EARTH SCIENCE LABORATORY DIVISION
UNIVERSITY OF UTAH RESEARCH INSTITUTE
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July 1, 1981

IDAHO OPERATIONS OFFICE
U.S. DEPARTMENT OF ENERGY
550 Second Street
Idaho Falls, Idaho 83401

Title: Technical Support for Geothermal Programs Administered by the Idaho Operations Office of DOE.

Type of Request: Modification to and Continutation of Contract No. DE-AC07-80ID12079

Amount Requested:

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INTRODUCTION

Within the Federal Government, the U.S. Department of Energy, Division of Geothermal Energy has lead responsibility for instituting and administering programs to facilitate development of geothermal energy. During the past four years the University of Utah Research Institute (UURI) and the University of Utah (UU) have been providing support to DOE for technical aspects of its geothermal programs. This proposal addresses a continuation of that support with modifications that reflect program changes, additions and progress.

As a result of philosophical changes in the administration of the U.S. Government during the past year the Federal geothermal program is being modified. Certain programs, mainly those that offer incentives to the private sector to develop geothermal resources, will be discontinued during FY 1981 and FY 1982 in favor of emphasis on research and development in those areas that are high-risk but potentially have high payoff. According to the document "Geothermal Energy Program, Assistant Secretary for Conservation and Renewable Energy: U.S. Department of Energy, April 1981.":

> "The aim of the geothermal program is to transform the many types of geothermal resources into an array of technically, economically, and environmentally sound sources of energy. The strategies reflect the different conditions of technical and economic readiness of the three resource types (hydrothermal, geopressured, and hot dry rock)."
>
> "For hydrothermal energy, the strategy is to continue to work with industry to identify technical problems that significantly affect the technical and economic feasibility of hydrothermal applications, to assess the need for Federal involvement in seeking solutions, and, where applicable, to perform the high risk/high payoff research and development needed."
>
> "The potentially useful geothermal resources in the United States span a broad spectrum of reservoir temperatues and fluid chemistry. The higher temperature (T>400°F) liquid-dominated hydrothermal resources are presently marginally cost competitive with alternative energy sources and are the major target of the private sector's development activities. However, the temperature distribution of the resource is such that most of the potential occurs at temperatures below 400°F where technological innovation is required to make development economically feasible. The

objective of the geothermal R&D program is to develop new or improved technology that will expand the economically exploitable resource base (by a factor of four or more) while complementing current private sector activities."

"The goal is to reduce geothermal field development costs by 25 percent, to reduce capital costs for electric generating facilities by 20 percent, to improve resource utilization efficiency, and to reduce the risks in all aspects of geothermal fluid handling (production, utilization, treatment, and disposal), which by the year 1987 will have the overall effect of reducing the electric busbar costs by 10 to 15 percent for high-temperature geothermal resources and as much as 30 percent for moderate-temperature resources."

In line with these goals and strategies, this proposal addresses sharply decreased activity during FY 1982 under the Industry Coupled Case Studies Program, the User Coupled Confirmation Drilling Program, and the Outreach Program, with an orderly phase out of these programs by the end of FY 1982. We propose a continuation during FY 1982 and beyond of the Exploration and Assessment Technology Program, the Geothermal Sample Library the M-X/RES Program, and the Federal Buildings Program. The Seismic Monitoring Program and Planning and Analysis Program now underway will be terminated at the end of FY 1981.

Implementation of the work proposed herein will take place under the management of the Idaho Operations Office (ID) of DOE. There will be some interaction between UURI and Nevada Operations Office (NVO), especially during phase out of the Industry Coupled Program. Assistance and support will be provided to UURI by the Department of Geology and Geophysics of the University of Utah, who will work through a subcontract.

OBJECTIVE AND STRATEGY

The overall objective of the work proposed herein is to facilitate development of geothermal energy in the United States. The basic strategy for accomplishing this objective is to provide technical support for the U. S. Department of Energy geothermal programs. The University of Utah Research Institute (UURI) will maintain a center of excellence in geosciences and will make staff and facilities available to DOE for the support it requires.

TECHNICAL DISCUSSIONS AND STATEMENTS OF WORK

In the sections that follow are technical discussions and statements of work for the projects proposed by the Earth Science Laboratory Division of the University of Utah Research Institute. The following table compares the scope of programs in FY 1981 with that proposed for FY 1982.

Program Name	Proposed Scope of Programs
Exploration and Assessment Technology Program	decrease
Geothermal Sample Library	sharp decrease
M-X/RES Program	increase
Federal Building Program	same
Industry Coupled Case Studies Program	phase out in FY 1982
User Coupled Confirmation Drilling Program	phase out in FY 1982
Outreach	decrease
Planning and Analysis	terminate at end FY 1981
Seismic Monitoring	terminate at end FY 1981

University of Utah Research Institute - Earth Science Laboratory Division

1.0 Exploration and Assessment Technology Program

The objective of the Exploration and Assessment Technology program is to increase the cost-effectiveness of existing exploration and resource assessment tools and techniques and to develop new tools and techniques. For the high temperature systems of interest to the electrical geothermal industry, exploration has been carried out using certain methods originally devised for petroleum or mining exploration. These methods are not optimum nor sometimes even applicable for geothermal exploration or discovery. Even current thermal techniques have not been specifically developed for geothermal exploration, but rather are applications of conventional heat flow studies or of well logging. It is evident that much can be done to improve exploration for high-temperature systems.

Exploration and assessment techniques for low- and moderate-temperature geothermal systems are in an even more primitive state of development. Because there is no direct heat industry today, little effort has been expended in the private or government sectors to develop exploration and assessment techniques specifically for lower-temperature resources. Not all of the methods used for high-temperature exploration are applicable. In addtion, many direct heat projects are at such a scale that only a modest exploration program will be economically feasible. It is important for DOE to pursue development of techniques for direct heat exploration in order to increase the probability of success of the individual sites projects in the User Coupled Confirmation Drilling Program.

One important component of Exploration and Assessment Technology is the extramural component. Funds are made available for DOE solicitations that are

issued for specific topics. The selection of topics is carefully structured from data that UURI collects from industry and from other DOE Programs, such as the Industry Coupled Program, the State Coupled Program and the User Coupled Confirmation Drilling Program, on an annual basis. At the present time DOE-ID has 9 contracts in effect as a result of the FY 1979 procurements, and we expect 4 new contracts as a result of FY 1980 procurements. For anticipated FY 1981 procurements we will continue to update our lists of the highest priority topics for DOE-funding.

A second important component of the Exploration and Assessment Technology Program is the in-house technology development that UURI and UU perform. The team of geoscientists that we have assembled has unique qualifications to perform certain aspects of geothermal technology development. We maintain an integrated team of experts whose individual members work closely together. For convenience in discussion and in our management, we have divided the presentation of tasks into those concerned with geological, geochemical, and geophysical technique development. But the proposed program is fully coordinated both in-house and also with the extramural program. We have proposed work on only those topics that are high priority and for which we have specific expertise. Each of the items of proposed work is designed to contribute optimally to our overall technology development objectives and/or to specifically support programs such as the Industry Coupled Program, the State Coupled Program and the User Coupled Confirmation Drilling Program, that will lead to industrialization.

The specific tasks proposed under this program are:

1.1 Technical Assistance:

1.11 Provide support for program planning. Maintain the Exploration

and Assessment Technology Program plan up-to-date as requested by DOE.

1.12 Provide data and recommendation to DOE regarding solicitations for extramural technology development. Obtain updated information from industry regarding the highest priority items for technology development work.

1.13 Provide assistance in monitoring contracts that result from DOE solicitations under this program.

1.2 Geological Technique Development

1.21 Fission Track Systematics. A base line of geochronologic data, including an evaluation of land uplift rates, was established for Roosevelt Hot Springs, Utah in FY 1980. Continued work in FY 1981 will evaluate variations in the size of the geothermal system at Roosevelt Hot springs during its evolution with time. Also in FY 1981, roughly 20 fission track mineral dates from Beowawe, Nevada will be obtained to establish an understanding of the tectonic history and begin to evaluate the time/space relationships of the goethermal system.

1.22 Fault Permeability Studies. Evaluate fault systems exposed at Beowawe, Nevada to determine the permeability of faults and of fault intersections. In most geothermal systems, faults and fractures associated with faults provide conduits for the geothermal fluids and are the usual target of exploration drill holes. However, fault zones may change permeability along strike and with depth and may grade from highly permeable to impermeable in short distances. It is therefore of great importance to develop an understanding of the behavior of these

structures in order effectively to explore for the geothermal fluids that they may contain.

1.23 Low- to Moderate-Temperature Case Studies. Case studies will be done on one low- to moderate-temperature geothermal system to continue the development of exploration techniques for these sytems which we have initiated in FY 1980. This task will be coordinated with efforts under Geochemical and Geophysical Technique Development to insure integrated approaches to exploration for these systems. The work will most immediately benefit the exploration efficiency of projects funded under the User Coupled Confirmation Drilling Program.

1.3 Geochemical Technique Development: Geochemical studies since 1977 have been directed toward the development of exploration techniques designed to predict subsurface reservoir conditions and locate thermal brines in geothermal systems. An exploration model based on multi trace element zoning, mineralogic zoning, and isotopic techniqes has been developed for the Roosevelt Hot Springs, Utah geothermal system. It is being tested by UURI, with apparent success, in several other geothermal systems in the western United States. The proposed tasks in the FY 1981 geochemical program are as follows:

1.31 Quantify the geochemical models currently being developed; test and quantify geochemical zoning models by comparison with measured subsurface conditions, predicted and known stability fields of the associated mineral assemblages and, where possible, other geochemical thermometers. Extend trace element distribution models to other elements present in the geothermal

fluids. Acquire additional surface and drill samples from geothermal systems for which subsurface data are available in order to test and refine these models.

