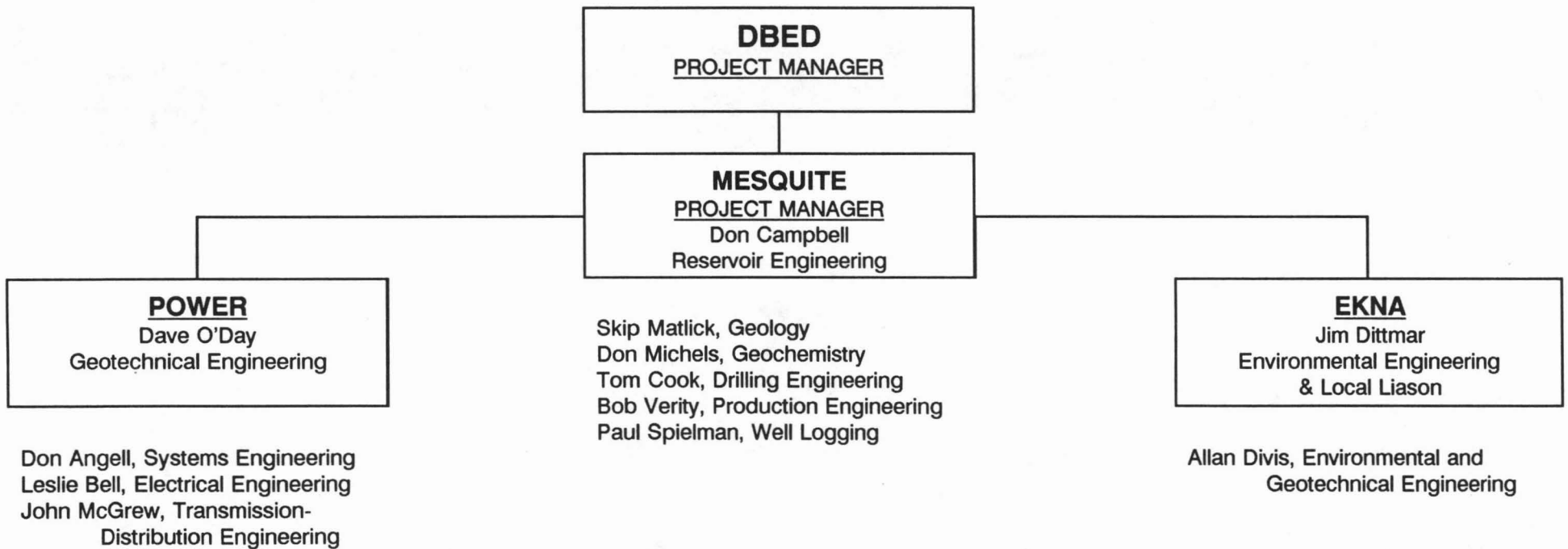
3.2 RESPONSIBILITIES

The proposed specific technical responsibilities of firms and individuals are summarized below relative to the Scope of Work and the Anticipated Work Efforts and Products from the RFP. It should be noted,

ORGANIZATION CHART

FOR

TECHNICAL ADVISORY SERVICES RELATING TO GEOHERMAL RESOURCE ASSESSMENT



however, that in many instances the work requires a team effort and others may contribute to some tasks besides the staff member(s) with the designated responsibility.

• <u>Scope of Work</u>	<u>Technical Responsibilities</u>	
	<u>Firm</u>	<u>Personnel</u>
• assist DBED and DLNR in establishing priorities among available resource assessment methods, including (as examples): exploratory drilling; core-sampling and well-testing; surface and aerial surveys; and regional mapping. Guidance in this regard must be sensitive to budget constraints.	Mesquite	Campbell Cook Matlick Verity Spielman
• assist DBED and DLNR in planning the direction of and managing the SOH program and in evaluating available exploratory drilling methods, with cost effectiveness being a major criterion.	Mesquite	Cook Matlick
• assist DBED and DLNR in designing and planning appropriate well test, surface and aerial surveys, and/or mapping projects. Provide advice on appropriate instrumentation and equipment, methods and procedures, personnel, and budgets.	Mesquite	Verity Matlick Spielman
• assist DBED and DLNR by providing technical guidance relative to the geothermal/cable project master plan and EIS being prepared by the consulting firm ERCE.	EKNA	Dittmar Divis
• assist DBED and DLNR by providing technical guidance relative to planning and design of the geothermal/cable project by the consortium and HECO.	POWER	O'Day Angell Bell McGrew
• assist DBED and DLNR to make reasonable judgments and to reach objective, scientifically supported, conclusions about the extent and characteristics of geothermal resources, recognizing that such judgments and conclusions may serve as the basis for public policy and/or investment decisions.	Mesquite	Campbell Matlick Michels

- advise DBED and DLNR on well-field design and management in order to assist them in adopting appropriate policies, standards, and design criteria to avoid over-production and premature depletion of geothermal resources. Mesquite Campbell Verity

- Anticipated Work Efforts and Products

Technical Responsibilities
Firm Personnel

- attendance upon request at key meetings of State interagency technical and policy committee involving DBED, DLNR, other State agency officials, and, on appropriate occasions, representatives of involved institutions such as the University of Hawaii and USGS. Mesquite Campbell POWER O'Day EKNA Dittmar Others, as appropriate

- preparation, as needed, of written reports addressing specific aspects of or problems concerning resource assessment work in progress and making specific recommendations. Mesquite Campbell Others, as appropriate

- submission, on or before December 1, 1991 (approximately one month prior to the start of the 1992 legislative session), of an interim draft written report on geothermal resource assessment, consisting of the following information: (1) a status report on the State's geothermal resource assessment program; (2) a description and brief analysis of available data and information from all public and accessible private sources; and (3) a summary of reasonable judgments and objective conclusions which the consultant is able to make from the available data and information about the extent and nature of geothermal resources. Mesquite Campbell POWER O'Day EKNA Dittmar

- submission, at least 45 days prior to the end of the one-year contract term, of a draft annual report on geothermal resource assessment including the following kinds of information: (1) a status report on the State's geothermal resource assessment program; (2) a comprehensive analysis of available data and information from all public and accessible private sources; (3) a summary of reasonable judgments and objective conclusions which Mesquite Campbell POWER O'Day EKNA Dittmar

the consultant is able to make from the available data and information about the extent and nature of geothermal resources; (4) a discussion of the accomplishments of the consultant in assisting the program during the contract term; and (5) recommendations with regard to future needs, priorities, and plans. DBED will work cooperatively with the consultant during the early part of the contract term to develop an outline for this report in order to make it as meaningful as possible. The report should address each of the elements covered by the foregoing scope of work.

- submission, at least 5 days prior to the end of the one-year contract term, of a final resource assessment report, incorporating any changes suggested or required by DBED.
- | | |
|----------|----------|
| Mesquite | Campbell |
| POWER | O'Day |
| EKNA | Dittmar |

It is anticipated that a significant portion of the work required to properly advise the DBED and DLNR and generate the specified reports will involve an extensive literature search, gathering of other pertinent data, and discussions with the various participants in the State's geothermal activities. EKNA will perform much of the initial literature search and data gathering to minimize costs, but after initial analysis a number of the Mainland based key personnel will need to travel to Hawaii for in depth discussions relative to their particular specialties. Subsequent updating and detailed analysis can probably be handled in the team's respective home offices for the most part. Attendance at meetings as requested by DBED and DLNR should generally provide ample opportunity to update and expand the data base during the course of the contract term without additional special trips from the Mainland.

4.0 ACCESSIBILITY AND RESPONSIVENESS

EKNA will provide expert local representation of the team and ready accessibility for the DBED and DLNR. They can attend meetings on short notice and facilitate communications between all parties. Even the Mainland based team members will be able to attend meetings as needed with two days notice in almost all instances. Back-up expertise is also available within each team member organization in the unlikely event that a key technical person assigned to the project is unavailable for a short period. Both Mesquite and POWER are accustomed to working with clients remotely located from their home offices, having successfully concluded or actively working on projects in Asia, Latin America, and Alaska. With today's telephone, FAX, and overnight delivery services, and frequent Mainland/Hawaii and inter-island flights, communications, accessibility, and responsiveness on a timely basis is not expected to be a problem.

5.0 BILLING RATES/EXPENSES

5.1 LABOR COSTS

Standard schedules of charges for each of the team member firms providing hourly labor costs by person and/or category follow on successive pages. In order to make the team's services more cost effective, it is proposed that travel time from the Mainland to Honolulu (and return) will not be charged. Further, it is proposed that a maximum of eight hours per day will be charged while in Hawaii, even if overtime hours are worked.

5.2 EXPENSES

It is difficult to estimate expenses as requested in the RFP, as the number of trips and travel days for Mainland based personnel are not yet definable. Recent experience has also shown that airfares from the Mainland to Honolulu are highly variable, depending upon how far in advance bookings can be made with certainty. Since the beginning of the year, Mesquite has paid from less than \$400 to over \$1,100 for round trip airfares between Honolulu and Los Angeles. However, assuming pre-paid bookings at least three days ahead of departure (with a firm return) date and a typical five working-day trip, the per man cost would be about:

Airfares to Honolulu/Los Angeles	\$ 650	(round trip)
or Honolulu/Boise	1,000	(round trip)
and Inter-island	100	(if required)
Per Diem (lodging, meals, phone, incidentals)	625	(5 days)
Car Rental	125	(5 days)
Mileage/Airport Parking	<u>50</u>	(Mainland)
Total	\$1,450 to \$1,900	

Assuming two man-trips per month on average for Mainland based personnel during the twelve month term of the contract, travel expenses might be on the order of \$37,000. In addition EKNA will have local mileage and inter-island travel expenses (say, \$200/month). There would also be miscellaneous office expenses

for phone, FAX, overnight deliveries, etc., estimated to be about \$150/month. With a 10% handling charge on expenses, a total expense budget of around \$45,000 for the contract term might be a reasonable expectation.

In reality, expenses will be highly dependent on whose expertise is required by DBED and DLNR at meetings, how often it is required, and how much notice of a firm schedule can be provided. The team will make every effort to minimize expenses, especially airfares, but cannot estimate expenses more definitively at this time.

MESQUITE GROUP, INC.
SCHEDULE OF CHARGES

(Effective July 1, 1990)

<u>Professional Services</u>	<u>\$/Hour^{1 2}</u>
D.A. Campbell Project Management, Reservoir Engineering	85.00
T.L. Cook Drilling Engineering and Management	85.00
D.E. Michels Geochemical Engineering	85.00
R.V. Verity Engineering Management, Production Engineering	75.00
C.E. Fisher Field Construction and Operations Supervision	65.00
S. Petty Reservoir Engineering, Hydrology	65.00
J.S. Matlick Geology, Geochemistry	65.00
P.B. Spielman Production and Logging Engineering	55.00
 <u>Clerical Services</u>	 25.00
 <u>Expenses</u>	
Mileage	\$0.30/mile
Other Direct Costs ³	Cost to MGI plus 10% for handling

Notes:

¹ Includes salary, burden, G & A, in-house computer, and fee.

² Maximum service charge for *field work* is ten hours per day, even if more hours worked.

³ Other Direct Costs include the costs of travel, reproduction, FAX and telephone, plus all outside services, subcontracts and purchased materials billed through Mesquite Group, Inc.

POWER Engineers, Inc.

SCHEDULE OF CHARGES - 1991

This standard Schedule of Charges is for professional services. Unless agreed otherwise, charges for work on continuing projects will be based on the then current Schedule of Charges. A new Schedule of Charges will be issued to be effective January 1 of each new year and as necessary on an intermediate basis to accommodate new items or revised charges. Invoices will be submitted monthly and/or upon completion of the work and will be due and payable when issued. All accounts not paid within thirty (30) days from the invoice date will bear a **SERVICE CHARGE OF 1.5% PER MONTH** for each month the invoice is unpaid.

PERSONNEL CLASSIFICATION

Senior Project Manager	\$ 97.00/hr.
Principal Consultant	
Project Manager	\$ 87.00/hr.
Senior Consultant	
Project Engineer	\$ 77.00/hr.
Consultant	
Senior Project Administrator	
Supervisory R-O-W Agent	
Engineer III	\$ 68.00/hr.
Designer IV	
Engineering Technician IV	
Environmental Specialist III	
Senior R-O-W Agent	
Engineer II	\$ 59.00/hr.
Designer III	
Engineering Technician III	
Environmental Specialist II	
Purchasing Agent	
Senior Administrator	
R-O-W Agent	
Engineer I	\$ 49.00/hr.
Designer II	
Engineering Technician II	
Environmental Specialist I	
Administrator	
Field Representative IV	
Senior Purchasing Specialist	
Designer I	\$ 43.00/hr.
Engineering Technician I	
Administrative Assistant	
Field Representative III	
Purchasing Specialist	
Drafter	\$ 37.00/hr.
Staff Assistant	
Field Representative II	
Typist	\$ 27.00/hr.
Data Entry Operator	
Field Representative I	
Utility	

No premium is charged for overtime work. Personnel with specialized experience are employed by or on retainer to POWER. Charges for these specialists are negotiated on an individual basis depending on the assignment. Professional time for depositions and testimony is charged at 1.5 times the rate for services; full-day minimums apply.

POWER Engineers, Inc.

SCHEDULE OF CHARGES - 1991

This standard Schedule of Charges is for the current year. Unless agreed otherwise, charges for work on continuing projects will be based on the then current Schedule of Charges. A new Schedule of Charges will be issued to be effective January 1 of each new year and as necessary on an intermediate basis to accommodate new items or revised charges. Invoices will be submitted monthly and/or upon completion of the work and will be due and payable when issued. All accounts not paid within thirty (30) days from the invoice date will bear a **SERVICE CHARGE OF 1.5% PER MONTH** for each month the invoice is unpaid.

COMPUTER SERVICES

Apollo DN320 & DN300's	\$ 60.00/hr.
...includes software	
GIS Workstation	\$ 35.00/hr.
...includes software	
Engineering Workstation	\$ 35.00/hr.
...includes specialized software*	
Personal Computer	\$ 10.00/hr.
...includes standard software	
charges for special software will be added, see "Special Application Software Fee Rates".	
Drafting Station w/Software	\$ 20.00/hr.
...may include Procad, Autocad, Integraph	

SPECIAL APPLICATION PC SOFTWARE

Structure Spotting/Optimization**	\$ 60.00/hr.
Level I Software ***	\$ 10.00/hr.
Level II Software****	\$ 20.00/hr.

