GL01343

DOE/ID/12101-1

State Geothermal Commercialization Programs in the Rocky Mountain Basin and Range Region

Semi-Annual Progress Report
July - December 1979

August 1980

U.S. Department of Energy
Idaho Operations Office

DOE/ID/12101-1

STATE GEOTHERMAL COMMERCIALIZATION PROGRAMS

in Ten

ROCKY MOUNTAIN STATES

Semi-Annual Progress Report
July - December 1979

August 1980

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Contract No. DE-AC07-80ID12101

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Summary of DOE/State Geothermal Commercialization Projects in the RMB&R Region

Prepared by

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July 1980

SUMMARY OF
DOE/STATE GEOTHERMAL COMMERCIALIZATION PROJECTS
IN THE RMB&R REGION

CHAPTER ONE

1.0 INTRODUCTION

1.1 Purpose of Project

The Rocky Mountain Basin and Range Regional Hydrothermal Commercialization Project was initiated in 1977 to stimulate geothermal commercialization throughout the region. This program is a cooperative effort involving the U. S. Department of Energy (DOE) and ten Rocky Mountain States. The Department of Energy is cooperating with other groups of states throughout the country in similar commercialization programs. State and local participation are viewed as essential elements in the geothermal commercialization program in order to ensure that the program elements are implementable, that they reflect state and local, as well as national, goals and that they are as effective as possible. Indeed, realistic planning and policy development requires the concurrence of federal, state and local governments.

Furthermore, greater understanding and knowledge of events and conditions bearing upon geothermal energy development in each jurisdiction are found among those people working most closely with each locale. People working in the field on geothermal projects, particularly when they are identified as representatives of local or statewide government, can help expand the commercialization of geothermal energy through education, marketing and technical assistance activities.

The U. S. Department of Energy has provided support for state geothermal programs through cooperative agreements with state agencies that were selected by the respective governors' offices. The cooperative agreements support activities in planning, analysis, and marketing of geothermal energy and technical assistance to prospective users and developers. The state commercialization program is closely intertwined with the state-coupled geothermal resource assessment program, also DOE and State cooperative efforts. The latter provide inventories and reservoir data about the geothermal resource areas in each state. Coordination of these two closely-related programs helps assure that these efforts are all directed toward the single goal of appropriately using geothermal energy. Once the DOE-assisted state commercialization programs are well-established, state and local governments will have the expertise available to continue programs on their own to provide both technical information and assistance to prospective developers and users.

During CY 1979, the Idaho Operations Office of the Department of Energy (DOE-ID) signed cooperative agreements with ten Rocky Mountain Basin and Range states to conduct state geothermal commercialization programs. The states - Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, South Dakota, Utah and Wyoming - provided a portion of the funding to cost-share with the Department of Energy.

Each state has a State Commercialization Team consisting of the Team Leader and those principal staff people that are considered by each State to incorporate the kinds of expertise essential to its unique situation. Western Energy Planners, Ltd. (WEPL), under contract to DOE-ID, provides technical and managment assistance to the state teams.

The states are assisted in their efforts by additional contractors who provide technical support: the University of Utah Research Institute (UURI) provides resource assessment assistance; the New Mexico Energy Institute (NMEI) provides preliminary economic analyses, and EG&G, Idaho, Inc. (EG&G) provides preliminary engineering assistance and other support services.

This report contains four sections which describe the activities and findings of the state teams participating in the RMB&R Regional Hydrothermal Commercialization Program for the period of July through December of 1979. Section 1.0 is a summary of the state projects. Section 2.0 is a compilation of project accomplishments. Section 3.0 is a summary of findings, and Section 4.0 provides a concise description of the major conclusions and recommendations. Unless otherwise indicated, the information presented in this summary originates with the State Commercialization Team reports that make up subsequent sections of the report. Subsequent chapters describe the commercialization activities carried out by the individual teams in each state, and were prepared by the respective state teams using similar formats.

1.2 Objectives

Several major objectives are identified as means to effect the goal of increased geothermal commercialization through the activities of the state commercialization program. They include:

- Match geothermal sites with a potential market to identify and rank "targets of opportunity" where state commercalization efforts will be concentrated.

- Identify and describe the actions needed by both private and public participants for geothermal commercialization.
- Stimulate interest and cooperative action among participants in geothermal commercialization.
- Stimulate development of geothermal resources by providing technical information including permit requirements and financial, economic, engineering and resource information.
- Help stimulate economic development through identification of geothermal energy potential for industrial and utility use and coordination with state economic development agencies.
- Identify the constraints to geothermal commercialization and recommend ways to alleviate them where appropriate.

1.3 Technical Approach

The technical approach of the State Commercialization Projects has been to use existing information and data from available sources whenever possible. Interviews and discussions with a variety of state and local participants contribute data, direction and ideas. Both quantitative and qualitative analyses are performed as necessary. Within these parameters and the objectives indicated in Section 1.2, a number of specific tasks were defined and performed. Although the specific tasks vary in scope and detail, all the states incorporated the following tasks into their contracts with DOE.

- Outreach

  Outreach programs are conducted by each state to promote the use of geothermal energy by industry, utilities, private citizens, business, agriculture, government and communities. A technical assistance program provides prospective geothermal users and/or developers with information about all aspects of development including laws and regulatory processes, economic and engineering feasibility, and the geothermal resource.

- Prospect Identification

  Data about geothermal resource areas and sites are documented in order to identify the potential geothermal energy resources. These data include a classification of the resources as either electrical power generation or direct thermal application, and whether the resource is proven, potential or inferred, based on definitions for those terms that were established in previous studies (Meyer and Davidson, 1978).