1.32 Refine and test isotopic and geochemical models designed to predict reservoir permeability, porosity, water-rock ratios, and fluid residence times. Test these models in one or more documented geothermal systems.

1.33 Refine and test dynamic computer models designed to predict the physico-chemical conditions related to mineral dissolution, and precipitation (deposition) and alteration in geothermal reservoirs. Compare the results with actual mineral assemblages and distribution of recharge and discharge zones in a documented geothermal system.

1.34 Provide geochemical interpretations and analyses of rocks and fluids from one or more low-temperature geothermal systems. Integrate these studies with geological and geophysical models.

1.4 Geophysical Technique Development

1.41 Develop interpretation techniques for hole-to-surface acquisition of electrical geophysical data. Single holes will be common in low- and moderate-temperature resource evaluation, and development of techniques to further important to ultimate reservoir development.

1.42 Publish two- and three-dimensional MT catalogs for geothermal exploration.

1.43 Perform geophysical surveys and data analysis over one or more areas of low- to moderate-temperature. This work will be coordinated with tasks 5.23 and 5.34.

2.0 Geothermal Sample Library

The Geothermal Sample Library is a facility operated for DOE by UURI for the purpose of curating and making available to the public drill chip, drill core, surface rock, and drill hole and surface fluid samples from geothermal areas. The samples are accessible by the public in either of two ways: 1) samples and data may be studied and examined visually by anyone who visits the Library, or 2) samples may be obtained for special study in other laboratories by application to UURI and by approval by a special Sample Committee composed of three people who are not employees of UURI. DOE considers the curation and preservation of samples from geothermal areas vital to continued research in geothermal exploration and exploitation. The GSL facility is unique in its contents and methods of operation in the goethermal industry.

To date the Library contains chip samples from 234,600 feet of drilling, 6,177 feet of core samples, and approximately 510 hand surface samples. These samples have been obtained from 179 holes in 20 different geothermal areas, including Roosevelt Hot Springs, and Cove Fort-Sulphurdale, Utah; Coso, California; Baltazor, Beowawe, Colado, Desert Peak, Dixie Valley, Humboldt House, Leach Hot Springs, McCoy, McGee, San Emidio, Soda Lake, Stillwater, and Tuscarora in Nevada; the north-central Cascades; and Raft River INEL-1, Idaho.

As a result of severe reductions in the Federal geothermal program, we propose a radical curtailment of the activities of the Geothermal Sample Library. We will continue to curate samples and to make them available on open file and for distribution, but we will make a nominal charge to users of these latter two services to cover our costs. The samples will be curated in inactive storage space.

The specific tasks proposed for this program are:

2.1 Sample Curation: Maintain a reduced geothermal sample library facility in order to preserve geothermal samples. Make these samples and associated data sets available to geoscientists for inspection and study. Provide services for the aquisition, preparation, storage and distribution of geothermal samples and maintain and open-file capability. Charge a fee to users of these facilities.

3.0 M-X/RES Geothermal Program

4.0 Federal Building Program

5.0 Industry Coupled Case Studies Program

The objective of DOE's Industry Coupled Program is to facilitate reservoir confirmation activities by industry at high-temperature hydrothermal sites in the U.S. Cost-sharing for exploration and test drilling is provided by DOE through contracts with successful industrial proposers. In return, a delivery of exploration data, generally including the data generated by the cost-shared project as well as data previously obtained, is made to DOE by the industrial contractor. These data are sent to UURI for a) open filing to the public, and b) independent analysis and publication of interpretations. These data come to UURI in raw, uninterpreted form because most companies consider their data interpretation techniques to be proprietary. Some companies, especially smaller ones, have no interpretation and analysis capabilities, and one of UURI's contributions is to publish analysis and interpretations useful to all for the purpose of stimulating a larger industry.

It is generally the case that one or more data sets needed for development of appropriate topical reports and of a reservoir case study are missing from the data set, either because industry has kept them proprietary or because industry did not collect these data. UURI has been funded to collect critical missing items of data. We have found that geologic mapping adequate in scale and detail to develop a consolidated interpretation of all data sets is usually missing, and UURI has provided such geologic mapping over a total 274 square miles in the following areas: Roosevelt Hot Springs and Cove Fort-Sulphurdale KGRAs in Utah; Beowawe, San Emidio, Baltazor, Tuscarora, McCoy and Colado KGRAs in Nevada. This basic geologic mapping has been very important to companies working in the mapped areas and has been used by them to plan and execute further work. Other exploration work that has been provided either directly by UURI or by subcontractors funded by DOE through

UURI includes aeromagnetic surveying at Cove Fort-Sulphurdale KGRA, electrical resistivity surveying at Cove Fort-Sulphurdale KGRA, Beowawe and Colado, and gravity surveying at Baltazor. In addition UURI and UU have provided potassium-argon age dating, geochemical surveys, and isotope studies in many of the Industry Coupled contract areas. All of these data, and additional resistivity surveys at Baltazor and Tuscarora have been interpreted in a state-of-the-art manner using UURI-developed numerical modeling programs. The results are being made available to the industry operators and the geothermal community as a whole on a timely basis.

UURI deliverable items include both topical reports and reservoir case studies. Topical reports cover in detail the results of analysis of industry- or UURI-generated data at a site. Case study reports document a consolidated interpretation and reporting of all data sets, but in somewhat less detail than the topical reports. The case studies also attempt to develop a geologic reservoir model. These topical and case study reports are extremely valuable to the fledgling geothermal industry, which is still struggling with development of cost-effective techniques for exploration, drilling and testing of hydrothermal sites. To date 18 reports have been released by UURI and UU under this program, and about 5400 total copies of these reports have been distributed by UURI (excluding NTIS distribution).

The open-file data releases are also very valuable. To date UURI has released more than 120 different items to the public. This includes copying and distribution of well over 400,000 pages of printed material and about 30,000 maps. These are made available at our reproduction costs. Many requestors order a complete copy of all items released. In this manner we have put into the public domain exploration data whose original costs of

collection, mostly borne by industry, exceed $23 million.

During FY 1982 we propose to continue data collection and analysis on those areas for which industry will still be working under this program during FY 1981 and FY 1982, namely Roosevelt Hot Springs, Utah, and Leach Hot Springs, Beowawe, Colado, Baltazor, McCoy, Tuscarora, and Stillwater, all in Nevada. Apart from this, the proposed effort includes only completion of studies in progress and reporting.

The specific proposed tasks are:

5.1 Technical Assistance, Utah: Provide technical assistance to DOE for Southern Utah contracts awarded in response to RFP EY-R-08-007. Interface between DOE and the one remaining contractor, Geothermal Power Company, through the contract duration. Evaluate the technical content of data generated by Geothermal Power Company under their contract with DOE. Open file all data generated from this contract. Acquire and curate drill samples in the Geothermal Sample Library. Synthesize, study, interpret and publish technical reports on data generated by the contractors to DOE working in Southern Utah. Evaluate effectiveness and applicability of the exploration techniques used in the Utah case studies.

5.2 Technical Assistance, Nevada: Provide technical assistance for industry contracts awarded in the Northern Basin and Range Province Reservoir Assessment Program, DOE/DGE RFP ET-78-R-08-0003. Assistance will be identical to that outlined in Task 1.1 for the several industry contractors to DOE who are active in the Program.

6.0 User Coupled Confirmation Drilling Program

The User Coupled Confirmation Drilling Program provides cost-sharing for reservoir confirmation exploration and drilling for direct heat hydrothermal reservoirs, to be done by prospective users and developers in the private and public sectors. Because the individual site projects are performed largely by private sector expertise rather than by a federal agency or laboratory, development of a direct heat industry including exploration, drilling, reservoir engineering, architectural engineering, equipment manufacturing, financing and legal aspects is stimulated.

DOE will require technical assistance during several phases of the User Coupled Confirmation Drilling Program. Because this program is basically an exploration program, geologic and exploration expertise are needed. Proposal review by experienced geoscientists is critical because DOE's intention is to support ~~select~~ only those proposals that have high probability of intersecting a usable resource. Once a cooperative agreement contract has been awarded, DOE monitors the progress of each site project, and acquires and independently analyzes the data generated by the project in order to make decisions about whether and how to continue ~~each phase~~ successive phases of the project. For example, careful analysis of exploration data is required to make sure that the data are consistent with the concept of a hydrothermal reservoir at depth and that the proposed test well is sited properly. Similar monitoring is required during the drilling and flow testing phases. This monitoring and analysis function is performed by a team of experts from DOE-ID, DOE-NVO, UURI and EG&G, Idaho, Inc.

When a site project is complete, the data generated by the project will be placed on open file to the public and end case studies will be published

for selected projects. Such publication will help build a geothermal exploration literature that does not exist today.

During FY 1981 DOE awarded ~~5~~ 2 contracts under this program, and anticipate awarding 2 others as follows:

1. GeoProducts, Inc., Honey Lake, CA. project.
2. City of Alamosa, Alamosa, CO. "
3. Wine Valley Inn, Calistoga, CA
4. Magic Resource Investors, Magic Reservoir, ID.