SURVEY SUPPLIES

Plastic Aerial Panels	\$ 3.50/ea.
Wood Stakes	\$ 8.50/bd.
4' Lath	\$ 12.50/bd.
Flagging	\$ 1.50/ea.
#5 x 20" Rebar	\$.50/ea.
Rebar Caps	\$ 30/ea.
Marking Paint	\$ 4.00/ea.
Field Books	\$ 5.00/ea.
GPS Equipment	\$1200.00/day

SURVEY EQUIPMENT

Survey Equipment to support field crew	\$125.00/day
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TRANSPORTATION

Cessna 210 (Wet, with Pilot)	\$205.00/hr.
Pilot Standby	\$ 30.00/hr.
Navajo	\$420.00/hr.
Vehicles	\$.28/mi.

TEST EQUIPMENT

	\$/Day	\$/Month
Current Transformer Test Set	\$150	\$ 1500
Doble Test System	\$160	\$ 1600
Oscilloscope	\$ 30	\$ 300
Strip Chart Recorder	\$ 40	\$ 400
Biddie DET-2	\$150	\$ 1500
Vibroground	\$ 10	\$ 100
RIS Loadlogger Kits	\$ 50	\$ 500
Oil Dielectric Tester	\$ 20	\$ 200
High Voltage Phase Rotation	\$ 15	\$ 150
Dynamometer	\$ 30	\$ 300
Phase Angle Meter	\$250	\$ 2500
Multiamp SR-76A	\$160	\$ 1600
Pole Tester	\$100	\$ 1000

PHOTOGRAPHIC RECORDING

Portable Video Camera	\$ 35.00/day
Video Tapes	\$ 8.00/ea.

REPRODUCTION

Blueprints (D size)	\$ 1.50/ea.
Mylar (D size)	\$ 4.00/ea.
Velum (D size)	\$ 2.50/ea.

CAMERA WORK

9" x 12" PMT	\$ 10.00/ea.
12" x 18" PMT	\$ 13.00/ea.
20" x 24" PMT	\$ 16.00/ea.
20" x 24" Mylar	\$ 16.50/ea.

DOCUMENTS

Copies	\$.10/ea.
Spiral Comb	\$ 5.00/ea.
3 Ring Binding	\$ 12.00/ea.

SHIPPING

Box or Tube	\$ 1.50/ea.
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Other expenses such as subcontractors, rental equipment, photography, transportation, rental vehicles, shipping, outside computer services, lodging, meals, other reproduction, long distance telephone, telecopier, express mail, courier/delivery service, special supplies, etc. are charged at cost plus a carrying and handling charge of 10%.

*Specialized software included in the UNIX Engineering Workstation fee are the following Integraph packages: MICAPLUS, MODELVIEW, INROADS, EESCHEMATIC, INSITE, IRASC, EEWPD, INFLOW, INFORMIX.

**Structure Spotting/Optimization will normally be billed on a specific project basis.

***Includes, among others Artemis, CPM, Traverse PC, Structural Design, Foundation Design, HVAC Design, and Conveyor Design.

****Includes, among others Distribution Power System Analysis, Piping Design, Cost of Service/Rate Review, Electrocon Transmission System Analysis and specialized estimating programs

EDWARD K. NODA and ASSOCIATES, INC.

SCHEDULE OF CHARGES

(1991)

Professional Services

\$/Hour

J.G. Dittmar

Project Management,
Environmental and
Alternative Energy
Engineering

97.00

A.F. Divis

Environmental and
Geotechnical Studies
Specialist

82.00

Clerical Services

27.00

Expenses

Mileage

\$0.32/mile

Other Direct Costs

Cost to EKNA plus 10% for handling

6.0 CONFLICT OF INTEREST

None of the firms or individuals proposed for work on this project have any interest in any private firms involved in geothermal exploration/development or the geothermal/cable project in Hawaii. However, two team members, Mesquite and EKNA are currently employed as consultants by private firms engaged in Hawaii geothermal activities. It is our view that such employment does not constitute any real or potential conflict of interest, but we wish to explain it in detail for completeness.

- Mesquite is currently a consultant to Constellation Energy, Inc. (CEI - a wholly owned subsidiary of Baltimore Gas and Electric) regarding the Puna Geothermal Venture (PGV) project. Constellation provides the equity investment funding for this project and is a joint venture partner with Ormat Energy Systems, Inc. (OESI), the project operator. The PGV project is actively developing a small area of the KERZ to supply resource to a 25 MW_e plant being constructed by the project. PGV also has leaseholds comprising several thousand acres in the KERZ. Mesquite's role is primarily to review OESI's resource assessment and development plans, monitor operations, evaluate results, and advise CEI with regard to such PGV development activities. In the past, but not currently, Mesquite has also worked directly for OESI on this and other geothermal exploration/development projects.

No conflict of interest is perceived, as even in the remote chance that Mesquite should become privy to some information of potentially competitive advantage to private developers as a result of working for the DBED, such information would be held confidential until published or otherwise made publically available by DBED. Maintenance of confidentiality is a normal requirement in the resource consulting business and would not be breached in anyway by Mesquite.

- EKNA currently has a very minor subcontract (\$5,000) with ERCE, the firm preparing the geothermal/cable project master plan and EIS. This minor relationship simply involves providing data, and will in no way influence EKNA's technical guidance to DBED/DLNR regarding the geothermal/cable project.

7.0 APPENDICES

7.1 KEY TECHNICAL PERSONNEL RESUMES

- Mesquite Group, Inc.
 - D.A. Campbell
 - T.L. Cook
 - J.S. Matlick
 - D.E. Michels
 - P.B. Spielman
 - R.V. Verity

- POWER Engineers, Inc.
 - D. O'Day
 - D. Angell
 - L. Bell, Jr.
 - J. McGrew

- Edward K. Nada and Associates, Inc.
 - J.G. Dittman
 - A.F. Divas

Mesquite Group, Inc.

MESQUITE GROUP, INC. - CLIENT/PROJECT LISTING

I. CURRENT MAJOR PROJECTS

CLIENT	PROJECT DESCRIPTION	SERVICES RENDERED	DATES	
			Initiation	Expected Conclusion
Philippines National Oil Company - Energy Development Corporation (Funded by U.S. Trade and Development Program)	Evaluate eleven prospective geothermal areas and develop the viable resources for electric power generation - Islands of Luzon and Leyte, Philippines	<ul style="list-style-type: none"> ●Prime contractor for a group of consulting firms providing complete technical review of PNOC-EDC's resource assessments and recommended development strategy. ●Project involves critical review of geological interpretations, geophysical and geochemical exploration results, well drilling and testing, reservoir engineering evaluations, development strategy planning and environmental impact mitigation. Resource assessment reports serve as basis for World Bank financing of field development and power plant construction. 	4/90	6/92
Pacific Energy - Subsidiary of Pacific Enterprises Corporation	Evaluate and develop geothermal field for expansion (2 additional power plants) - Casa Diablo Field, Mammoth Lakes, California	<ul style="list-style-type: none"> ●Prime contractor in charge of exploratory drilling, testing, and evaluation (2 wells). ●Assist in permitting for field development to support 2 new power plants. ●Upgrade instrumentation and monitoring programs for existing operations. Automate data gathering systems. ●Assess existing well operations and recommend/implement improvements. ●Conduct reservoir/well tests, construct numerical reservoir model, predict future performance, and estimate development costs. ●Prime contractor for development planning, well testing and evaluation for 15-well field expansion. ●Supervise start-up of expansion well field. ●Provide continued monitoring and analysis of field performance. 	1/86	Expansion completed 10/90 - Monitoring and analysis continuing

CLIENT	PROJECT DESCRIPTION	SERVICES RENDERED	DATES	
			Initiation	Expected Conclusion
Constellation Energy, Inc. - Subsidiary of Baltimore Gas and Electric	Develop additional (or new) geothermal resources for new power plants - Soda Lake Field, Nevada; Stillwater Field, Nevada; Puna Field, Hawaii; East Mesa Field, California	<ul style="list-style-type: none"> ●Review plans and monitor drilling, testing and evaluation activities of operator (Ormat). Recommend drilling targets and improvements in operating procedures. 	11/90	6/92
City of Colton/ California Energy Commission	Assess potential for direct use resource development in City and conduct feasibility study	<ul style="list-style-type: none"> ●Prime contractor for geochemical/geophysical exploration assessment, drilling of two exploration wells, and feasibility study for district heating system. 	1/91	3/92
SIGC Partners (Ormat Systems, Inc./Heber Geothermal Corp./ Centennial)	Develop up to 50 MW _e additional geothermal field capacity for new binary plant - Heber Field, Imperial Valley, California	<ul style="list-style-type: none"> ●Evaluate available data, revise numerical simulation model of field (Chevron's), run and evaluate feasibility of various development scenarios. ●Assist client in acquisition negotiations. 	6/89	6/91 Suspended during 1990, now active.
Sandia National Laboratories/U.S. Dept. of Energy	Develop cost data base for various geothermal regimes and incorporate into cost sensitivity studies to identify critical uncertainties requiring research.	<ul style="list-style-type: none"> ●Develop field cost data base and software algorithms. 	1/89	10/91
Harding Lawson Associates/Victor Fine Foods	Construct new waste treatment system and disposal well - Lodi, California	<ul style="list-style-type: none"> ●Provide waste injection well design and reservoir engineering calculations for EPA permit. Prime contractor for drilling and evaluation of well. Provide routine operations/regulatory monitoring. 	10/89	Well complete - Monitoring continuing
Radian Corp./Electric Power Research Institute	Prepare State-of-the-art manuals on 13 basic aspects of geothermal technology.	<ul style="list-style-type: none"> ●Subcontractor in charge of preparing volumes on reservoir assessment, well stimulation and geochemistry. Provide assistance to Radian for other volumes as requested. 	4/89	Geochemis-try complete - Others deferred

II. COMPLETED MAJOR PROJECTS

CLIENT	PROJECT DESCRIPTION	SERVICES RENDERED	STATUS
EG&G, Idaho/U.S. Air Force	Drill and test at least one geothermal exploration well - Ascension Island	<ul style="list-style-type: none"> ●Design well test plan and test facilities, fabricate equipment. Summarize, analyze and report test data. 	Complete
Ben Holt Co./ Utah Municipal Power Agency/MEI, Inc.	Drill, test, and evaluate additional outstep wells to support power plant expansion - Cove Fort Field, Utah	<ul style="list-style-type: none"> ●Design, supervise and evaluate well testing to verify resource. Review performance data and predict reserve. Formulate plans for development of deep, hot water resource. 	Complete
Bechtel National, Inc./U.S. Dept. of Energy	Conduct ±30 day test of completed, deep geothermal well - Salton Sea Scientific Drilling Project	<ul style="list-style-type: none"> ●Plan well test data gathering program, supervise data gathering, analyze test results and report. ●Assist Bechtel in facilities design and advise on operations. 	Complete
GEO Operator Corp.	Develop deep resource for 50 MW _e field expansion - East Mesa Field, Imperial Valley, California	<ul style="list-style-type: none"> ●Plan and conduct well tests and evaluation of four outstep wells. Conduct multiwell interference test. 	Complete
Pacific Lighting Energy Systems (now Pacific Energy)	Assess feasibility of PLES acquisition and development of various geothermal fields in the Western United States.	<ul style="list-style-type: none"> ●Review and summarize parameters of each available resource and estimate field costs for various development scenarios (6 properties/fields evaluated). 	Complete
Atlanta Gold Corp./ Strongbow Resources	Drill and evaluate ±30 core holes for gold content - Mono County, California	<ul style="list-style-type: none"> ●Supervise core hole drilling and geologic logging for assays. ●Conduct surface and subsurface geological mapping. 	Complete
Ben Holt Co./U.S. Energy	Develop field (production, injection and water source wells) to support new 7 MW _e plant - Brady Hot Springs, Nevada	<ul style="list-style-type: none"> ●Evaluate cooling water resource and predict well productivity. Revise production/injection well drilling programs and estimate well costs. 	Complete
Trendwest, Inc.	Explore for geothermal resource suitable for direct use industrial park - Olene Gap, Oregon	<ul style="list-style-type: none"> ●Design and supervise drilling of temperature gradient holes and resistivity surveys. Evaluate results. 	Complete

CLIENT	DESCRIPTION	SERVICES RENDERED	STATUS
GEO Operator Corp.	Evaluate treatment of produced fluids and direct injection of steam condensate - Geysers Field, California	<ul style="list-style-type: none"> ● Assess DOW treatment process. Model condensate and cooling water. Evaluate effects on materials. 	Complete
Catalyst Energy Corp.	Evaluate interest for acquisition - Vulcan Project, Salton Sea Field, Imperial Valley, California and Casa Diablo Field, Mammoth Lakes, California	<ul style="list-style-type: none"> ● Review existing operations and assess operating problems. Predict performance of reservoir and wells. Estimate future costs. 	Complete
Munson Geothermal, Inc./EG&G Hydro, Inc./HydraCo Ent.	Develop field to support two new power plants - Brady Hot Springs Field, Nevada	<ul style="list-style-type: none"> ● Plan and supervise drilling, well testing and evaluation of two most recent wells. Plan additional development. 	Complete (First Phase)
Dames & Moore/ Alaska Power Authority	Assess feasibility of developing geothermal resource of Makushin Volcano for electricity supply - Unalaska Island, Alaska	<ul style="list-style-type: none"> ● Provide field planning and cost estimates for economic assessment of various development scenarios. Advise power plant engineers and environmental planners of resource characteristics and operations logistics. 	Complete
Cyprus Metals Co.	Assess value of four geothermal prospect areas for acquisition by competitive bid - Medicine Lake, Salton Sea, Truckhaven, East Brawley, California	<ul style="list-style-type: none"> ● Summarize parameters and estimate reserves, well performance and development costs 	Complete
Ormat Systems, Inc.	Develop field (production and injection wells) sufficient to support 30 MW _e power plant - East Mesa Field, Imperial Valley, California	<ul style="list-style-type: none"> ● Assemble and organize East Mesa field resource data and development history data. ● Assist operator in planning, logistics, construction, and operation of tests for existing wells. ● Advise on downhole production pump design and installation. ● Advise on injection fluid treatment and filtering. 	Complete
Texaco	Evaluate suitability of oil field waste water for reinjection - San Ardo Oil Field, California	<ul style="list-style-type: none"> ● Sample, analyze, interpret and report on feasibility, treatment and compatibility with formation fluids. 	Complete

CLIENT	DESCRIPTION	SERVICES RENDERED	STATUS
Energy Services	Evaluate reservoir for electrical generation potential - Cove Fort Field, Utah	●Review resource data and prepare report.	Complete
Squire-Whitehouse, Inc.	Develop high temperature instrumentation for measuring pressure, temperature, rate, sampling, etc.	●Advise on geothermal applications.	Complete

III. MESQUITE STAFF PROJECTS WHILE AT REPUBLIC GEOTHERMAL, INC.

NAME	DESCRIPTION	SPONSOR/OWNER	SERVICES RENDERED
East Mesa Exploration and Development	Drill, test and evaluate geothermal reservoir and wells.	Republic Geothermal, Inc. (in-house properties)	Drilled and tested seven producers and three injectors. Conducted long-term flow tests and interference tests. Performed multiple well and reservoir simulations to predict future performance and reserves. Sold to Ormat Systems for commercial development (underway).
Niland (Salton Sea) Exploration	Drill, test and evaluate geothermal reservoir and wells.	Republic Geothermal, Inc. (in-house properties)	Drilled and tested two producers. Conducted long-term flow tests. Evaluated scaling, plugging, and corrosion potential of hypersaline brine. Sold to Parsons Corp. for commercial development.
Niland (Salton Sea) Development	Drill, test and evaluate geothermal reservoir and wells.	Parsons Corporation	Drilled and tested three producers. Conducted long-term flow tests. Predicted future well and reservoir performance. Project suspended.
Westmorland Exploration and Development	Drill, test and evaluate geothermal reservoir and wells.	Republic Geothermal, Inc. (in-house properties)	Drilled and tested four producers and two injectors. Sold to UNOCAL for commercial development.
General Exploration	Identify multiple exploration drilling prospects.	Republic Geothermal, Inc. (in-house properties)	Complete exploration of over 170,000 acres of RGI leases in the Western U.S. Surface mapping; soil and fluid sampling; magnetotelluric resistivity, gravity, seismic, side-scan radar, and satellite photo survey planning and supervision and analysis; drilled and measured over 200 temperature gradient holes; interpreted all data; identified 13 major prospects.
Geothermal Well Stimulation Program	Extend oil and gas well stimulation technology to geothermal wells and demonstrate with eight major field experiments.	U.S. Dept. of Energy/Los Alamos National Laboratory	Prime contractor in charge of entire laboratory, design, field execution and evaluation program. Conducted experiments at East Mesa, Raft River, Baca, Beowowe and the Geysers.
Unalaska Geothermal Exploration	Locate and test geothermal resources of Unalaska Island, Alaska suitable for electric power generation.	Alaska Power Authority	Prime contractor in charge of entire exploration, drilling, testing, and evaluation program. Discovered major resource.

NAME	DESCRIPTION	SPONSOR/OWNER	SERVICES RENDERED
General Exploration, Japan	Identify potential geothermal development prospects.	Idemitsu Kosan, Ltd.	Prime contractor for nationwide exploration program, including application of most known geothermal exploration techniques and 26 temperature gradient holes. Identified numerous prospects.
Nationwide Japan Geothermal Resources Survey	Identify potential geothermal development prospects.	Japanese Government (MITI)	Consultant to government management team. Performed integration of all subcontractor data into regional models for multiple prospective areas.
Deep Drilling, Kyushu, Japan	Drill and test seven deep geothermal wells to assess Takigami resource for electricity generation.	Idemitsu Kosan, Ltd.	Supervise drilling, design test facilities, evaluate test data. Development underway.
San Bernardino District Heating Project	Exploit low grade geothermal resource for district heating.	San Bernardino Water Department	Review data, recommend drill sites, supervise drilling of first well. Operational and expanding.
Sperry Conversion System	Construct and test gravity head binary conversion power plant.	U. S. Department of Energy	Drill large diameter well, evaluate well capacity, operate test site (terminated prematurely).
Calcium Carbonate Scale in Porous Media	Investigate mechanisms of scale formation in the field.	Lawrence Berkeley Lab/ U.S. Dept. of Energy	Prime contractor in charge of experimental apparatus, field operations, and interpretations.
Unalaska Power	Assess geothermal power plant feasibility for Unalaska Island.	Alaska Power Authority	Investigate various conversion installations at remote Alaska site.
Geothermal Chemistry	Recommended sampling and analysis techniques for geothermal fluids in handbook form.	TerraTek/U.S. Dept. of Energy	Contributed approximately one-half of handbook text.
Injection Tracer Studies	Investigate basic mechanisms of tracer injection/flowback in single well field tests.	EG&G/U.S. Dept. of Energy	Operated East Mesa wells. Provided partial interpretation and modeling of tracer absorption/flowback.

POWER Engineering, Inc.

GEO OPERATOR CORPORATION

EAST MESA GEOTHERMAL WELLFIELD FACILITIES

STUDY AND DESIGN PROJECT

IMPERIAL VALLEY, CALIFORNIA

CLIENT

GEO Operator Corporation (GEOOC)
Santa Rosa, California

CLIENT'S NEED

GEO Operator Corporation (GEOOC) needed study services and engineering design services for the East Mesa Geothermal Well Field, a steam and brine gathering and injection system serving two 18.5 MW geothermal generating units.

DESIGN SERVICES

- Assessment of utilization potential of existing facilities
- Pipeline survey
- Design of main and wellpad piping, including pipe and equipment sizing, network flow and pressure drop calculations, stress analysis, and pipe support design
- Design of brine treatment and steam release facilities
- Specification preparation
- Design of a wellpad electric power distribution system
- Construction support

PROJECT DESCRIPTION

GEO Operator Corporation (GEOOC) requested POWER to provide a design package for the East Mesa Well Field facilities, located in Imperial County, California.

The project is located within an area occupied by a geothermal power plant and gathering system formerly owned and operated by Magma Power Company.

The Study Phase

An important aspect of the project was the feasibility study. The objective of the study was to determine if existing production and injection systems could be beneficially utilized for the East Mesa Project.

The objectives and activities of this study were as follows:

- Determine suitability of piping design temperatures and pressures of the existing system
- Check process compatibility
- Define modifications to existing systems and new system requirements
- Prepare budgetary cost estimates
- Allow evaluation of trade-offs between capital and operating costs
- Evaluate and prepare recommendations.

The study was done with proceed or terminate decision points at each level of investigation.

POWER reviewed the Gathering System Operating Requirements and prepared a recommendation which took into consideration the pumping costs, scale control, capital and operating cost differences, and operating impacts.

The Design Phase

POWER prepared a gathering and injection system design in accordance with the system requirements, applicable codes, and GEOOC design criteria.

The gathering system goes from the discharge flange of the production well pumps to the plant battery limits.

The injection system piping goes from the discharge of the injection pumps to the various injection wells.

POWER designed a four-cell concrete rock muffler with internal diffusers to dissipate the energy of steam venting and control noise.

POWER recommended a redwood liner for the individual cells to prevent cracking of the concrete walls due to high thermal stresses.

Each unit will have one cell dedicated to high pressure steam and one to low pressure steam.

For each cell, it was recommended that the flow be split into two streams through back pressure, control valves to individual diffusers. These valves provide for control of steam venting during start-up, and turbine trip conditions.

PROJECT COMPLETION: 1989

GEO - EAST MESA LIMITED PARTNERSHIP EAST MESA GEOTHERMAL WELLFIELD BUILDOUT IMPERIAL VALLEY, CALIFORNIA

CLIENT

GEO - East Mesa Limited Partnership (GEMLP)
Santa Rosa, California

CLIENT'S NEED

GEMLP wished to add three new production wells and five new injection wells to its East Mesa geothermal brine field system, which serves two 18.5 MW geothermal generating units. Specifically, GEMLP needed engineering services for the design of the wellhead, gathering and injection piping, as well as wellhead electrics.

DESIGN SERVICES

- Preparation of as-built drawings of existing system
- Design of main and wellpad gathering and injection piping, including pipe and equipment sizing, pressure drop and network flow calculations, and stress analysis
- Civil/structural designs for pipe and vessel supports
- Design of wellpad electric power systems
- Preparation of construction specifications and bid packages

PROJECT DESCRIPTION

GEMLP requested POWER to provide a design package for the GEMLP buildout project.

The buildout involved the design of wellhead, gathering and injection piping to connect three new geothermal brine production wells and five new injection wells to the existing GEMLP

gathering and injection system, located in the East Mesa geothermal resource area in California's Imperial Valley.

The POWER team visited the East Mesa site to review the existing system and and prepare as-built drawings.

POWER then modified existing material and equipment specifications to solve operating problems experienced in the existing system, for use in specifying materials and equipment for the buildout.

The detailed mechanical design activities included design of wellhead piping for five injection wells and three production wells, as well as design of extensive runs of gathering and injection piping leading to and from the power plants.

Piping design tasks also included design of various items of miscellaneous and interconnection piping, stress analysis of piping, valve sizing, and pressure drop and network flow calculations.

The POWER design team prepared plan and profile drawings of the new piping by modifying existing drawings to show the buildout lines.

POWER provided civil/structural designs for pipe supports, support structures for a new sand separator, and for adaptation of existing road crossing structures to serve the new lines.

Electrical design work included design of wellhead electrical systems for several of the production and injection wells.

PROJECT COMPLETION: 1990

ZUNIL QUETZALTENANGO GEOHERMAL POWER PLANT CONCEPTUAL DESIGN AND ESTIMATING GUATEMALA

CLIENT:

Morrison-Knudsen Company
San Francisco, California

CLIENT'S NEED:

Morrison-Knudsen required expert geothermal design and estimating services for preparation of preliminary design and feasibility work for the proposed Zunil geothermal plant in Guatemala, for which Morrison-Knudsen had a design/build contract.

PROJECT SERVICES:

- Process Design Review
- Conceptual Designs
- Construction Cost Estimates using Questimate

PROJECT DESCRIPTION:

Morrison Knudsen retained POWER as a geothermal system design subconsultant on the Zunil project. POWER's work involved review of process design and the development of conceptual designs and cost estimates for a binary geothermal power plant.

Specifically, POWER prepared conceptual designs and cost estimates for two binary plant scenarios:

- A modular plant design
- A central plant design

POWER also prepared comparative cost estimates for a single-flash plant.

POWER prepared its comprehensive construction cost estimates using a specialized estimating software package, Questimate.

PROJECT COMPLETION: 1989

**MISSION POWER ENGINEERING
COSO NAVY 1
GEOTHERMAL POWER PLANTS
UNITS II & III
CHINA LAKE, CALIFORNIA**

CLIENT

Mission Power Engineering (MPE)

CLIENT'S NEED

Design, procurement and construction of two 25 MW geothermal power plants for California Energy Co. (CEC).

PROJECT DESCRIPTION

The client, MPE, undertook the design, procurement, and construction of two 25 MW geothermal power plants with CEC on a site located adjacent to an existing plant at the China Lake Naval Weapons Center. POWER Engineers was contracted to provide design and engineering services for the gathering and injection systems.

POWER provided design of the two-phase piping, the brine gathering piping, and steam, warm-up, and injection piping.

Technical specifications for separator safety, and relief devices, in accordance with operational and ASME requirements, were determined. Rupture disks sized to relieve two-phase flow were specified for this service.

Mechanical design included computer analysis of two phase brine flow. This was performed for thermal, weight, pressure, and seismic loading in compliance with ANSI B31.1. Design loads and deflections necessary for piers, supports, guides, and anchors were analyzed.

POWER provided construction plans and specifications including site layouts and construction details, and locating and sizing pipes, valves, supports, and foundations.

Further, POWER provided installation specifications for components, material quality controls, and procedures for site-fabricated materials including steel, reinforced concrete, concrete forming, and excavation/backfill compaction specifications.

PROJECT COMPLETION: May 1987

CALPINE CORPORATION

DIXIE VALLEY 50MW GEOTHERMAL PLANT

CONCEPTUAL DESIGN

DIXIE VALLEY, NEVADA

CLIENT

Calpine Corporation
San Jose, California

CLIENT'S NEED

Calpine required a conceptual design for its planned 50MW geothermal power plant in the Dixie Valley area of central Nevada.

PROJECT DESCRIPTION

POWER was retained to perform a conceptual design of the Dixie Valley plant.

The gathering system design was unusually interesting because of design requirements to accommodate dramatic elevation differences across the site. The plant process technology is two-stage flashed steam. The gathering system serves the plant from two different areas: In the first, both the high-pressure steam and the liquid was delivered to the plant by gravity flow.

The second source area, because of the distances from the power plant and the elevation differences, required liquid pumping for delivery to the plant.

POWER's work scope included the following

- Sizing and configuring the wellhead piping, two-phase supply piping to the separators, and the steam line from the separators to the plant boundaries
- Preparation of general arrangement and site layout drawings
- Complete materials takeoffs
- Development of a preliminary piping material specification
- Selection of valve types
- Sizing wellhead control valves and separator level control valves

POWER's design team also sized the spent geothermal liquids pumps and piping to deliver the fluids to an injection well.

PROJECT COMPLETION: 1986

ORMAT SYSTEMS DEPARTMENT OF ENERGY

ORMESA GEOTHERMAL PROJECT #1

WITNESS PERFORMANCE TESTING

SOUTHERN CALIFORNIA

CLIENT

Ormat Systems/Department of Energy

CLIENT'S NEED

POWER provided engineering review services for Ormat Systems for a 30 MW geothermal project in Southern California.

PROJECT FEATURE

- ASME Power test codes were used as the basis for establishing test criteria for the plant.

PROJECT DESCRIPTION

In this project, high temperature pumped geothermal fluid was supplied to a geothermal power plant. The plant utilized the fluid in 26 Ormat binary units arranged in three levels to produce 30 MW of gross power.

The power produced is wheeled over the Imperial Irrigation District (IID) grid and subsequently sold to Southern California Edison (SCE).

POWER was responsible for witnessing acceptance testing to ensure that the plant met the design performance requirements, thus assuring that long-term lenders and load guarantors could anticipate the projected return on their investments.