~~5.~~

It is anticipated that each of these ~~5~~ 4 contracts will be completed during FY 1982, and that at their completion UURI's involvement with this program will end. Until termination, the specific tasks proposed are:

6.1 Technical Assistance: Provide the following technical program assistance to DOE: Help to monitor the progress of contractors; perform independent analyses of data generated by contractors for the purpose of advising DOE on whether and how to continue contract; promote coordination of this program with other programs, especially the State Coupled, Outreach and Exploration and Assessment Technology Programs.

6.2 Open Filing: Place factual data generated by this program on open file, thus making these data available to the public.

6.3 Sample Acquisition: Acquire suites of chip and/or core samples from certain holes drilled under this program, and curate these samples in the Geothermal Sample Library.

6.4 Case Studies: Publish end case studies of selected projects for the purpose of building up a direct heat geothermal exploration literature.

7.0 Outreach Program

Doe's Outreach Program has the twin objectives of making prospective users and developers more aware of the potential that geothermal energy has for them and of providing them with enough technical assistance to stimulate them to carry through a successful geothermal project. This program is specifically aimed at the direct heat user since no direct heat industry exists today.

In its work on this program, UURI has found that the public is almost totally unaware of the potential contribution of geothermal energy to this country's energy needs. By contrast, solar energy, which is much further from commercial development, is well publicized. This is one result of the very large difference in federal funding that goes to these alternative energy sources. It is important that DOE stretch its information dissemination dollar as far as possible in publicizing geothermal energy.

Very few potential users and owners of geothermal resources understand how to actually go about development of the resource. Generally what is needed is technical assistance to get these people started on the right track and UURI provides geoscience and assistance to users on a request basis. This assistance is structure so as not to compete with private consultants and contractors by being limited to a maximum of 100 technical hours. We work cooperatively with EG&G, Idaho and the Oregon Institute of Technology, who each provide engineering assistance. We also involve State Coupled resource assessment geologists, who handle as many user assistance requests as they can.

During the period January 1980 to June 1980 we handled 58 user assistance requests. This represents a doubling in requests over the previous six-month

period, and provides an indication of the level of program growth. Our proposal for FY 1981 represents an increase over the FY 1980 level of effort to account for this high rate of increase. We believe this will be needed even though the state teams will be handling more user assistance requests than they have in the past. We anticipate that the User Coupled Confirmation Drilling Program will stimulate a great deal of user assistance requests, and that the User Assistance Program will help identify numerous sites suitable for User Coupled Drilling proposals.

The specific tasks proposed for this program are:

7.1 Information Dissemination:

7.11 Develop, schedule and conduct special training sessions and workshops for state resource and commercialization teams and others on various aspects of geothermal energy as needed.

7.12 Give presentations, seminars, and workshops on geothermal energy to professional societies, special meetings and interested parties upon request.

7.13 Develop information and participate with EG&G Idaho, Inc. in the preparation of non-technical pamphlets and brochures on geothermal resources.

7.2 User Assistance

7.21 Provide prospective users and developers in assigned states in the western U. S. with technical assistance in geology, geochemistry, geophysics, hydrology and other areas related to geothermal industrialization. Aid prospective users and developers in evaluating the geothermal resource potential of a specific site using literature research, field investigations and other techniques and provide users with suggested methods

for continued resource evaluation.

7.22 Coordinate and participate if requested in site-specific user assistance studies conducted by State Coupled geologic teams.

7.23 Coordinate resource applications evaluation with either OIT or EG&G Idaho, Inc.

7.24 Conduct a detailed investigation of the geothermal potential of two or more areas where there have been numerous user assistance requests, and publish the results of these studies.

7.25 Coordinate this program with the State Coupled resource assessment program and with the State Commercialization Program.

MANAGEMENT STRUCTURE

The University of Utah Research Institute is a non-profit corporation organized in 1972 under the Utah Non-Profit Corporation Cooperative Association Act and is under the immediate and complete control of the University of Utah. The Institute falls under Section 501-(c)3 of the Internal Revenue Code, and is also treated as a public charity by virtue of its being a separate organization controlled by the University of Utah. It has been issued its own employee identification number by the Internal Revenue Service. The Institute has 191 employees and is financially self-supporting and receives no state-appropriated funds for its operation. All services from the University are provided on a cost basis.

Although it is controlled by officers of the University as the Board of Trustees, all financial management, accounting, purchasing and contract administration are separate from the University. For purposes of government contracts, the Institute is subject to regular government audit in maintaining its own overhead, employee benefits, and other financial requirements.

The University of Utah Research Institute is directed by the President, who is appointed by the Board of Trustees. He is assigned by a Management Committee consisting of two Vice-Presidents, a Controller/Treasurer and Secretary, and the Officers of the Research Institute who are likewise appointed (Figure 1). The Management Committee is assisted by a staff consisting of the Accounting Department, Financial and Personnel Managers, Purchasing Agent, and the Secretarial Staff.

Three divisions presently comprise the University of Utah Research Institute. The Utah Biomedical Test Laboratory (UBTL) is a separate division

whose principal missions, as indicated by its title, are bioengineering and biomedical orientation to research and testing of medically-related products, services, and other biological studies. The Applied Technology Division (ATD) is comprised of the Environmental Studies Laboratory, Geospace Sciences Laboratory, and Microcircuit Laboratory. The Earth Science Laboratory Division (ESL) as a member of the Institute has the objective of assisting govenment and industry in energy development, mineral exploration, and basic studies in geology, geophysics, and geochemistry. The primary interest of the laboratory at present is geoscience aspects of geothermal energy under contracts with the Department of Energy (Figures 2 through 4).

The ESL staff has a broad range of education and experience in the earth sciences, particularly in exploration and assessment of geothermal resources, and in exploration for base and precious metals and uranium. Other major strengths include the application of geological, geophysical, and geochemical techniques (trace-element geochemistry and three-dimensional geophysical modeling are current examples), development of new instrumentation, and site-selection for nuclear waste disposal. Several key posts are filled by exploration and research people from Kennecott Exploration, Inc. and from the Uranium Division of the Anaconda Company.

MODIFIED MATRIX MANAGEMENT

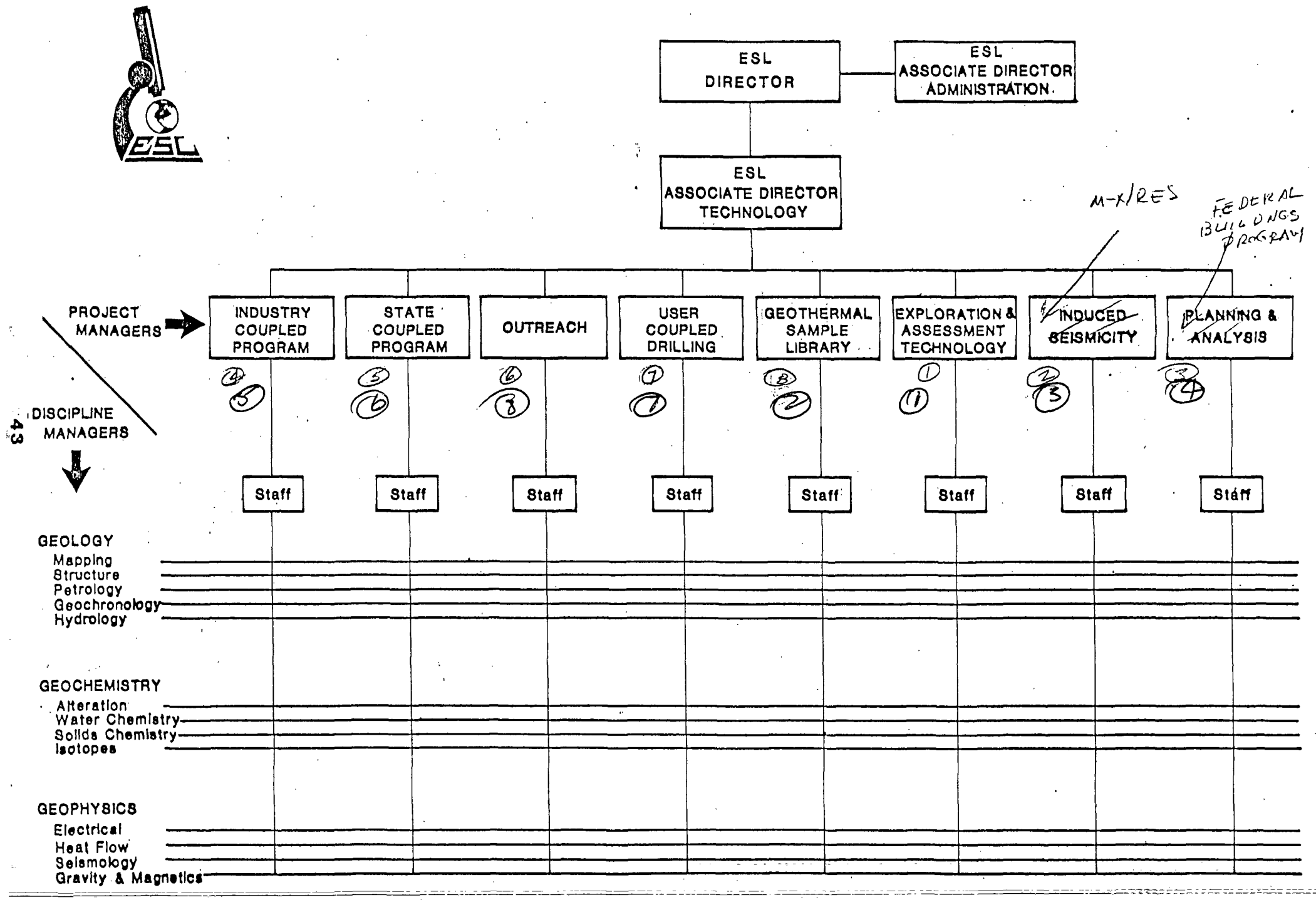


FIGURE 12

PROJECT MANAGEMENT
ESL/UURI & UU (Subcontractor)
DOE CONTRACT NO. DE-AC07-80ID12079