POWER provided technical expertise and support to the originally designated term lenders, John Hancock Mutual Life Insurance Company and Teachers Insurance and Amnity Association for the project. The overall aim of POWER's effort was to verify that the plant would operate as designed and thus would be capable of producing the planned revenue stream.

To accomplish this, POWER provided the following services:

1. Revised and approved the test procedures and specifications prepared by the contractor for individual pieces of equipment, systems, and the total plant
2. Reviewed systems and equipment test data
3. Witnessed the capacity and performance tests
4. Performed an overall general plant review for workmanship and operability
5. Reported on results of all tests and reviews with recommendations as to any items which required additional work on rectification.

When the original lenders withdrew, POWER was retained as an independent reviewer on behalf of the Department of Energy and the Federal Financing Bank, which succeeded John Hancock Mutual Life Insurance and Teachers Insurance and Amnity.

In summary, POWER recommended installation of office metering to improve reliability of instrumentation and plant data logs. Accuracy fluctuations in the original installed annubars made the consistency of the data logs questionable.

PROJECT COMPLETION: June, 1988

ALASKA POWER AUTHORITY UNALASKA GEOTHERMAL PROJECT INDEPENDENT COST ESTIMATE UNALASKA ISLAND, ALASKA

CLIENT

Alaska Power Authority (APA)

CLIENT NEEDS

- Independent Cost Estimate
- Design Review

DESIGN SERVICES

- Detailed Plant Design Review
- "Base Case" Cost Estimate
- "Alternate Case" Conceptual Design
- "Alternate Case" Cost Estimate
- Cost Estimate of Transmission Lines, Substations, and SCADA Systems

DESIGN FEATURES

- Review of Design Concepts
- Proposed Alternate Design
- Effect on Project Cost

PROJECT DESCRIPTION

The APA contracted POWER to perform an independent cost estimate of the agency's Unalaska Geothermal Project. This estimate was based on the design and other project data found in a report prepared by an outside contractor. POWER compared engineering concepts and costs associated with the potential development of this 7MW geothermal power plant on Unalaska Island.

The report addressed two scenarios. The first, referred to as the "Base Case," was based on the original report prepared by the outside contractor. The second, referred to as the "Alternate," was based on POWER's conceptual design.

POWER's full range of services provided detailed investigations not only of the plant, but of the associated factors that influenced the project cost and schedules. These included the transmission line, substations, and SCADA systems that would support the generation plant, the production and injection well system, the necessary environmental impacts and permitting, and various logistical factors such as construction camp costs.

By identifying alternatives for the geothermal plant, POWER pointed to the potential for significant cost savings for APA. These alternatives ranged from different technologies for the geothermal process to different locations for the facilities.

Because no access road was included in its proposal, the Base Case required almost \$1 million in helicopter support for drilling activities and production piping system construction. The production system for the Base Case consisted of 13,000 feet of combined 24-, 20-, and 14-inch piping. It also had potential freezing problems in case of a plant shutdown.

In contrast, the alternate identified an access road and had a very short production system. The proposed 14-inch piping would be buried below the frost line to be protected from freezing and therefore would not require any above-grade support structures.

The geothermal process for the Base Case combined two different technologies. It proposed using single-flash two-steam turbine trains and two binary generation modules. POWER determined that this complex system had a poor resource utilization rate due to the relatively high flash pressure and inefficient

energy conversion of the binary modules. POWER's alternative, a dual-flash system, would produce the same net power with 10% less geothermal fluid. The alternate thus proved to be simpler, less expensive, and better proven for geothermal applications.

The final capital cost estimate for the two scenarios exhibited almost \$14 million difference, with POWER's alternate being the least expensive. In addition to these capital cost

estimates, POWER also performed an operating and maintenance (O&M) cost estimate.

CONTRACT COST: \$25,000

PROJECT COMPLETION: December 1987

GEOHERMAL DEVELOPMENT ASSOCIATES ROUND MOUNTAIN GOLD GEOHERMAL HEATING OF LEACH LIQUOR ROUND MOUNTAIN, NEVADA

CLIENT

Geothermal Development Associates

CLIENT'S NEED

To evaluate a heat exchange system that uses geothermal brine to heat barren liquor. Special concerns entailed the potential for scaling and corrosion of the process equipment due to the geothermal fluid.

ENGINEERING SERVICES

- Fluid Chemistry Evaluation
- System Recommendations

STUDY FEATURES

- New application for geothermal fluids

PROJECT DESCRIPTION

Geothermal Development Associates (GDA) contracted POWER Engineers to recommend the practicality of using geothermal fluid to heat leach liquor for a Nevada gold mine owned by Round Mountain Gold. This system presented a new application for geothermal energy.

To address GDA's concern, POWER evaluated the chemistry of both the cyanide liquor and the geothermal fluid. POWER also reviewed the system schematic, which included estimated flow rates, temperatures, and pressures. Another important factor was the heat exchanger performance and dimensional data. POWER reviewed this information, supplied from the manufacturer.

For the geothermal fluid chemical analysis, POWER analyzed the scaling potential from calcium carbonate, calcium sulfate, and silica.

GDA planned to use a Tranter plate and frame heat exchanger for the system. GDA expressed concern whether the stainless steel alloy 316 (316 SS) was adequate for the exchanger or if titanium should be used instead. POWER evaluated the effectiveness of 316 SS for both the heap leach solution and the geothermal fluid.

POWER recommended several methods for GDA that would provide early detection of scaling and corrosion.

STUDY COMPLETION: August 1987

VARIOUS CLIENTS GEOTHERMAL SYSTEM ENGINEERING AND SUPPORT SERVICES

CLIENT

Oxbow Geothermal Company
Reno Nevada

ON-GOING ENGINEERING SERVICES:

POWER is providing engineering review and support services on an as-requested basis for Oxbow. Projects to date have included:

- Evaluation of a two-phase flow gathering system versus a single-phase flow gathering
- Determination of flow reaction forces and support design for a well flow test assembly to be used on a two-phase flowing well producing 1-1.5 million pounds per hour.

PROJECT DATE: Ongoing

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CLIENT

Geysers Geothermal Company
Santa Rosa, California

TESTING & TROUBLESHOOTING:

POWER performed testing and troubleshooting with respect to operational problems which had developed at the rock muffler steam release facility at one of Geysers Geothermal's sites in northern California.

PROJECT DATE: 1987

CLIENT

Private Client
California

COST/ECONOMIC ESTIMATE:

POWER developed an operating and maintenance cost estimate and potential energy sales projection for a 10 MW double-flash geothermal plant, potentially to be located in Churchill County, Nevada. POWER's O&M estimate addresses labor requirements and costs, maintenance parts, utilities, supplies, and miscellaneous expenses. Potential electrical power customers were contacted to determine probable power sales rates. POWER's team provided an overall report summarizing findings.

PROJECT DATE: 1987

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CLIENT

Unocal

CONCEPTUAL DESIGN/COST ESTIMATE:

POWER personnel performed a detailed design and cost estimate for this generating plant located in the Salton Sea KGRA. The plant utilized high temperature, high-salinity geothermal brine as the heat source for a 49MW double-flash plant. The report included a general arrangement plan, a gathering system routing, site layout, equipment sizing, capital and O&M cost estimates, and the preparation of a process flow diagram with detailed material and energy balances.

PROJECT DATE: 1985

GEO OPERATOR CORPORATION

EAST MESA GEOTHERMAL WELL FIELD FACILITY

DUAL-FLASH SCALE TEST SKID

IMPERIAL VALLEY, CALIFORNIA

CLIENT

GEO Operator Corporation
Santa Rosa, California

CLIENT'S NEED

In order to allow the design of efficient gathering and injection piping systems for its East Mesa geothermal power project, GEO desired to assess the potential for scaling of the East Mesa resource fluids, a superheated brine containing mineral salts and sand. GEO also wished to identify an inhibiting reagent which could be introduced into the gathering system to reduce scaling of piping and equipment.

GEO retained POWER to provide detailed design for a pilot plant to simulate anticipated temperature and pressure conditions and allow scale testing with sample materials and inhibitor reagents.

PROJECT DESCRIPTION

Using process flow data and vessel specifications provided by GEO, POWER designed a skid-mounted dual-flash pilot plant to allow scale potential and reagent testing of the East Mesa well fluids.

The module duplicated, in miniature, the processes found in the high-pressure and low-pressure flash and injection system of a dual-flash geothermal power plant.

The plant included two centrifugal flow separators designed to vent steam into the atmosphere and deliver spent brine at specified pressures to a sampling chamber, where the brine was recirculated to allow system engineers to assess scaling to the test materials exposed to the hot brine.

The plant was designed with flow, level, temperature and pressure monitoring and control equipment to allow accurate determination of scale deposition potential for the East Mesa well fluids.

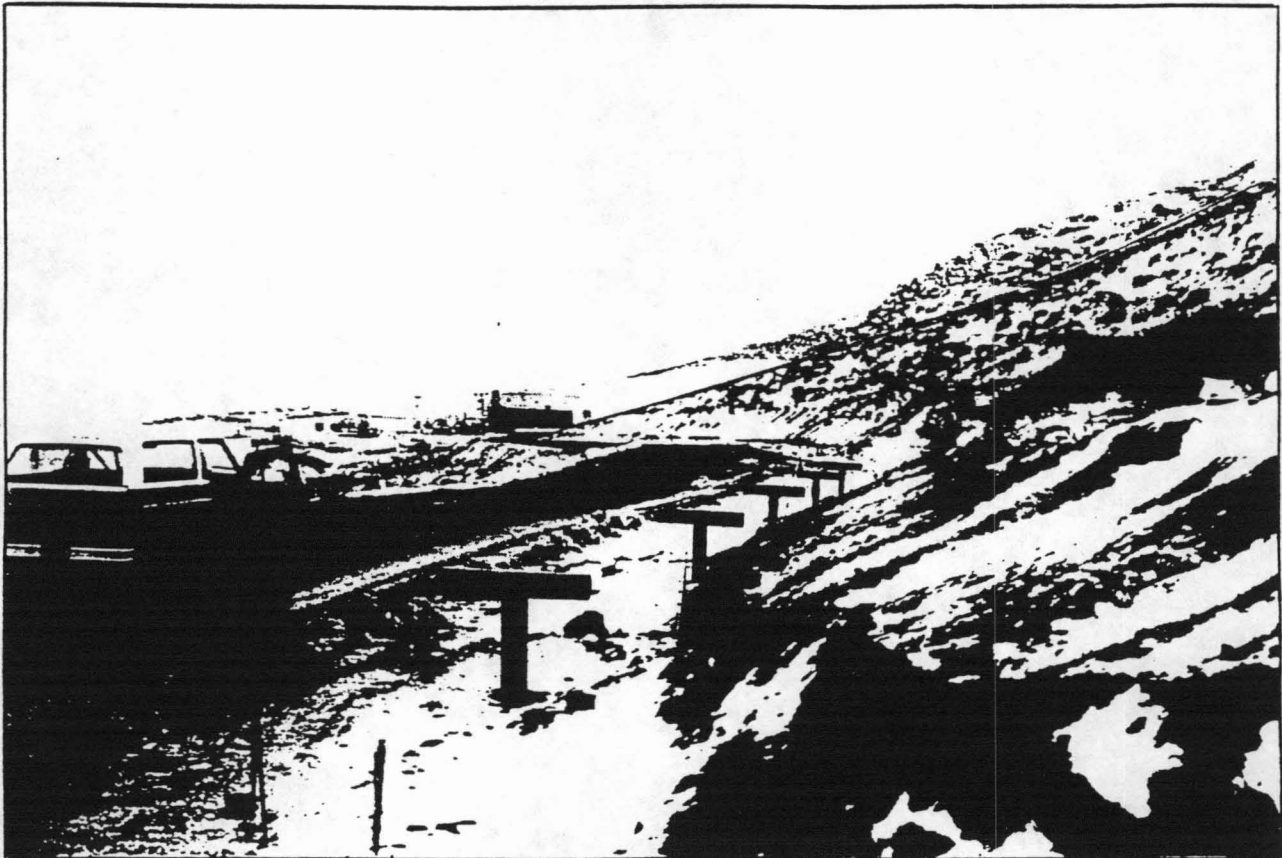
The module was designed to be totally skid mounted so as to be self-contained and portable. It was also designed with valves to allow extraction of process fluid samples at various points in the process stream, and with connections to allow equipment vendors to connect test equipment downstream from the separators.

The pilot plant included mixing equipment for introducing scale inhibitors upstream from the separators so that GEO's engineers could identify a commercial inhibiting reagent that would minimize scaling in piping and power plant equipment.

GEO used the test module to collect samples of spent geothermal fluids at a range of temperatures downstream from the flash separator, and used the sampling chamber to test, in a realistic process environment, the scale susceptibility of materials and the potential of inhibitors to reduce scaling.

PROJECT COMPLETION: 1988

YANKEE / CAITHNESS GEOHERMAL FIELD & INJECTION PIPING SYSTEMS STEAMBOAT SPRINGS, NEVADA



CLIENT

A joint venture of Yankee Power Inc., Tulsa, Oklahoma, and a partnership group managed by Caithness Resources (YCJV).

CLIENT'S NEED

Yankee/Caithness required a complete design package for a pipe system involving two phase piping to conduct steam from the wellhead, plus brine injection piping. The system needed to provide more than 11,000 feet of piping, much of it specially insulated. In addition, the system had to be designed, detailed, and constructed within a four month time frame over rugged terrain.