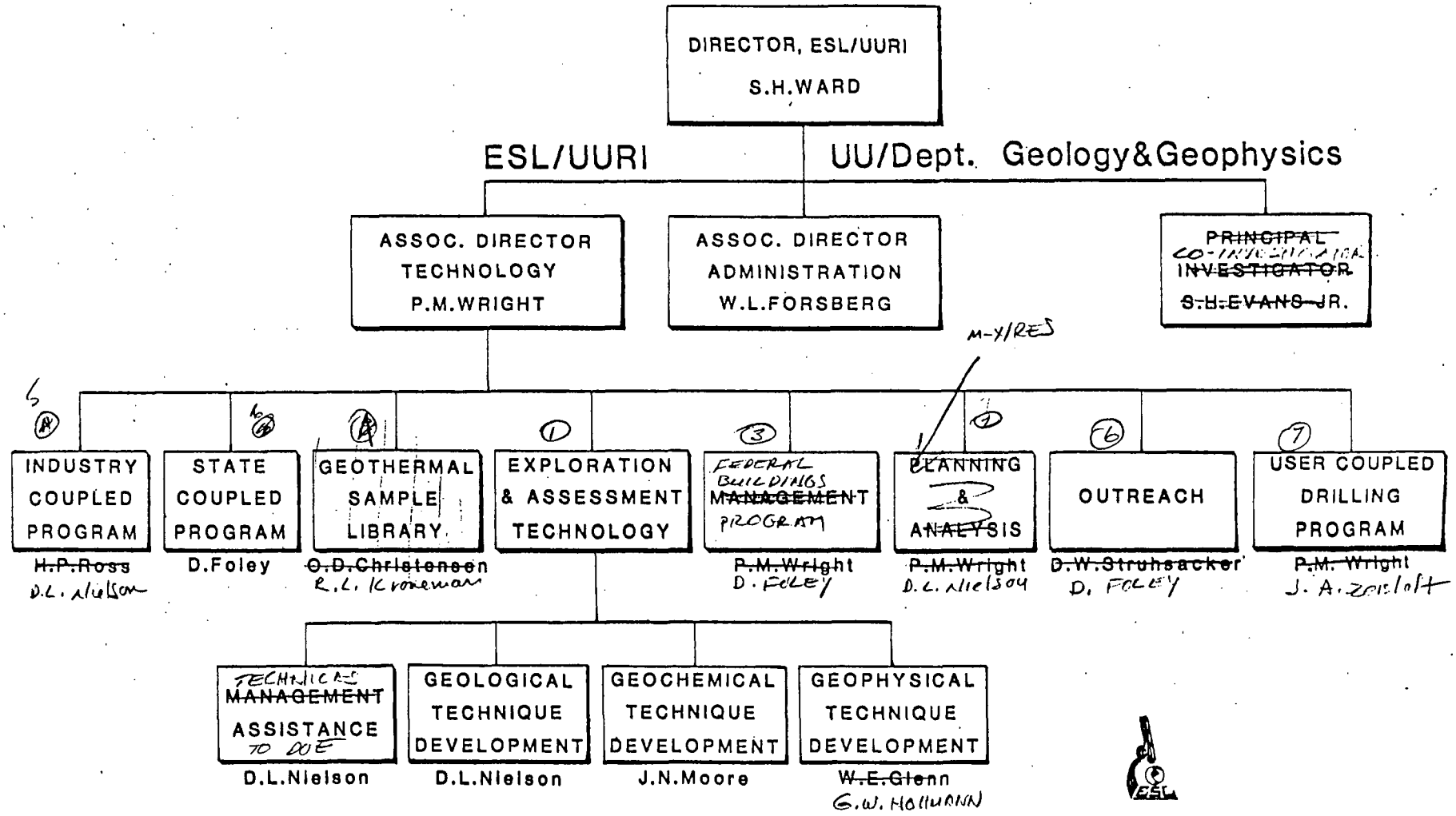


FIGURE 43

ADMINISTRATIVE MANAGEMENT
ESL/UURI & UU (Subcontractor)
DOE CONTRACT NO. DE-AC07-80ID 12079

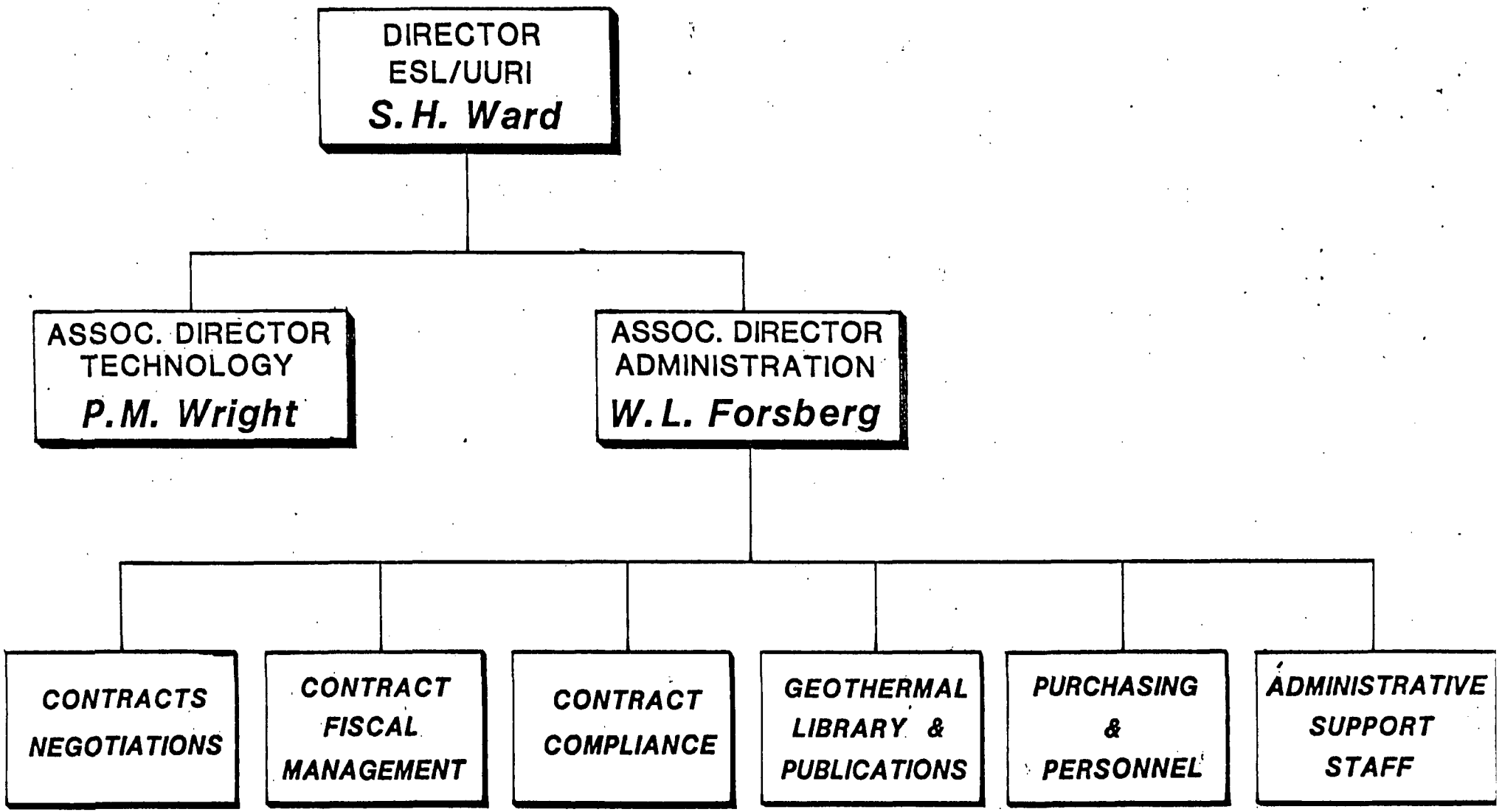


FIGURE 5

update - need other labs

UNIVERSITY of UTAH RESEARCH INSTITUTE

ORGANIZATIONAL CHART

under ATD

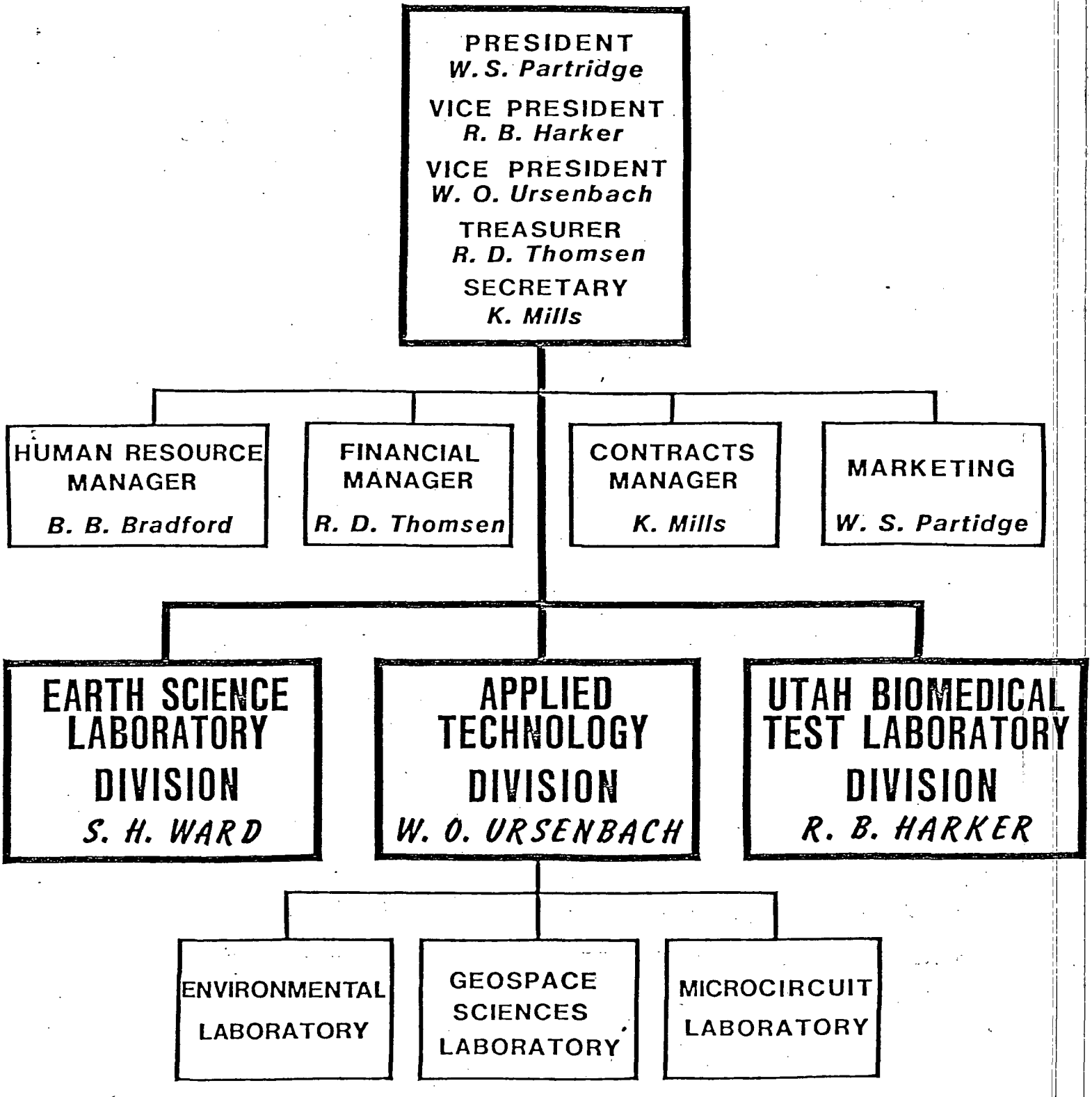


FIGURE 2 1

MEMORANDUM

June 19, 1981

TO: DOE Project Managers: Duncan Foley, Gerry Hohmann, Joe Moore
Dennis Nielson, Jon Zeisloft

FROM: Mike Wright

SUBJECT: FY 1982 DOE Program Philosophy

Attached are select pages from a much larger document by the U.S. DOE. I have the full document, and anyone who wants to see it is welcome. I have chosen these pages because they reflect how the current administration's philosophy will affect our work in hydrothermal energy development. I have highlighted the sections you will be most interest in.

In the past we have drawn funds mainly from the Hydrothermal Industrialization/Resource Definition and Geothermal Technology Development/Component Development line items. As Table III-I-2 shows, the former has been zeroed out.

Under section 4.1 -- Program Goals, it is stated that DOE's efforts will be to facilitate developing the <400°F resources that aren't commercial today. I believe we should identify our proposed research with these goals. At the same time, vertually everything associated with low-temperature development is being dropped. Thus we are guided to concentrate on the lower-temperature electric resources and the higher-temperature direct resources, with emphasis on the former. We should aim at high risk but potential high-payoff research projects.

Under 6.4.1.5 -- Geoscience Technology the write-up reflects our work but gives little guidance for the future. Atleast they know a bit about what we have done. Table III-I-11 shows $900K as the estimated Exploration Technology budget for FY 1982. This level is projected into the future until at least 1987. We have been told by DOE that our share is $600K, so either the $900K has been cut or LBL is still in for a share.

At any rate, the philosophy portrayed in these pages should guide our proposal, even though future changes are likely. We should remain flexible enough to accomodate such changes.

Mike

cc: Wil Forsberg
Stan Ward

WRIGHT
9 June 1981

GEOTHERMAL ENERGY PROGRAM

ASSISTANT SECRETARY FOR

CONSERVATION AND RENEWABLE ENERGY

U.S. DEPARTMENT OF ENERGY

APRIL 1981

3.0 PROGRAM STRUCTURE AND BUDGET

The basic program structure has not been changed even though the program has shifted from emphasizing both commercialization and R&D to primarily R&D. The private sector should now pursue the shorter term industrialization aspects of geothermal resource development. Major research and development elements that will be supported under DOE's redirected program include hot dry rock technology development, geopressured resource definition, and advanced technology development.

The geothermal energy program consists of five activities:

- Hydrothermal Industrialization
- Geothermal Resource Development Fund
- Geopressured Resources
- Geothermal Technology Development
- Program Direction.

Table III-I-2 presents the actual program activity funding levels for FY 1980 and the estimated funding levels for FY 1981 and FY 1982. The following sections describe these activities in more detail.

3.1 HYDROTHERMAL INDUSTRIALIZATION

This activity has included research, development, and demonstration projects designed to stimulate hydrothermal resource development, including:

- Resource definition in cooperation with the U.S. Geological Survey, state agencies, and industry.