DESIGN SERVICES

- Two phase piping from well heads to steam separator
- Brine injection piping from steam separator to injection well
- Process flow design
- Two-phase flow system analysis
- Pipe sizing, arrangements, site layout, and road crossings
- Steam separator evaluation
- Pipe stress analysis including expansion loop design
- Pipeline insulation
- Component foundations
- Equipment and material specifications.
- Pipeline survey
- Construction support

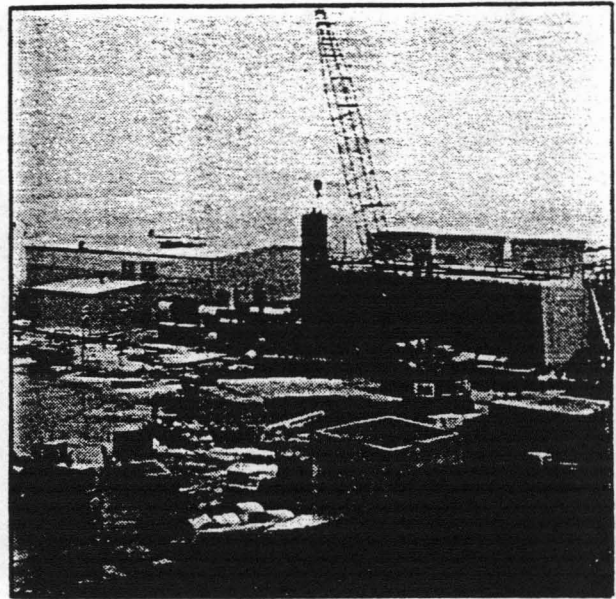
PROJECT DESCRIPTION

Yankee Caithness requested POWER to provide a complete design package for a well field collection system for two-phase brine and steam. The well field collection system runs from well heads to the steam separator. Design of the brine injection piping from the steam separator at the plant to the injection wells was also part of POWER's design services.

POWER provided a complete design package including pipeline survey, process flow design, piping design, material selection, equipment sizing and evaluation, and pipe stress analysis.

Design data and drawings developed by POWER included the following: material specifications and bills of material, design drawings, details, installation specifications, instrumentation, site work, arrangement, planning, and logistics.

PROJECT COMPLETION: January 1988



The special expertise of POWER Engineers in geothermal well field hydraulics was brought to bear on this project. This expertise assured rapid decisions to support the four-month design and completion schedule.



TRANSPACIFIC GEOTHERMAL CORPORATION AMEDEE GEOTHERMAL PLANT DESIGN AND CONSTRUCTION MANAGEMENT HONEY LAKE, CALIFORNIA

CLIENT

TransPacific Geothermal Corporation
Oakland, California

CLIENT'S NEED

TransPacific required complete engineering design, specification and construction management services needed to build a 1MW geothermal power plant in Northern California, using two modular energy conversion modules.

PROJECT DESCRIPTION

POWER was selected to perform complete engineering design and construction management for this 1 MW geothermal power plant located on the shores of Honey Lake east of Susanville, California.

The project scope included selecting and specifying the geothermal fluid pump, design of the liquid transfer system from the wellhead to the power plant, and selection of accessory equipment to support the two 750 kW Ormat binary generation modules.

POWER designed and specified equipment foundations, equipment enclosures, maintenance buildings, and supervised procurement of materials and construction for the project.

POWER was also responsible for interface to the transmission grid of CP National Corporation, who wheeled the power to Pacific Gas & Electric.

Transpacific ultimately plans to build a 5 MW power plant at Honey Lake, but is proceeding incrementally because of present limitations of the transmission system.

PROJECT COMPLETION: 1986

CALIFORNIA ENERGY COMPANY AND CALPINE CORPORATION

COSO NAVY 1, UNIT 1 - GATHERING SYSTEM REVIEW

CHINA LAKE, CALIFORNIA

CLIENT

California Energy Company
Calpine Corporation

CLIENT'S NEED

The project developer, California Energy Corporation, selected POWER to perform ongoing design review services in conjunction with turnkey construction by Atkinson-Mitsubishi Joint Venture (AMJV) of the 30 MW Unit No. 1 on the Navy I resource.

PROJECT DESCRIPTION

POWER was selected by the project developers, California Energy Corporation and Calpine Corporation, to perform design review services, engineering services, and design services for the Coso Hot Springs 30 MW Geothermal Project in Southern California.

On behalf of CEC, POWER Engineers conducted ongoing design review services in conjunction with turnkey construction by Atkinson-Mitsubishi Joint Venture (AMJV) of the 30 MW Unit No. 1 on the Navy I resource.

Services included review of the two-phase gathering system designed by AMJV in conjunction with the contract, design of the project transmission line, and assistance with negotiating the final scope of the installation.

POWER also performed engineering support services in conjunction with overall development of the total 240 MW resource.

GATHERING SYSTEM DESIGN REVIEW

Another task included preliminary design of the two-phase flow gathering system and single phase flow steam and injection systems for Units II and III on the same resource.

POWER was contracted by Calpine Corporation to implement engineering review and support services. POWER completed design review of the stress analysis and slug flow calculations for the two-phase gathering system. The design was analyzed with respect to conformance to codes and overall adequacy of the piping and pipe support design.

TRANSMISSION LINE DESIGN

POWER was also contracted by Calpine Corporation to design 28.5 miles of 115kV transmission line running from the plant to a Southern California Edison substation.

The line was routed across lava beds and a sensitive archaeological area, requiring POWER personnel to develop special design criteria for the line and its structures.

COST-SAVING NEGOTIATIONS

POWER, after doing a detailed construction cost estimate, represented the client in negotiations with the construction contractor resulting in a reduction of approximately 20% in the cost of a new wellhead system.

PROJECT COMPLETION: September 1987

OXBOW GEOTHERMAL COMPANY PUMP AND TWO-PHASE PIPING INSTALLATION

DIXIE VALLEY, NEVADA

CLIENT:

Oxbow Geothermal Corporation
Reno, Nevada

CLIENT'S NEED:

Oxbow Geothermal plant experienced severe vibration near flash vessels at its 50 MW power plant in Dixie Valley, Nevada.

Oxbow asked POWER to study the vibration problem, identify a remedy, and design piping and pumping systems required to solve the problem.

PROJECT SERVICES:

- Piping Vibration Evaluation
- Piping Design and Specification
- Piping Stress Analysis
- Pump Specification
- Pump Electrical System Design

PROJECT DESCRIPTION:

The Study

Oxbow retained POWER to study the vibration problem. Bill Lewis, POWER's geothermal

specialist, inspected the piping at the Dixie Valley plant.

Mr. Lewis inspected the piping, evaluated pressure, temperature and flow data, and determined that the vibration was caused by slug flows, the result of premature flashing upstream of the control valves in the lines leading to the flashing vessels.

Mr. Lewis determined that the flashing problem could be relieved by boosting the fluid pressure upstream from the flash vessels, and recommended that Oxbow install pumps to provide the required pressure increase.

Piping and Pump System Design

POWER is now assisting Oxbow in developing detailed designs and specifications for the pump installation recommended in Mr. Lewis' report.

The design project involves piping design, valve sizing and specification, pump sizing and specification, civil/structural designs for supports and foundations, and preparation of electrical and controls designs for the pumps.

PROJECT COMPLETION: 1991

GEO OPERATOR CORPORATION MAIN STEAM SEPARATOR REPLACEMENT AND REDESIGN GEYSERS, CALIFORNIA

CLIENT

GEO Operator Corporation (GEO)

CLIENT'S NEED

Deterioration of GEO's existing separator necessitated its replacement. GEO needed a design analysis of the replacement separator to verify that it would meet their needs. In addition, steam and condensate system changes were needed for automatic operation and to improve plant operations and life expectancy. The facility needed a spray wash system with tanks and pumps, to remove impurities from the steam. It was also important that the project be fast-tracked, so that construction could take place during a scheduled plant shutdown.

PROJECT SERVICES

- Maximum utilization of existing plant equipment.
- Development of a spray wash system for steam cleaning.
- Development of an automatic separator wash and flush system.
- Flow and operations analysis of steam and flush piping.
- Technical evaluation of steam separator configuration, efficiency, and mechanical operating integrity.
- Mechanical and piping system design.
- Separator pressure vessel design analysis for conformance to ASME codes.
- Welding specification review.
- Redesign of vessel support foundation.
- Special slurry erosion testing of hardness treatment procedures.
- Instrumentation and control systems design.
- API tank design and specification.

PROJECT DESCRIPTION

POWER provided a design evaluation of a new geothermal steam separator proposed for the replacement of existing equipment. The evaluation included flow velocities, individual cyclone and total separator efficiency, metallurgy, erosion, corrosion, spray wash and flow patterns, nozzle location, and flushing design.

The pressure vessel was also evaluated for conformance to ASME codes. POWER developed a slurry erosion test procedure for the evaluation of component hardening procedures.

POWER made design changes to the separator and flush water components to extend life expectancy. POWER designed new and redesigned existing steam, condensate, flush and service systems to improve performance, provide automatic operation, and provide a steam wash system to remove steam impurities.

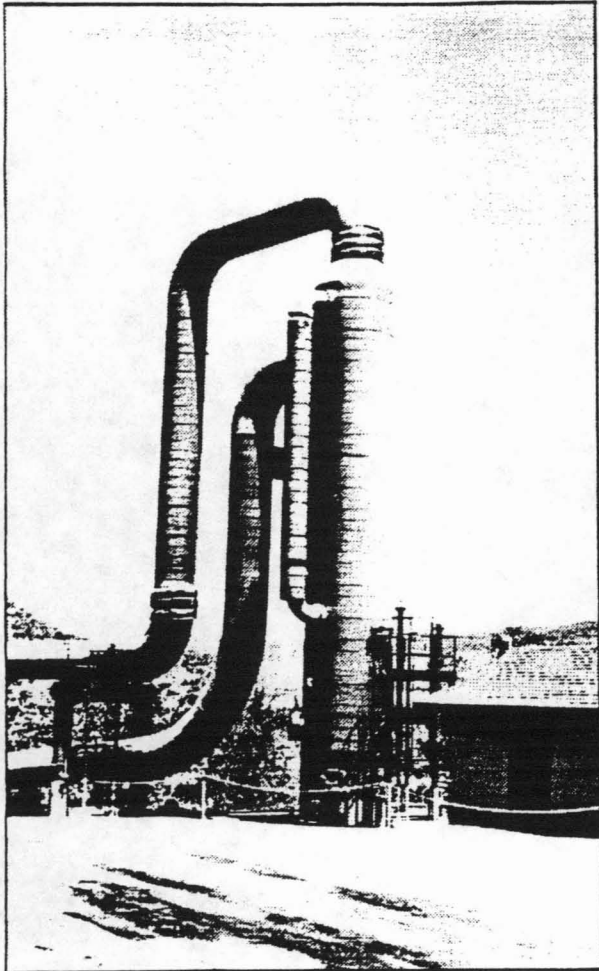
The project had a fast-track completion schedule to allow for installation during a scheduled maintenance shutdown.

Existing piping and component systems were redesigned to meet the requirements identified during the design and installation phases. This design included pipe stress and flow analysis, tank and foundation design, and pump and valve specifications.

PROJECT COMPLETION: December, 1987

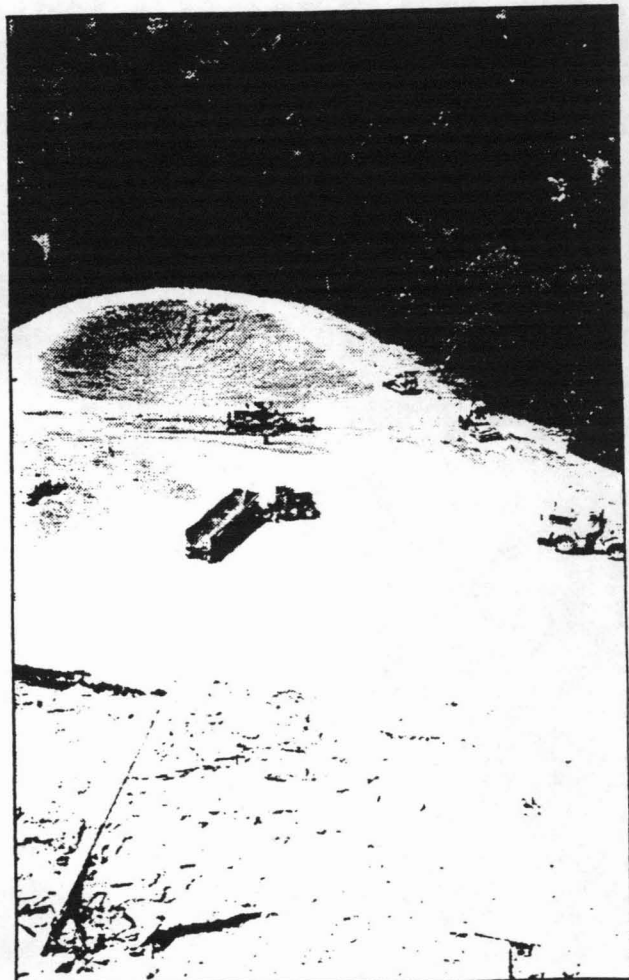
PROJECT COST: \$300,000

GEYSERS GEOTHERMAL COMPANY PG&E UNIT 16 STEAM GATHERING SYSTEM GEYSERS GEOTHERMAL AREA, CALIFORNIA (PERSONNEL EXPERIENCE)



PROJECT DESCRIPTION

For this 15,000-foot, cross-country steam gathering system, POWER geothermal personnel provided design services including all civil/structural and mechanical plan and profile drawings and support designs. Mechanical activities also included pipe stress analysis and design for both above ground and buried piping, P&IDs, process vessel design, specifications, bid evaluations and vendor drawing review.