- Nonelectric demonstrations to determine the engineering and economic aspects of using hydrothermal resources for direct heat. The participants have been selected through competitive solicitation.
- Planning and analysis activities and interagency coordination programs and state commercialization teams.
- Private sector development activities involving technical assistance centers, transfer of technology developed under the Federal geothermal energy program to the private sector, and legal and regulatory streamlining and reform.

Table III-I-2

Funding Levels for Geothermal Energy Activities FY 1980 through FY 1982

Activity	Budget Authority (Dollars in Thousands)					
	Actual FY 1980	Estimate FY 1981	FY 1981 Rescission	Revised Estimates FY 1981	Estimate FY 1982	Increase (Decrease)
Hydrothermal Industrialization	**70,412**	**67,935**	**(12,374)**	**55,561**	**6,000**	**(61,935)**
Resource Definition	12,634	21,224	(8,100)	13,124	0	(21,224)
Non-electric Demonstration	9,778	11,500	0	11,500	0	(11,500)
Planning and Analysis	6,011	6,081	0	6,081	0	(6,081)
Private-Sector Development	3,409	2,378	(274)	2,104	0	(2,378)
Geothermal Facilities	35,363	24,152	(4,000)	20,152	6,000	(18,152)
Environmental Control	2,184	2,600	0	2,600	0[a]	(2,600)
Capital Equipment	1,033	0	0	0	0	(163)
Geothermal Resource Development Fund	**181**	**43,266**	**(22,066)**	**21,200**	**200**	**(43,066)**
Program Direction	181	193	0	193	200	7
Guaranty Reserve Fund	0	41,982*	(22,066)	19,916	0	(41,982)
Loan Evaluation Fund	0	1,091	0	1,091	0	(1,091)
Energy Security Act	0	0	0	0	0	0
Geopressured Resources	**34,692**	**35,800**	**(3,865)**	**31,935**	**20,336**	**(15,464)**
Resource Definition	33,032	32,126	(3,865)	28,261	18,900	(13,226)
Supporting Reserach and Development	1,360	3,474	0	3,474	1,436	(2,038)
Capital Equipment	300	200	0	200	0	(200)
Geothermal Technology Development	**41,178**	**49,910**	**(2,261)**	**47,649**	**20,439**	**(21,810)**
Component Development	25,058	35,300	(2,261)	33,039	10,439	(24,861)
Hot Dry Rock	14,000	13,500	0	13,500	10,000	(3,500)
Capital Equipment	2,120	1,110	0	1,110	0	(1,110)
Program Direction	**1,802**	**2,376**	**0**	**2,376**	**1,600**	**(776)**
Total Geothermal Energy	**148,265**	**199,287**	**(40,566)**	**158,721**	**48,575**	**(150,712)**

* Represents reapproprlation of unobligated balances in FY 1981.

a Transferred to Geothermal Technology Development.

- Geothermal facilities constructed and operated to perfect new geothermal equipment and process techniques, particularly for electric power production. These facilities include a 50-MWe demonstration flash-steam power plant to produce electric power from a high temperature hydrothermal reservoir.

- Environmental control research and development seeking technological solution to environmental problems that might deter geothermal development.

3.2 GEOTHERMAL RESOURCE DEVELOPMENT FUND

The Geothermal Energy Resource Development and Demonstration Act of 1974 provided for the establishment of the Geothermal Loan Guaranty Program and the Geothermal Resource Development Fund to support the federal geothermal energy program. Five loans have been guaranteed. The loan guaranty program is now being phased out as responsibility is being shifted to the private sector. The Energy Security Act (1980) authorizes expenditures from the fund for reservoir confirmation loans and feasibility study loans. The Energy Security Act also provides for a study of the need for a reservoir insurance program. If such a program is enacted, appropriations will be required prior to the start-up of this program. To date, no appropriation bill has been enacted for any of the Energy Security Act programs.