CLIENT

Geysers Geothermal Company
Santa Rosa, California

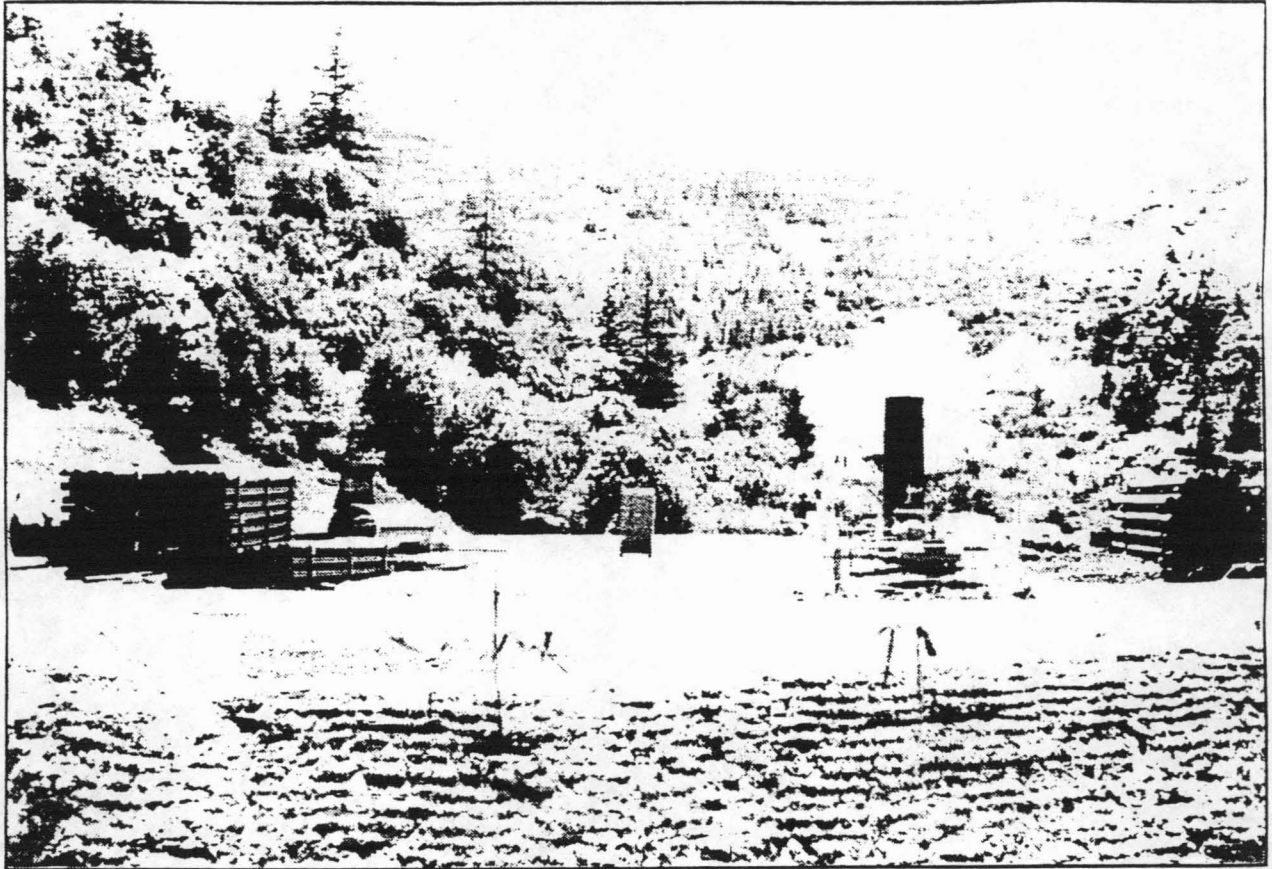
CLIENT'S NEED

Geysers Geothermal Co. needed a complete design package for a large cross-country steam gathering system in the Geysers Geothermal Area in Northern California.

The system was the first in the Geysers Geothermal Area in which the steam gathering system for one unit was interconnected with another unit utilizing an automated crossover. This allowed a computerized transfer of steam in the event of a shutdown of one unit, thus minimizing the steam loss, associated energy waste, and amount of H₂S released to the environment in the event of a turbine trip.

Project duration was from February 1984 to April 1985. The engineering services were performed concurrently with a fast-track construction schedule, and the project was completed on time and under budget.

COMPLETION: April 1985



CLARENDON HOT SPRINGS PRELIMINARY GEOTHERMAL RESOURCE EVALUATION DEER CREEK, IDAHO

PROJECT DESCRIPTION

In 1988, a prospective buyer of property in Deer Creek Canyon, Idaho, including the Clarendon Hot Springs resource, retained POWER to evaluate the hot spring resource's potential as a direct heat source for a contemplated residential development.

POWER visited the site and made preliminary temperature and flow determinations for a number of freely-flowing hot water sources in the Clarendon area. The POWER team selected four of the sources to be tested for mineral content, collected samples, and retained a certified laboratory to determine the pH, hardness, and dissolved salt content of the samples.

POWER provided the prospective owner with a report outlining the estimated heat available from the most promising sources, and noted engineering and environmental requirements for use and disposal of the mineral-rich water.

ENGINEERING SERVICES

- Chemical analysis of samples from four candidate springs and wells
- Calculations of available heat for residential development
- Preliminary identification of engineering and environmental impacts of the resource

COMPLETION: 1988

WELLS RURAL ELECTRIC COMPANY GEOTHERMAL RESOURCE UTILIZATION ASSISTANCE WELLS, NEVADA

PROJECT DESCRIPTION

POWER provided Wells Rural Electric Company (WREC) with consulting services to develop a plan for establishing a geothermal district heating system for the city of Wells, Nevada, using a hot-water well already owned by WREC.

POWER worked with WREC on development of a preliminary business and engineering plan for establishing an operating company and designing a cost-effective district heating system which would allow WREC to better use its electrical power capacity to serve the utility's growing service base.

POWER assisted WREC in applying for an energy conservation pilot project grant from the state of Nevada to fund a detailed feasibility study for the district heating system.

ENGINEERING SERVICES

- Development of a preliminary business/engineering plan for development of the district heating system.
- Preparation of Nevada Energy Office grant application.

COMPLETION: 1988

UNION OIL COMPANY

SALTON SEA STEAM GATHERING SYSTEM

IMPERIAL VALLEY, CALIFORNIA

(PERSONNEL EXPERIENCE)

CLIENT

Union Oil Company, Indio, California

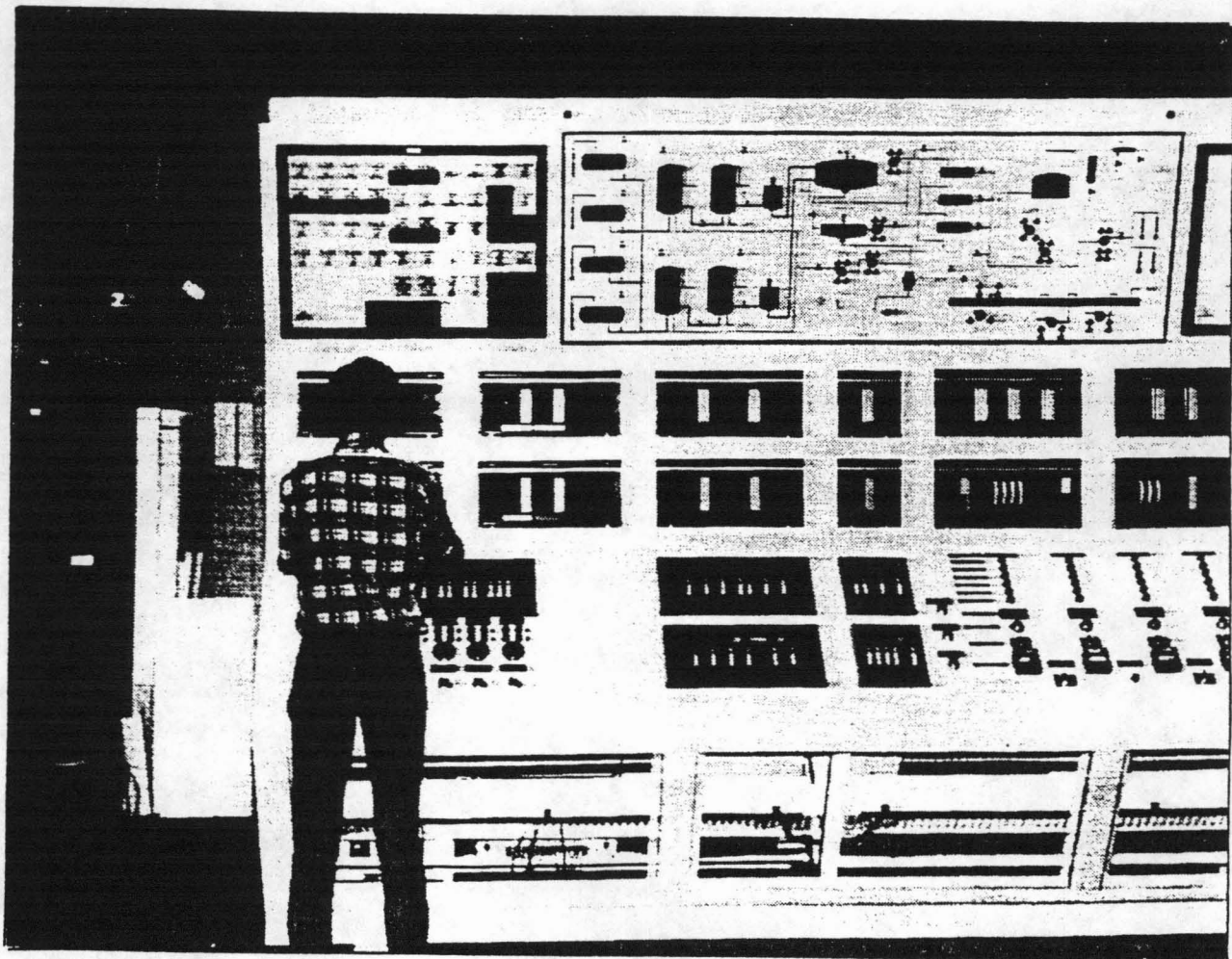
The system also needed to incorporate innovative features to control the scaling problems associated with the high-salinity brine.

CLIENT'S NEED

Union Oil needed a design package for a brine handling system to serve a 10 MW prototype geothermal plant in the Salton Sea Known Geothermal Resource Area (KGRA) in the Imperial Valley of California. The system needed to be designed with a comprehensive control system.

PROJECT DESCRIPTION

POWER's engineering team provided services to design a brine handling system for a 10 MW geothermal flash plant, located in California's Imperial Valley. Although this highly saline (200,000 ppm) geothermal resource had great energy potential, extreme scaling problems had previously precluded its use.



SCALING CONTROL FEATURES:

The system designed by the engineering team currently at POWER, however, uses a crystallization system with a seed recycle system. This system successfully resolved the scaling problems.

The crystallizers rely on a seeding process of adding finely divided solids to the brine, promoting precipitation of the scale forming compounds.

By providing a high ratio of seed surface area to equipment surface area, the scale deposits occur preferentially on the seed.

THE CONTROL SYSTEM:

The design team also designed a complete control system including specification, selection and evaluation of controls, instruments and monitoring equipment.

The personnel team now at POWER supervised the instrumentation and control system construction, start-up work, installation, and calibration and testing.

THE GATHERING SYSTEM DESIGN PACKAGE:

The engineering team was also responsible for process flow definition, piping and instrumentation diagrams (P&IDs), and equipment specification and selection.

PROJECT OUTCOME:

The new prototype system provided continuous service for six months after start-up. It produced sufficient steam to generate 10 MW of power, which was sold to Southern California Edison.

The system was stopped after six months for data gathering and research purposes. Since then, several other plants have been designed and/or constructed based on similar technology.

DESIGN SERVICES

- Process Flow Design
- Control System Design
- Equipment Specification
- Equipment Selection
- Instrumentation Selection
- Piping & Instrumentation Diagrams
- Construction Inspection
- Installation Supervision
- Calibration and Testing

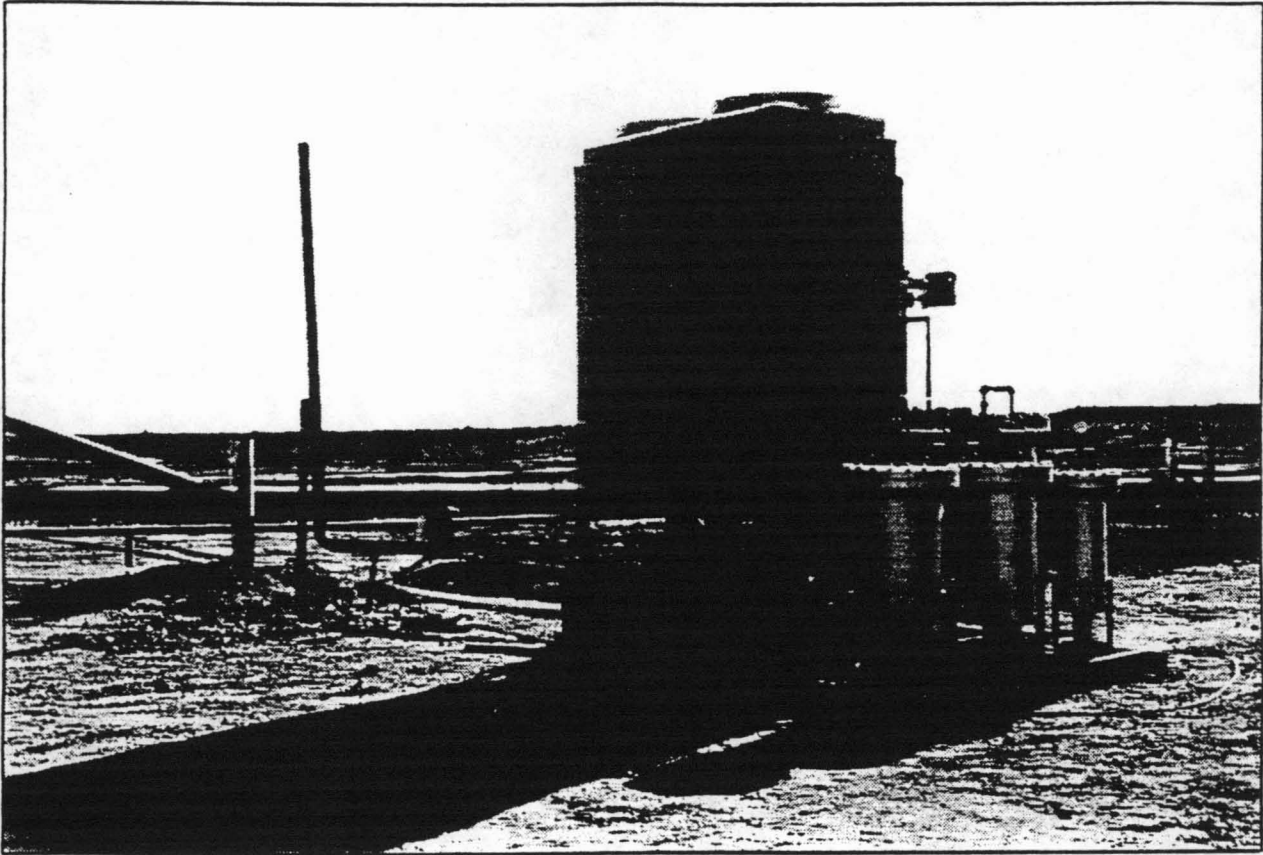
DESIGN FEATURES

- Geothermal brine containing 200,000 parts per million saline content
- Crystallization system with seed recycle

PROJECT COMPLETION: 1982

PROJECT COST: \$15,000,000

OXBOW GEOTHERMAL COMPANY PILOT PLANT FOR SCALE TESTING DIXIE VALLEY, NEVADA



CLIENT

Oxbow Geothermal Company
Reno, Nevada

CLIENT'S NEED

In order to design a new geothermal power plant, Oxbow desired to assess the potential of spent fluids from its Dixie Valley geothermal resource to cause silica scaling in the piping and equipment. Specifically, Oxbow wished to determine the temperature at which the Dixie Valley fluids would begin to cause significant scaling, so that its plant could be designed to maintain effluent temperature high enough to avoid major scaling problems.