3.3 GEOPRESSURED RESOURCES

The objective of this activity is to assess the onshore geopressured geothermal resource by delineating, through data gathering and surface work, optimum Gulf Coast reservoir areas, and by performing confirmation drilling and testing to obtain reservoir and brine characteristics needed to establish the commercial viability of the resource to provide heat, hydraulic pressure energy, and entrained or dissolved methane.

Wells that have been drilled into or through geopressurized reservoirs by the private-sector petroleum industry in the search for oil and gas have been made available for testing and provide information on important properties of the reservoir fluids (e.g., salinity, water chemistry, gas chemistry, and gas-to-water ratios) and on the reservoir characteristics around the wellbore.

These activities include supporting research and development addressing the longer term technology development required for ultimate commercial use of geopressured resources by the private sector.

3.4 GEOTHERMAL TECHNOLOGY DEVELOPMENT

The Geothermal Technology Development activity seeks technical solutions to the problems of operating in geothermal environments. The component technology efforts focus on: developing

techniques, materials, and equipment specifically tailored to geothermal conditions; and reducing technology costs.

Research into high-temperature drilling technology, reservoir stimulation, wellbore pumping, and binary power plants will have a great impact on geothermal energy costs. Research in exploration technology and reservoir engineering will accelerate discovery of new resources and provide a methodology for evaluating the financial risk of reservoir-related development. In most instances, major technological advances will result in more economic recovery of energy from geothermal resources.

The activity also assesses the potential of hot dry rock resources and supports development of new energy extraction techniques. Although research began in 1972, the present hot dry rock program was started in FY 1979 after successful operation of a 5-MWt thermal loop at the Fenton Hill site in New Mexico in 1978. The general objectives of this effort are: (1) to confirm the potential of HDR resources; (2) to develop a technology base for HDR energy extraction; (3) to verify the acceptability of environmental and social consequences of HDR energy development.

3.5 PROGRAM DIRECTION

Several hundred DOE geothermal projects are active throughout the United States and abroad. In addition, DOE has significant federal interagency coordination responsibilities with respect to geothermal development.

Management of such a complex program requires a geographically dispered organization that employs a wide range of professional skills. DOE's management approach is to concentrate policy, planning, overall budget definition, and program defense activities at its Washington, D.C. headquarters. DOE field organizations (i.e., operations offices, national laboratories, and regional representatives) are responsible for project definition, day-to-day project management in the field, and coordination with state and local authorities.

DOE, designated as the lead agency for Federal geothermal development, works through the Interagency Geothermal Coordinating Council (IGCC) to guide the Federal Geothermal Program. The Council, chaired by DOE, is made up of representatives at the Assistant Secretary level from 8 federal agencies involved in geothermal activities; about 25 agencies are represented in working groups, panels, and committees. The major research and development is carried out by DOE and by agencies of Department of Interior (DOI), especially the U.S. Geological Survey (USGS), the Bureau of Mines, and the Bureau of Reclamation. Environmental research, monitoring, and policy development is the primary responsibility of the Environmental Protection Agency, as well as USGS and U.S. Fish and Wildlife Service, and DOE. Federal geothermal land leasing is accomplished by DOI's Bureau of Land Management with the assistance of USGS, and the U.S. Forest Service on Federal lands administered by the U.S. Department of Agriculture.

4.0 GOALS, STRATEGIES, AND PRIORITIES

4.1 PROGRAM GOALS

DGE's goals are different for each resource reflecting the different stages of development of their respective technologies.

4.1.1 Hydrothermal Resources

The potentially useful geothermal resources in the United States span a broad spectrum of reservoir temperatures and fluid chemistry. The higher temperature (T>400°F) liquid-dominated hydrothermal resources are presently marginally cost competitive with alternative energy sources and are the major target of the private sector's development activities. However, the temperature distribution of the resource is such that most of the potential occurs at temperatures below 400°F where technological innovation is required to make development economically feasible. The objective of the geothermal R&D program is to develop new or improved technology that will expand the economically exploitable resource base (by a factor of four or more) while complementing current private sector activities.

The goal is to reduce geothermal field development costs by 25 percent, to reduce capital costs for electric generating facilities by 20 percent, to improve resource utilization effiiency, and to reduce the risks in all aspects of geothermal fluid handling (production, utilization, treatment, and disposal), which by the year 1987 will have the overall effect of reducing the electric busbar costs by 10 to 15 percent for high-temperature geothermal resources and as much as 30 percent for moderate-temperature resources.

4.1.2 Geopressured Resources

Several recent investigations have indicated that the geopressured-geothermal aquifers of the Texas and Louisiana Gulf Coast contain vast quantities of dissolved natural gas and represent a significant source of hydraulic and thermal energy (for electric power production and direct heat uses). The reservoir characteristics of the geopressured aquifers have not been adequately examined even though thousands of oil and gas wells have penetrated the geopressured formations.

The goal is to conduct R&D activities directed primarily at resource definition (including the confirmation of optimum reservoirs), and to identify and resolve key engineering, environmental and institutional problems. These R&D activities will provide a basis for industry to begin developing geopressured resources by 1986.

4.1.3 Hot Dry Rock Resources

Extracting heat energy from hot dry rock has proved to be technically feasible on a small scale at Fenton Hill in New Mexico.

development. The strategy is to concentrate on energy extraction experiments to refine the technology and to decrease costs. Development of drilling and fracturing technology for high temperature environments will be emphasized in the 20-50-MWe thermal loop experiment.

4.3 PRIORITY

The highest priority of the program is to conduct research and development on the high-risk/high-payoff technologies. The geopressured program focus is on determining the technical and economic feasibility of obtaining methane from the geopressured resources. The hot dry rock program focus is on determining the technical and economic feasibility of obtaining energy from this vast resource. To benefit the development of all geothermal resources, component technology R&D development focuses on long-term, high-risk/high-payoff activities.

5.0 ISSUES

This section describes the key impediments to the development of geothermal resources and DGE's response.

The energy potential and longevity of hydrothermal systems is unknown. DGE collaborates with USGS to conduct regional and national assessments of hydrothermal resources. Reservoir engineering, and reservoir modeling and assessment techniques are being developed. Producing reservoirs are being monitored to obtain data and to test the models. Private industry will be reluctant to develop economically viable projects without sufficient information about the extent of the resources.

Current costs of utilization technologies make some resources unattractive. To reduce the cost of exploiting hydrothermal resources, DGE conducts research and development to create more reliable, efficient, and less costly technologies. Development of the marginal geothermal resources will be limited if the technology is not improved.

The discovery and utilization of geothermal resources is impeded by a lack of materials and equipment appropriate to geothermal conditions. Technology improvements would reduce the cost of the wells that must be drilled to bring geothermal power on line. DGE works with research laboratories and private industry to develop and field-test new methods, equipment and materials capable of withstanding the effects of heat, brine, and other characteristics of geothermal fluids. This activity produces advancements in drill bit and pump technology, geochemical engineering and materials, energy conversion and environmental control technology.

Because of the expense involved in developing this new and specialized technology for a currently small market, it is unlikely that private industry would find it cost-effective to develop these technologies. Without the technical progress provided by these activities a large portion of the resource will not be made available for development.

The size and producibility of geopressured resources is unknown. DGE conducts activities to determine the magnitude, availability, and producibility of geopressured resources. Because the characteristics of geopressured aquifers vary widely, a substantial number of tests will be required to predict the potential of this resource. DGE focuses on well tests to identify reservoir characteristics and basic drive mechanisms that enable the production of geopressured brine.

Because of the complexity and variability of the geopressured resource base, research is still in the initial stage. Without this research, private industry will not undertake development of a resource of such uncertain and long-range potential.

The technical feasibility of fracturing hot dry rock to economically recover heat energy is unknown. Development of this resource depends on significant improvements and cost reduction in current drilling and fracturing technology. DGE has successfully operated a 5-MWt loop facility at Fenton Hill, New Mexico. A 20-50 MWt loop is also being developed at Fenton Hill for research and demonstration of thermal energy extraction.

Without technical field experiments and pilot projects, the economic viability of hot dry rock technology cannot be assessed. A potentially significant source of energy would remain undeveloped.

The private sector has limited knowledge about the long-term potential of geothermal resources and technologies. Private development of geothermal resources has been impeded because information on which to base the necessary long-range planning decisions has been unavailable or very costly. The exploratory and technical development activities of DGE are designed to expand this information base. In addition to publications, surveys and forums for technology transfer to private industry, DGE also provides potential users with information on the availability and competitive cost of geothermal energy.

Knowledge about the geothermal resource base and the technology to exploit it is growing steadily. Without programs to facilitate transfer of technology, private industry will not be able to pursue economically competitive projects in a timely and least-cost way.

The environmental effects of extensive production of geothermal energy are not known. The cost of complying with environmental regulations can be a barrier to private developers. Without assurance of the existence of environmental compliance technology, private industry is discouraged from investing in geothermal resources.

6.0 PROGRAM ELEMENT DESCRIPTIONS

6.1 HYDROTHERMAL INDUSTRIALIZATION

Hydrothermal resources consist of hot water and steam trapped in the earth. Different energy conversion systems are used to recover the energy found in hot water or steam hydrothermal resources. Electricity is generated from dry-steam deposits by passing the steam directly through turbines. Liquid-dominated deposits are exploited for electric power either by flashing the hot liquid into usable steam at the surface (flash-steam system) or by transferring its heat to a secondary working fluid which in turn is vaporized to drive a turbine-generator (binary-cycle system).

Energy derived from hydrothermal resources can also be used for direct thermal applications. These non-electric applications, primarily space conditioning and industrial process heat, are feasible using fluids from reservoirs at temperatures suitable for electric power generation as well as at lower temperatures. Hot water is piped directly from the geothermal reservoir over relatively short distances to the point of use.