PROJECT DESCRIPTION

Oxbow Geothermal Company retained POWER Engineers to design, build and start up a silica scale test module at the Dixie Valley site. The module was to be portable, and to allow sampling of the resource's fluids over a wide range of temperatures, to allow testing for scaling potential. The module also had to be designed, built and delivered on a fast-track design and delivery schedule.

The module duplicated, in miniature, the processes found in the low pressure flash and injection system of a dual-flash geothermal power plant.

The module included a centrifugal two-phase flash separator and a cooling tower. These specialized pieces of apparatus were designed by POWER and specially fabricated to POWER's specifications. The test module also included level and pressure controls, temperature and pressure indicators, a six-point fluid sampling system, and an array of test chambers for collecting precipitates.

The module was totally skid mounted. It was trucked from POWER's office and design facility in Idaho to the remote Dixie Valley site, in Central Nevada, where it was unloaded in a single operation and started up.

Oxbow and POWER used the test module to collect samples of spent two-phase geothermal fluids at a range of temperatures downstream from the flash separator. The test chambers allowed POWER's geothermal specialists to determine scaling potential in a realistic process environment. The design allowed for tests at

various operating conditions to ascertain the impact of off design point and start-up operation.

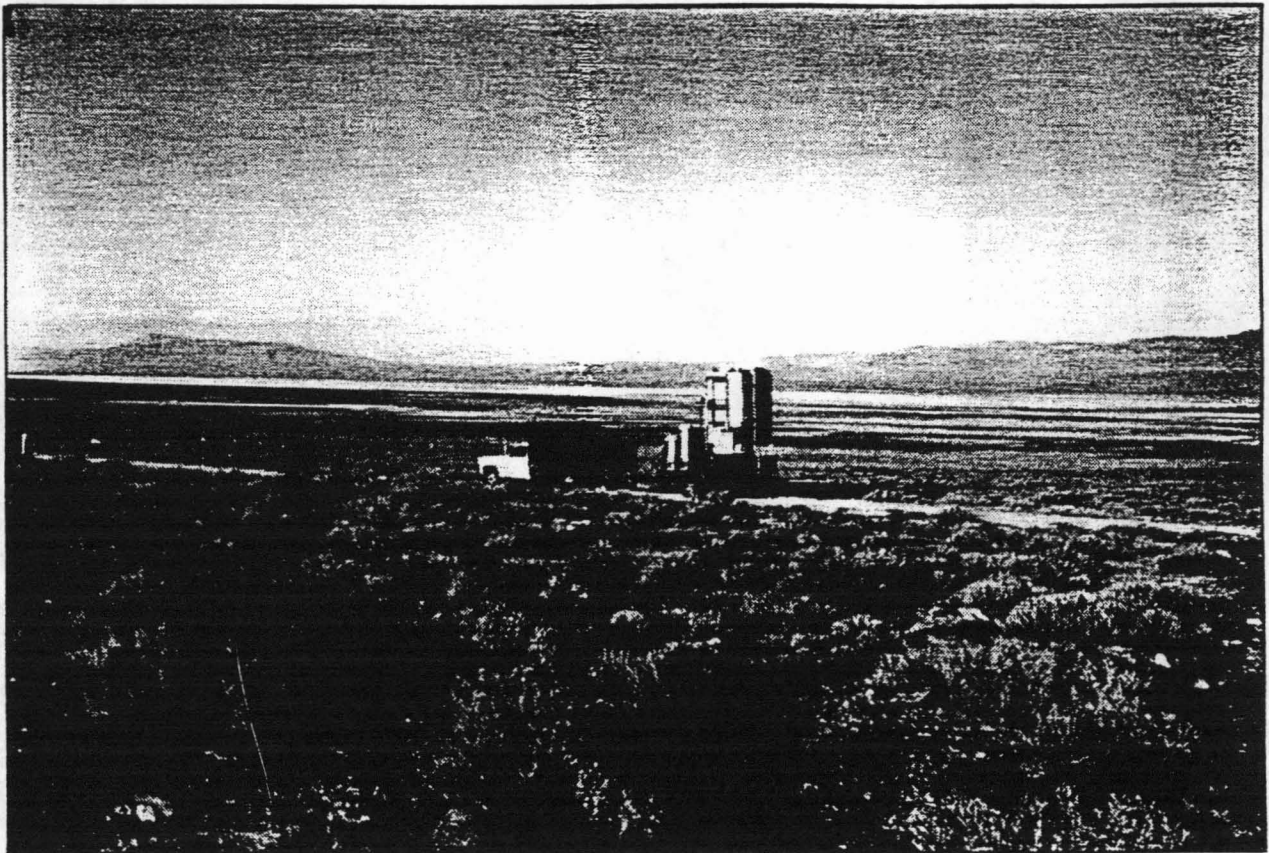
These sampling and test features allowed Oxbow to realistically determine minimum fluid temperature range for its future power plant and injection system.

POWER's responsibilities included complete design, specification, fabrication, supply, and startup of the test module.

The module was also completed in a remarkably short time. Oxbow and POWER signed the contract for the test skid in the third week of June, 1986. By August 9, the unit had been designed, fabricated, transported to Dixie Valley, and placed in operation.

PROJECT COST: \$40,461

PROJECT COMPLETION: 1986



Edward K. Noda and Associates, Inc.

Specifically related to underwater power cable design studies in the Hawaiian Islands, the following provides a brief description of relevant past projects:

1. Project: Hawaii Deep Water Cable Program
Sponsor: U.S. Department of Energy,
Sub-Contract With Hawaiian Dredging & Construction Co.
Date: Completed September 1990

This research, development and demonstration program sponsored by the U.S. Department of Energy involves the evaluation of the feasibility of connecting the islands of Hawaii and Oahu with an underwater power cable. The focal point of the evaluation is the deep (6,000 ft) and formidable Alenuihaha Channel between the islands of Hawaii and Maui. This program which was initiated in 1982 and recently culminated in a very successful At-Sea Test Program in November 1989. EKNA had many major task responsibilities which include extensive field measurements of waves and near-surface currents (2 years) and near-bottom currents along both the Hawaii and Maui slopes of the channel (2 years), the development of the oceanographic and environmental design criteria for the at-sea operations, the design, fabrication and operation of a high-resolution bottom roughness measuring system which obtained excellent bottom roughness data with operational resolutions of 4-6 inches in water depths of 6,000 ft and the design, fabrication and operation of the entire data acquisition system during the At-Sea Test including wind, waves and current data and all technical parameters associated with the cable laying operation.

EKNA was responsible for the analysis of oceanographic data from the At-Sea Test Program and assisted in the development of the Final Report dated September 1990. In addition to the Final Report preparation, EKNA also performed many additional final tasks, including the feasibility and cost estimates for the trenching and burial of the power cable along the coastal and nearshore areas. This work was performed in association with R.J. Brown and Associates of America, Inc.

2. Project: Tri-Island Cable Project (TIC)
Sponsor: Hawaiian Electric Company, Inc. (HECO)
Date: Ongoing

Hawaiian Electric Company is evaluating the feasibility of connecting the islands of Maui, Lanai and Molokai with an underwater power cable system to unify the Maui Electric Company system. As part of this feasibility study EKNA has been given the following technical responsibilities:

- o Develop the oceanographic design criteria for the underwater cable system including both the deep water and nearshore areas. This effort includes the hindcasting of hurricane design wave conditions, the transformation of deep-water wave conditions to their shallow-water characteristics, calculation of wave forces, evaluation of scour protection, tsunami wave evaluations, etc.
- o Field measurement of ocean currents along 5 potential underwater routes. This program involves the deployment of 12 current meters on 9 individual moorings along 5 proposed underwater routes between the 3 islands.

In addition to submarine power cable related projects in Hawaiian waters, Edward K. Noda and Associates, Inc. has developed extensive expertise and capabilities in the use of CAD and GIS to assist in the evaluation, analysis and display of engineering and technical data. The following projects provide a brief description of GIS related studies:

1. Project: Development Of An Ocean And Coastal Database
Sponsor: Department of Business and Economic Development
State of Hawaii
Date: July 1987

This study involved the evaluation of the development of an State-wide ocean and coastal information management system in association with the implementation of a geographic information system (GIS) to provide real-time graphical data for use in planning and decision-making. The main tasks of this project included the following:

- o Identify and analyze coastal and ocean information needs.
- o Inventory available ocean resources information.
- o Analyze the ocean resources information inventory and identify deficiencies.
- o Recommend improvements to the ocean resources information inventory, provide a priority listing of ocean data that would create a comprehensive database and recommend hardware and software systems to implement the ocean information management program.

2. Project: Develop and Demonstrate A Hawaii Ocean And Coastal Information Management System (OCIMS)

Sponsor: Department of Business and Economic Development (DBED)

State of Hawaii

Date: 1988

As a follow-on phase to the previous development of the ocean and coastal database, DBED selected two prime contractors to implement the OCIMS project. Environmental Systems Research Institute (ESRI) was selected to provide the ARC/INFO GIS software and the Prime computer hardware system and Edward K. Noda and Associates, Inc. was contracted to provide peripheral hardware systems (digitizer and plotter), system design and database development services, and to conduct demonstrations of the ocean and coastal information management system for representatives of State, Federal, and local government agencies which could benefit from the use of a GIS.

In addition to the above projects, the following provides a brief description of other past and ongoing projects.

1. Project: Keehi Lagoon/America's Cup Marina Facilities Conceptual Engineering Design, Update Recreational Plan and Environmental Impact Statement

Sponsor: Harbors Division, Department of Transportation, State of Hawaii

Date: Ongoing

Edward K. Noda and Associates is the prime contractor for the development of the Environmental Impact Statement for new marina facilities for Keehi Lagoon and what was hoped would be the site of the America's Cup race. While the America's Cup race will not be held in Hawaii, over 1,000 small craft slips are being planned for the Keehi Lagoon area. As part of this ongoing project, subtasks include conceptual engineering design, bathymetry surveys, the updating of the Keehi Lagoon Recreational Plan, water circulation computer modeling, water quality and benthic surveys and bioassays, and a wildlife (bird) survey.

2. Project: Kohanaiki Marina Resort Development

Sponsor: NANSAY Hawaii, via Engineering Concepts, Inc.

Date: Ongoing

Under contract to Engineering Concepts, Inc., Edward K. Noda and Associates, Inc. is responsible for all oceanographic

tasks related to the marina development. The entire development includes an 18 hole exclusive golf course, three major resort hotels, resort condominiums, single-family residences and commercial facilities and a 170 slip marina. The project is in the conceptual design phase where EKNA has performed the following tasks: Market Study to evaluate the types and mix of expected vessels, Ocean Current Measurement Program, Preliminary Bathymetry (Hydrographic) Survey, Development Of The Oceanographic Design Criteria for the marina including the breakwater and jetty design, Conceptual Design And Layout Of The Marina, Construction Cost Estimation and Environmental Impact Assessment.

3. Project: Mokapu Ocean Outfall Inspection Project
Sponsor: Division Of Wastewater Management, Dept. Of Public Works, City And County Of Honolulu
Date: Ongoing (Final Report - March 1990)

The objective of this study was to evaluate the performance of the existing Mokapu outfall and diffuser system under both present and future design flow conditions. This study involved multiple task efforts and included the following:

- o An underwater engineering inspection and survey of the outfall and diffuser pipe sections and pipe protection using both video and still photography documentation.
- o The measurement of ocean current at 5 location at and surrounding the diffuser and the measurement of density profiles.
- o A hydraulic and dilution evaluation to determine the performance of the diffuser system for present and future flows, and provide recommendations on the optimum port-closure configuration and port-opening schedule.

The results of this study indicated that the Mokapu Ocean Outfall is in excellent physical condition and the present and expected future performance of the diffuser system is well within the design criteria. Dr. Robert C.Y. Koh participated as a consultant on the diffuser plume dilution analysis.

4. Project: Thermal Impact Evaluation Of The Cooling Water Discharge From The Port Allen Generating Station
Sponsor: Citizens Utilities Company (CUC),
Kauai Electric Division (KED)
Date: March 1989 (Final Report)

Due to increases in electrical power demand, CUC/KED proposes to install four 7.8 megawatt electric (MWe) diesel engine-

generators, Units 6-9, to meet future demand. The primary objective of this study was to quantitatively estimate the extent of the thermal plume due to the proposed cooling water discharge operations. As part of this objective, a specific task was to define the Zone of Mixing (ZOM) needed to insure that water temperatures outside the ZOM will not vary more than 1°C from ambient conditions.

In order to carry out the study objectives, an ocean water temperature field measurement survey was performed to accurately define the present thermal plume field. In addition, an analytical methodology was developed to predict the extent of the thermal impact areas, based on a scaling of the ocean water temperature data obtained from the field measurement program.

5. Project: Thermal Impact Evaluation Of The Cooling Water Discharge For The Kahe Generating Station Associated With The Addition Of Units 7 and 8
Sponsor: Hawaiian Electric Company, Inc.
Date: Unit 7 Study-July 1987, Unit 8 Study-December 1988

These two studies provided the results of a thermal impact evaluation of the surface and bottom thermal plumes due to the cooling water discharge from the Kahe Generating Station (KGS) associated with the proposed addition of Units 7 and 8 respectively. The objectives of these studies was to evaluate two alternative configurations of the KGS cooling water discharge system for compliance with the thermal excess limits contained in the National Pollutant Discharge Elimination System (NPDES) Permit No. HI 0000019 and the State of Hawaii, Department of Health, Zone of Mixing Permit (ZOM) for the present operations of KGS Units 1-6.