Thirty-seven states contain hydrothermal resources; most western states contain known geothermal resource areas. Substantial electric power and direct use capacity is expected to be realized by 1984. Projections of approximately 2,600 MWe of electric power generating capacity and nearly 300 MWt of thermal power reflect the near-term potential for this resource.

The major objective of the Hydrothermal Industrialization activity was to encourage private-sector development and commercial use of hydrothermal resources for electric power production and direct heat applications. The activity consists of RD&D projects designed to stimulate geothermal development by the private sector.

The Hydrothermal Industrialization activity is divided into five major subactivities:

- Resource Definition
- Non-Electric Demonstration
- Planning and Analysis
- Private-Sector Development
- Geothermal Facilities.

These subactivities and the tasks comprising them are described in the following sections.

6.1.1 Resource Definition

DOE and USGS are collaborating on a federal program to establish the extent of geothermal resources and their locations throughout the United States. The objectives of the assessment program are: (1) to characterize the geological nature of each type of geothermal resource; (2) to estimate the location, distribution, and energy content of geothermal resources in the United States; and (3) to evaluate geothermal energy potential in the United States through inventory of the identified portion and prediction of the undiscovered portion of the nation's resources.

In pursuit of these objectives, DGE has worked with the USGS to conduct regional and national assessments of hydrothermal resources. Additionally, DGE supports drilling to confirm high-temperature reservoirs with near-term commercial potential under projects cost-shared with private resource developers. Areas of high promise for low- to moderate-temperature reservoirs are the targets of geological and geophysical analyses in projects supported by joint federal and state funding. Further, an exploratory drilling task has focused on several regions with potential for direct heat applications, but without confirmed hydrothermal reservoirs. DOE support for this task will end in FY 1981 with responsibility being shifted to the private sector.

6.1.2 Nonelectric Demonstration

Use of geothermal energy for nonelectric purposes by the private sector within the United States has been limited. There is, however, a large potential market for thermal energy in the 50° to 150°C temperature range used in industrial processing (paper mills, sugar refineries, and other chemical and food processing plants); agribusiness (space-, soil-, and water-heating in applications such as greenhouses, fish farming, and animal husbandry); and space/water-heating of commercial downtown business districts (shopping centers, schools, hospitals); and in residential buildings.

6.1.3 Planning and Analysis

This activity formulates geothermal development plans, maintains a national progress monitoring system, assesses the market penetration potential for hydrothermal resources, and identifies direct heat markets suitable for early market penetration. Other activities encompass continuing interagency coordination and policy development.

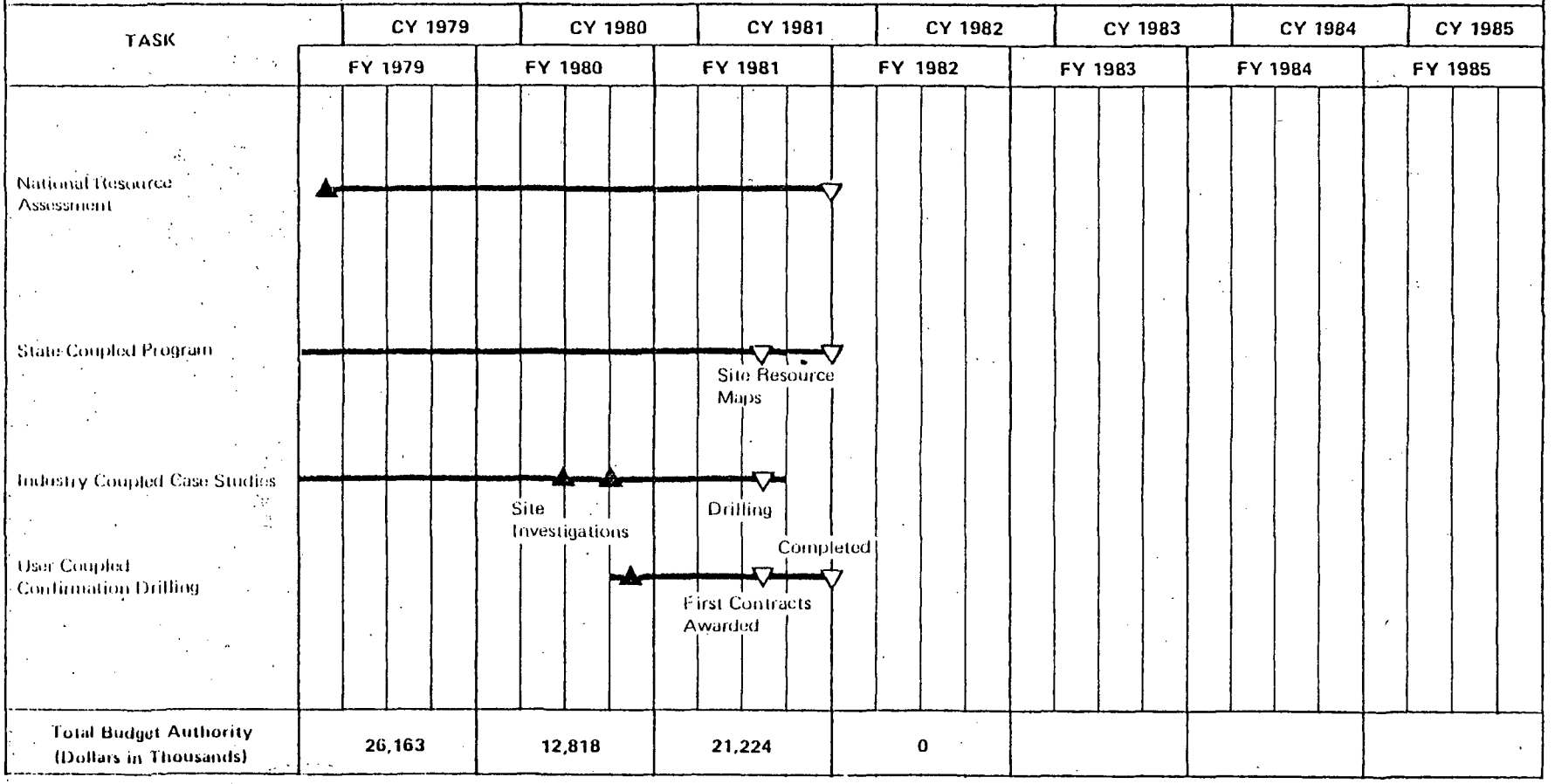
6.1.4 Private-Sector Development

This subactivity includes projects designed to acquaint potential users with: the availability and competitive cost of hydrothermal energy; the availability of financial assistance through various federal programs; the availability of technical assistance to start projects; and the availability of legal assistance to help states prepare appropriate legislation.

Exhibit III-4-1

ACTIVITY HYDROTHERMAL INDUSTRIALIZATION
SUBACTIVITY RESOURCE DEFINITION

LEGEND
△ BEGIN MILESTONE
▽ END MILESTONE
◁ DECISION MILESTONE
▲ COMPLETED TASK
◆ ORIGINAL MILESTONE



Total Budget Authority (Dollars in Thousands)	26,163	12,818	21,224	0			

The geopressure-environmental control task supports continued research on potentially adverse environmental effects of sustained high-volume production of geopressured brines. The high pressure of the fluids produced and the large volume of fluid withdrawal present potentially far more serious environmental problems than does production of conventional resources.

The two main environmental concerns are subsidence and fluid disposal. Subsidence is a particular concern on the Gulf Coast. In many localities, elevations are low and large-scale subsidence could have a serious impact. Current waste treatment technology is probably adequate to prevent contamination of drinking water, but new technology may be needed to remove hazardous substances from geothermal fluids.

The Pleasant Bayou Test Well in Brazoria County, Texas, has been instrumented to measure environmental parameters, including subsidence, micro-seismicity, and air and water quality. Data obtained for the monitoring of the well tests will be used to gauge the potential environmental impact of geopressured aquifer development.

Environmental assessment and monitoring of well sites in Texas and Louisiana will be accelerated to keep pace with drilling. Environmental documentation will be prepared as necessary in connection with well-testing activities conducted under the resource definition subactivity.

The engineering applications task seeks to establish the technical and economic feasibility of recovering energy from geopressured resources. This is essential for industry interest and development. It requires establishing the technical feasibility of high-volume brine production and disposal and the economic recovery of the produced energy, gaining an improved technical and mathematical understanding of the resources, and resolving any legal and institutional constraints that may impede timely development. The program is carried out under two basic categories, (1) surface technology and resource utilization, and (2) well drilling and completion.

Activities in surface technology and resource utilization have been conducted for methane fuel production, direct heat utilization, and power generation. This work includes conceptual design of facilities for electric power generation and for direct heat applications from geopressured resources. Appropriate experiments will be undertaken in FY 1982 and FY 1983. Studies on methane stripping will take place in FY 1981.

The development of well drilling and completion technology will focus on problems related to the high temperature, pressure, and salinity associated with geothermal wells.

6.4 GEOTHERMAL TECHNOLOGY DEVELOPMENT

Geothermal resources can be exploited with technology similar to that used for oil and gas exploration and production. Oil

field equipment and water well equipment can be used safely and economically for some low-temperature geothermal applications. However, the special conditions associated with moderate- and high-temperature geothermal resources often exceed the design capabilities of existing techniques, materials, and equipment.

DGE's geothermal technology development program seeks technical solutions to the problems of operating in geothermal environments. Efforts focus on developing techniques, materials, and equipment specifically tailored to geothermal conditions, reducing technology costs, and encouraging establishment of industry-wide standards for geothermal materials and equipment. DGE is also developing techniques to extract energy from hot dry rock (HDR).

The activity is divided into two major subactivities:

- Component Development
- Hot Dry Rock.

These subactivities are discussed in detail in the following sections.

6.4.1 Component Development

This subactivity is organized into several tasks aimed at improving the overall discovery and exploitation of a geothermal resource.

The drilling and well completion tasks could reduce the cost of geothermal wells 25 percent by 1983 and 50 percent by 1987. These technology improvements would affect the cost of the wells that must be drilled in order to bring geothermal power on line.

The conversion tasks are developing pumps, heat exchangers, and systems for use with moderate-temperature geothermal fluids for economic production of electricity.

The reservoir stimulation task seeks ways to increase production from individual wells, thereby reducing the number of wells required to exploit a reservoir.

The geochemical engineering and materials task addresses the special character of geothermal fluids and their interaction with other materials. Program efforts focus on developing materials and methods to combat problems of scaling, corrosion, injection well plugging, and materials failure.

The geoscience task concentrates on improving the technologies for exploration, reservoir engineering, logging instrumentation, and log interpretation.

6.4.1.1 Drilling and Completion Technology

Private industry has identified improvements in drilling and well completion technology as a major requirement for reducing

Table III-I-7

Funding Levels for Geothermal Technology Development Subactivities FY 1980 through FY 1982

Subactivity	Budget Authority (Dollars in Thousands)			
	Actual FY 1980	Estimate FY 1981	Estimate FY 1982	Increase (Decrease)
Component Development	25,058	35,300	10,439	(24,861)
Hot Dry Rock	14,000	13,500	10,000	(3,500)
Capital Equipment	2,120	1,110	0	(1,110)
Total	**41,178**	**49,910**	**20,439**	**(29,471)**

Table III-I-8

Funding Levels for Component Development Tasks FY 1980 through FY 1982

Task	Budget Authority (Dollars in Thousands)			
	Actual FY 1980	Estimate FY 1981	Estimate FY 1982	Increase (Decrease)
Drilling and Completion Technology	6,530	9,400	2,539	(6,861)
Energy Conversion Technology	8,311	10,703	2,500	(8,203)
Reservoir Stimulation	1,656	3,200	1,900	(1,300)
Geochemical Engineering and Materials	3,931	4,700	700	(4,000)
Geoscience Technology	4,630	7,297	2,300	(5,627)
Environmental Control Technology	0	0	500	500
Total	**25,058**	**35,300**	**10,439**	**(24,861)**

East Mesa. In return, DOE will gain information on fluid characteristics. Among the new instruments being developed as part of this project are high-temperature meters, specific ion electrodes, conductivity meters, and corrosion-monitoring equipment.

Materials Development. In order to achieve overall economy in construction, operation, and maintenance of geothermal systems, durable materials resistant to corrosion and catastrophic failure are required. To help develop such materials, DGE has been involved in forming a special committee of the American Society for Testing and Materials on geothermal resources and energy to evaluate standards for geothermal materials and procedures.

In 1978, DGE published an analysis handbook of materials available for electric applications of geothermal energy. A completely revised edition of the handbook will be published in March 1981. This expanded edition will include information on non-electric applications and extensive international information. In addition, DGE issues a monthly newsletter, "Geothermal Materials Review."

A series of high-temperature well cements have been developed and tested at the National Bureau of Standards as part of an American Petroleum Institute task group effort to develop geothermal well cement standards. With laboratory development complete, field testing of high-temperature well cements will begin under an arrangement with the Mexican government.

Alternate Materials Development. Polymer concrete, high-temperature elastomers, and casing materials have been developed with 15 to 20 percent improvements in durability and corrosion resistance for geothermal environments. Polymer concrete-lined pipes and flash tanks were tested at Niland, California, and at East Mesa. Carbonate scale did not adhere to the concrete surface, thereby offering a potential remedy to the scaling problem in geothermal fields with high carbonate content.

The manufacture of commercial, prototype polymer concrete pipes and of a high-temperature logging cable and the technology transfer of new high-temperature elastomers were initiated during 1978 and 1979. A non-destructive evaluation technique to predict drill pipe failure will be field tested in FY 1981.

Work on geothermal materials in FY 1981 will emphasize development and testing of elastomers, metals, and cements that are durable at high temperatures and resistant to localized corrosion, wear, fracture, and fatigue failures. Improvements in these materials are essential for the success of downhole pumps, cables, and motors, and for greater longevity of surface, well, and drilling equipment.

6.4.1.5 Geoscience Technology

Improvements in technology related to exploration for geothermal resources and assessment of reservoirs are essential to

Table III-I-11

Funding Levels for Geoscience Technology Subtasks FY 1980 through FY 1982

Subtask	Budget Authority (Dollars in Thousands)			
	Actual FY 1980	Estimate FY 1981	Estimate FY 1982	Increase (Decrease)
Exploration Technology	1,138	2,938	900	(2,038)
Reservoir Engineering	2,110	2,320	1,400	(920)
Logging Instrumentation	956	1,699	0	(1,699)
Log Interpretation	426	340	0	(340)
Capital Equipment	285	50	0	(50)
Total	**4,915**	**7,347**	**2,300**	**(5,047)**

maintain the current rate of discovery and development. The geoscience technology task consists of four subtasks:

- Exploration technology
- Reservoir engineering
- Logging instrumentation
- Log interpretation.

Exploration Technology. The objective of this subtask is to develop an effective strategy, based on demonstrated methods, that will accurately locate hydrothermal resources in a number of varying geological settings. In order to do this, a series of exploration case studies have been accumulated, particularly under the industry-coupled task. These case studies are used to evaluate the effectiveness of different geological, geochemical, and geophysical techniques in providing pertinent information on the location and extent of the resource. Where case histories were incomplete under the industry-coupled task, additional surveys were funded under exploration technology so that a complete set of survey techniques could be evaluated for their effectiveness in delineating reservoirs confirmed by drilling.

For the first time, two- and three-dimensional models have been developed for use in interpreting data from magnetotelluric and resistivity surveys. Factors such as topographic variations, layering, and other structural features can be introduced into the models, thereby affording a more meaningful interpretation of results.

Reservoir Engineering. The major emphasis to date in reservoir engineering has been on the analysis and simulation modeling of high-temperature reservoirs.

Cooperative agreements with countries having geothermal reservoirs with long production histories have permitted development of valid reservoir simulation models. These models are continually refined as additional data become available and as understanding of reservoir behavior improves.

Logging Instrumentation. The well-logging services presently available are often unsuitable for the hostile environments of geothermal wells, and essential data for reservoir engineering are difficult to acquire. Logging instrumentation activities are therefore aimed at upgrading tool capabilities from the present rating of 180°C to typical geothermal temperatures of up to 275°C.

Development of high-temperature (275°C) components for logging tools will not receive DOE support after FY 1981. Prototype tools that use high-temperature circuits have been made commercially available. Sandia Laboratories and Union Oil Co. have successfully tested hand-wired prototype temperature, pressure, and flow tools. Other prototype tools that use commercially made circuits are being evaluated.

Log Interpretation. To improve techniques of log interpretation, DOE is participating in the construction of a calibration/test facility at the Denver Federal Center. Two large, heated tanks containing samples of rock representative of those found in geothermal reservoirs have been completed, with one more in progress. Saw cuts in the rock simulate fractures that control production of geothermal reservoirs. When completed, the facility will be available for use by geothermal developers, logging companies, and others as a standard for calibrating tools. In addition, two wells, one at East Mesa, and the other at Roosevelt Hot Springs, Utah, are available to the public at no charge. The East Mesa well was used six times and the Roosevelt well, four times. DOE support of these facilities will not continue after FY 1981 as responsibility is shifted to the private sector.

6.4.1.6 Environmental Control Technology

Environmental control technology (ECT) issues and priorities were established in the "Status of Environmental Controls for Geothermal Energy Development - April 1980" prepared by the Environmental Control Panel of the Interagency Geothermal Coordinating Council. Research is needed to improve the state-of-the-art of geothermal ECT to comply with federal, state, and local environmental regulations. To accomplish this, DOE and the U.S. Environmental Protection Agency (EPA) are pursuing a research program to control hydrogen sulfide and other air emissions, injection of geothermal fluids as they may affect underground sources of drinking water, solid waste resulting from geothermal operations, induced subsidence, and induced seismicity.

H_2S Technology. Hydrogen sulfide (H_2S), ammonia, boron, carbon dioxide, methane, arsenic, radon and mercury vapor have been found associated with geothermal fluids. H_2S, which is found in high concentrations in certain geothermal fluids, has required particular control. Stringent state air quality standards have been established to reduce H_2S odor and protect public health.

DOE and EPA have jointly initiated a project to develop a process that removes H_2S and at the same time produces a usable by-product (sulfur) rather than solid waste. This process will be field tested during FY 1981-1982. Laboratory and field testing of other H_2S removal systems is planned for 1981-1982.

A demonstration of an EIC Corporation prototype process to scrub 100,000 pounds of raw steam per hour, was tested at the Geysers field in California. Supported by DOE, EPA, and Pacific Gas & Electric Co. (PG&E), this process removes H_2S during stream stacking (when the plant is shut down). Following the pilot-scale field test of the process, PG&E contracted with EIC Corporation for a full-scale plant. Installation should be complete by 1984.

DGE is continuing work on theoretical H_2S research and on improving the economics and applicability of existing systems.