This study was carried out by Edward K. Noda and Associates with Dr. Robert C.Y. Koh, California Institute of Technology, as a major consultant.

6. Project: Kealakehe Ocean Outfall Design, North Kona, Hawaii
Sponsor: R.M Towill Corporation, Prime Contractor, Sponsored By The Department Of Public Works, County of Hawaii
Date: June 1986

This project involved the design of the outfall and diffuser system for the Kealakehe Ocean Outfall. Subtasks included the development of alternative diffuser designs and the computer modeling of the nearfield initial dilutions of the wastewater plume in the receiving waters. This project was terminated since it was decided not to construct an ocean outfall.

7. Project: Saipan Marina/Hotel Project, Garapan, Saipan
Sponsor: APEX International Corporation, Tokyo, Japan
Date: November 1988

This project involved the new development of a Resort Hotel and Marina Complex, including the construction of a breakwater and the dredging of a long entrance channel. Edward K. Noda and Associates was involved in the conceptual design phase and our tasks included the following: The development of the Conceptual Design Criteria for the marina; Master Plan of the Marina Complex; Preliminary design of the breakwater and entrance channel alignment and cross section.

8. Project: Nansay Hotel Development, Saipan, CNMI
Sponsor: Coastal Resources Management Office, Commonwealth of Northern Mariana Islands, Saipan
Date: 1988

As a coastal engineering consultant to the Coastal Resources Management Office, CNMI, Edward K. Noda and Associates technically reviewed the development plans for the Nansay Hotel Complex proposed for Saipan. This effort primarily focused on the evaluation of the salt water lagoon system and the biological and hydraulic design of the system.

9. Project: Development Of An Erosion Management Plan
For The State Of Hawaii
Sponsor: Coastal Zone Management Program, Office Of State Planning, State Of Hawaii
Date: June 1989 (Final Report)

The purpose of this study was to provide a comprehensive overview of erosion and erosion management in Hawaii, as an initial step towards the goal of developing a uniform method or regulatory process for the implementation of structural and non-structural measures. Specific study tasks included the following:

- o Description of the nature of shoreline erosion and erosion-related problems in Hawaii.
- o Discussion of structural and non-structural measures which have been used and/or which are available to prevent or manage erosion and erosion-related problems.
- o Evaluation of the effectiveness of existing measures, as well as the problems associated with implementation and management of such measures.

- o Examination of case study sites to serve as specific examples. Three case study sites were studied; Makaha and Kailua-Lanikai, Oahu and Kukuiula-Poipu, Kauai.
- o Development of general recommendations to improve the overall erosion management in Hawaii.

10. Project: Windward Oahu Beach Erosion Project
Sponsor: Sam O. Hirota, Inc. for the City and County of Honolulu, Department of Parks and Recreation
Date: Completion - October 1988

In order to develop an overall understanding of the severity, priority and cost of erosion control measures for seven selected windward Oahu public beach parks, Edward K. Noda and Associates as a subcontractor to Sam O. Hirota, Inc., is carrying out a generalized study of the beach erosion character at these seven beaches. The seven beach parks are Laie Beach Park, Hauula Beach Park, Punaluu Beach Park, Kaaawa Beach Park, Kalae-Oio Beach Park, Swanzy Beach Park and Kualoa Regional Park. As part of this study task, Edward K. Noda and Associates, Inc. has obtain all available historical aerial photographs of the beach areas at these 7 windward beach parks. The beach lines (waterline and/or vegetation line) on the aerial photographs have be electronically digitized and, utilizing the appropriate selections of targets within each photograph, the horizontal length scales have been made identical. Computer software was then be used to undistort the digitized waterlines. The historical beach lines have been computer plotted to develop an understanding of possible historical trends in beach erosion or accretion characteristics.

11. Project: Lanikai Flood Control Project
Sponsor: Kwock Associates, Inc. For The City And County Of Honolulu
Date: September 1989

This project involved the preliminary and final design for the Lanikai Flood Control Project in Lanikai, Oahu. EKNA was responsible for the oceanographic analysis of the ocean drainage discharge structures. As part of this evaluation, both the shoreline and vegetation lines were electronically digitized from available aerial photographs. These lines were undistorted and properly scaled using an in-house computer program. Analysis was then performed to evaluate the long-term trends in shoreline erosion.

12. Project: Beach Processes Study, Kailua Beach, Oahu, Hawaii

Sponsor: Planning Branch, U.S. Army Engineering Division,
Pacific Ocean

Date: September 1977 (Report)

This project involved the analysis of the dynamic beach processes associated with beach erosion problems at Kailua Beach, Oahu. The analysis involved the analytical and numerical transformation of deep water wave statistics to the point of breaking on the beach using the processes of wave refraction, shoaling, bottom energy dissipation, diffraction, and finally wave breaking. The subsequent littoral transport of beach sand was calculated and the modeling of the subsequent shoreline was performed.

Of particular interest was the fact that extensive use of aerial photographs were incorporated in the evaluation. In order to provide as much accuracy as possible, the shorelines shown in the aerial photographs were electronically digitized using computer equipment. Known targets which appeared on all the available aerial photographs were also selected and digitized. A computer program was written to undistort the digitized shorelines and correct for photographic scale factor differences to produce a single drawing of all the shorelines in an identical coordinate system.

13. Project: Bathymetry Surveys Of Potential OTEC Sites In
American Samoa, Guam And The Commonwealth Of The
Northern Mariana Islands (CNMI)

Sponsor: Pacific International Center For High Technology
Research (PICHTR), Commonwealth Energy Office, CNMI,
And The US Department Of Energy, Technical Assistance
Program (TAP)

Date: Completed August 1989

In order to provide detail bathymetry maps potential OTEC sites, deep-water bathymetry surveys to a depth of 1,000 meters were carried out at the following sites:

- a. Punta Hagman, Saipan, CNMI
- b. Cabras Island, Guam
- c. Fatuasina Point, Tutuila, American Samoa

In addition to the bathymetry survey, expendable bathythermograph (XBT) temperature profiles were also obtained.

14. Project: Design Of The Agat-Santa Rita Wastewater System
And Tipalao Outfall

Sponsor: Public Utilities Agency Of Guam

Date: Ongoing

Edward K. Noda and Associates, Inc. is a sub-contractor to Duenas and Swavely, Inc., Guam related to coastal and oceanographic engineering of a new wastewater outfall and diffuser off Tipalao Bay, Guam. EKNA will be responsible for the development of the oceanographic design criteria for the outfall and diffuser including the specifications of the typhoon design waves and associated wave forces on the outfall. In addition, a diving reconnaissance survey will be performed and physical oceanographic measurements will be obtained.

15. Project: Ammunition Port Facilities, U.S. Naval Magazine, Orote Point, Guam, Mariana Islands
Sponsor: Pacific Division, Naval Facilities Engineering Command
Date: June 1977 (Report)

As a subcontractor to CE Maguire, Inc./R.M. Towill Corporation (J/V), Edward K. Noda was responsible for the ocean engineering analysis of the Ammunition Wharf breakwater design which included the typhoon design wind and wave analysis and breakwater model studies. This work was performed while Dr. Noda was employed at Tetra Tech, Inc., Pasadena, California.

16. Project: Wave Monitoring And Analysis, Apra Harbor, Guam
Sponsor: U.S. Army Corps of Engineers, Pacific Division
Date: January 1978 (Report)

Edward K. Noda and Associates was a subcontractor to R.M. Towill Corporation related to the analysis of waves at the entrance to Apra Harbor, Guam associated with the salvage operations of the M/V Caribia. The project involved the measurement of wave conditions during diving salvage operations being performed by the contractor Nippon Salvage. A large claim was expected due to severe wave conditions being experienced at the salvage operations site. EKNA was responsible for formulating the wave measurement program and fully responsible for all wave data analysis including the extensive hindcasting of typhoon generated waves during the 2 year salvage period.

17. Project: Ocean Thermal Energy Conversion (OTEC) Projects (Various)
Sponsor: U.S. Department of Energy, State of Hawaii, Private Organizations
Date: 1978 To Present

Edward K. Noda and Associates has been involved in every major

OTEC Project in Hawaii since 1978 and continues to provide oceanographic services on ongoing projects. The following provides a listing of some of these projects.

o Site-Selection Bathymetry Survey, Keahole Point, Hawaii
In Conjunction With OTEC Proposed Shorebased Test Facility

This project was carried out by Dr. Edward K. Noda during 1977, while associated with the University of Hawaii, College of Engineering, Department of Ocean Engineering. This was the first major survey of the deep-water bathymetry off Keahole Point, Hawaii, with the objective of accurately defining the bathymetry for OTEC CWP route selection evaluations. This data was used for the subsequent Proof-of-Concept Mini-OTEC CWP mooring design as well as other OTEC program off Keahole Point, Hawaii.

o Mini-OTEC Design Criteria Development And CWP Deployment

Under contract to the Research Corporation of the University of Hawaii (RCUH), EKNA developed the general design criteria for the CWP design, and participated in the deployment operations for the Cold Water Pipe (CWP). EKNA's responsibilities during the deployment included current measurements and the accurate offshore positioning of the main mooring anchor.

o Bottom Current Survey, Keahole Point, Hawaii
In Conjunction With Proposed OTEC Seacoast Test Facility

This 1978-1979 project involved the measurements of near-bottom ocean current (20 feet off the bottom) at various locations along a proposed CWP route off Keahole Point, Hawaii, from water depths of 65 ft to 1,500 ft. The objective of this data acquisition program was to provide operational and design current data for the design evaluation of OTEC CWPs.

o Manned Submersible Reconnaissance Survey, OTEC Seacoast Test Facility Proposed Pipeline Route, Keahole Point, Hawaii

As part of the field data acquisition program off Keahole Point, Hawaii related to the design of an OTEC CWP, Dr. Noda contracted for and was the observer in a reconnaissance submersible dive on October 21, 1977 to a water depth of 1,400 ft using the submersible Star II, which was owned by Maui Divers, Inc. The University of Hawaii, Hawaii Undersea Research Laboratory (HURL) has subsequently purchased this submersible and renamed it the Makalii.

o Interim 12" Cold Water Pipe Construction And Deployment At
The Natural Energy Laboratory of Hawaii (NELH)

Under a contract with RCUH, Edward K. Noda and Associates, Inc.

was responsible for the construction supervision of the nearshore CWP system including the underwater pump station and provided services during the deployment of the offshore section of the CWP. During the CWP deployment, EKNA provided real-time current measurements and other responsibilities included offshore navigation services to accurately locate the pipeline in the design corridor.

o 48" CWP Deployment Off Keahole Point, Hawaii At NELH

EKNA under contract to Hawaiian Dredging and Construction Company (HD&C) participated in the deployment of the 48" CWP of Keahole Point, Hawaii. EKNA's responsibilities included real-time current measurements and all offshore navigation and positioning services to deploy the CWP on the design alignment.

o OTEC Environmental Benchmark Surveys At Keahole Point, Hawaii And Kahe Point, Oahu

Under contract to the Lawrence Berkeley Laboratory (LBL), University of California, Berkeley, EKNA was directly responsible for the acquisition and analysis of extensive environmental data including current and wave measurements, physical oceanographic parameters such as water temperature and salinity and chemical and biological parameters. In addition, under this contract pre-, post- and during-operation surveys for the OTEC-1 operations were performed. This included a detail mixed-water discharge plume survey using dye tracers.

o OTEC Cold Water Pipe At-Sea Test Program

Under contract to HD&C sponsored by the U.S. Department of Energy, EKNA had major responsibilities in this multi-year, multi-phased program. Phase 1 involved the design of a barge-suspended 8 ft diameter CWP test program. Phase 2 was the at-sea test of the suspended CWP off Honolulu and Phase 3 involved the design and at-sea test of the CWP in a bottom mounted configuration off Keahole Point, Hawaii.

EKNA was responsible for the oceanographic design criteria for all phases of the program including design waves, winds and current criteria as well as operational criteria. During each of the at-sea test phases, EKNA was responsible for the acquisition of oceanographic and environmental data including wind, wave and currents. In addition, for the Phase 3 program, EKNA was responsible for the design, fabrication, installation and operation of the entire data acquisition system which included wave forces on the CWP. Finally, EKNA was involved in the deployments of both at-sea test pipelines, including the monitoring of real-time waves and currents, the forecasting of meteorological conditions and the responsibility for all

offshore navigation and positioning tasks.

o HOST Park CWP Design

Under contract to R.M. Towill Corporation, sponsored by the State of Hawaii, Department of Accounting and General Services, EKNA developed the oceanographic design criteria for the offshore pipelines. This analysis included the evaluation of the design hurricane waves, design currents and design water level. In addition, design wave water-particle velocities and accelerations were developed along the CWP axis alignment for force calculations.

o HOST Park CWP, Hawaiian Abalone Farms CWPs And NELH CWP Deployments During June-October 1987 & August-Nov 1989

In support of the following projects,

1. Hawaiian Abalone Farms 2 16" CWP Deployments
2. HOST Park 40" CWP Deployment By Kiewit Pacific Company
3. NELH 18" CWP Deployment By American Divers, Inc.
4. Ocean Farms Of Hawaii Deployment Of 6 CWPs

Edward K. Noda and Associates, Inc. provided various services including the monitoring of real-time currents using a in-situ current meter with a RF telemetry system to a shore receiver and direct computer printout. This real-time current measurement program was critically important to the scheduling of the high-risk CWP deployment. In addition, weather conditions were monitored and forecasted.

o 40 Mw OTEC Pilot Plant Design Program

This multi-year, multi-phase program was sponsored by the U.S. Department of Energy and involved the Conceptual and Preliminary Design of a 40 Mwe OTEC Pilot Plant off Kahe Point, Oahu. EKNA was a subcontractor to TRW, Inc., the primary technical support contractor. Many tasks were completed by EKNA, including the development of the oceanographic design criteria for the Land Based Containment System (LBCS) [offshore island] and the CWP and Mixed-Water Discharge Pipe, evaluation of wave forces on the LBCS, extensive field measurements including currents (16 current meters), waves, water temperature, bathymetry and sub-bottom seismic surveys, submersible reconnaissance surveys, biological and chemical oceanographic surveys, mixed-water discharge effluent plume modeling including biological interaction modeling, nearshore circulation computer modeling, littoral drift and sediment transport analysis and many environmental impact related tasks.