- Energy and Economic Analyses

  Energy consumption and economic data are collected and analyzed to provide a basis for calculating current and future energy demand. This in turn is used to estimate the market

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- Energy and Economic Analyses

  Energy consumption and economic data are collected and analyzed to provide a basis for calculating current and future energy demand. This in turn is used to estimate the market demand for geothermal energy. Energy consumption is described or estimated by type of use and by commercial, residential and industrial sectors. Industrial users are described by four-digit standard industrial classification (SIC) codes.

- Area Development Plans (ADP's)

  This task provides an assessment of the possible geothermal supply and demand over time. It covers a broad area, either a county or several counties in most cases, and includes the known resource sites and the identified prospective energy users within that area. It is a source of energy and economic data for the New Mexico Energy Institute analyses as well. The Area Development Plans generate the targets for the Site Specific Development Analyses.

- Site Specific Development Analsyses (SSDA's)

  Using targets identified by ADP's or other selection processes, the Site Specific Development Analyses are written as a tool for marketing geothermal energy. They identify specific applications of the energy for business, industry, government and residential sectors. Analyses are prepared for major geothermal resource prospects and uses or users. They include examination of a variety of issues including the technology, economics, environmental, institutional, developmental and utilization. Communication with the prospective users and/or developers is established and maintained to assure realism and implementability.

- Time-Phased Commercialization Project Plan (TPPP's)

  If additional detailed planning is required beyond the SSDA document, detailed project management plans showing specific activities and deadlines are prepared. These plans are completed for a limited number of sites that are in advanced stages of development or commercialization. They reveal actions by both private and government sectors needed to achieve commercial operation, and they stimulate cooperative interactions to accomplish the project milestones. Step-by-step procedures are described and shown on a time-line chart. Direct communication between the geothermal developer and the governmental entities is required and produced during the process.

- Institutional Analyses and Handbooks

  The local, state and federal regulatory systems and practices for geothermal activity are documented and analyzed to understand the effects upon the rate of commercialization. A regulatory handbook to guide geothermal development participants has been or is being prepared by each state.

- State and Regional Aggregations of Development Plans

  The geothermal prospects included in all three types of plans are aggregated to obtain estimates of the amount of geothermal energy that can be developed and used between now and the year 2020.

- Identification of Constraints and Recommended Actions

  Technological, environmental, economic and institutional constraints that might delay or preclude the development of geothermal energy are examined. Possible solutions are evaluated, leading to recommendations for action, to be taken by local, state and federal governments and by the private sector.

- Marketing

  As this commercialization program progresses the emphasis is changing from a planning activity to outreach and finally to marketing geothermal energy within the states. During the period covered by this report the marketing activities were just entering the formative period and will be discussed in the next period report.

1.4 Benefits

The benefits to be gained from geothermal commercialization projects are numerous. The ultimate goal is the replacement of energy from imported oil with energy from untapped domestic resources. Conserving natural gas and other fossil fuels can either directly or indirectly effect that goal. The value of the conventional energy saved, less the total project costs to put geothermal energy on line, gives a conservative estimate of benefits. However, when funds are spent within this country rather than being exported, they have a multiplier effect that should be considered. Taxes paid by the developer or user are an additional benefit to the governments.

For national planning, programming and budgeting purposes, the information produced by the State Commercialization Projects is essential. The projects provide realistic assessments of how much geothermal energy can and is likely to be produced within a specific time frame and by what consuming sectors. From this information, public and private expenditures, congruent with the amount of energy, can be appropriately allocated to stimulate geothermal production and utilization.

Indirect benefits include local values such as lower fuel bills for users and economic development stimulated by the lower cost of energy. Furthermore, the assurance that a supply of energy will be available at a comparatively stable price can help both the private and public sectors to plan for their futures.

2.0 PRODUCTS

A variety of products have resulted from the State Geothermal Commercialization Projects. These include policy and programmatic changes, initiation of actual commercial projects, and improvements in laws, regulations, administrative procedures and tax incentives. The following tables summarize those accomplishments for the two year period 1977-1979.

2.1 Policy and Program Impacts of State Team/NMEI Activities

DOE Planning:

- Shift of Programming Emphasis to include Direct Thermal Applications
- Redirection, Continuation or Expansion of State Commercialization Planning Projects
- Use of State Teams to Augment Planning by United Indian Planners Association and Four Corners Regional Commission (Rural Development Program)
- Update of Mitre Corporation's Project Two Compilation and Analysis of Site Specific Scenarios: Expansion to Include Direct Thermal Applications

DOE Funding:

- Four DOE PONs in South Dakota from Actions Stimulated by Applied Physics Laboratory
- Prospective Use of State Teams to Screen Project Proposals from In-State Parties
- Emphasis of Need for More Industrial Process Heat PON Awards
- Special Study of Applicability of Geothermal Energy to Phosphate Industries

Congressional Legislation:

- Energy Tax Act of 1978 - NMEI/WEPL Public/Private Actions Analysis
- Geothermal Omnibus Legislation
    - EG&G/WEPL Evaluation of Small Business Requirements
    - State Team Communications to Congressional Delegations
    - Pacific Northwest Regional Workshop
    - Testimony of Governor Evans (Idaho) by D. McClain

- Windfall Profits Tax Amendments - State Team Communications to Senate Finance Committee

State Legislation:

- Enacted Legislation in Idaho, New Mexico, Montana and Nevada
- Pending/Proposed Legislation in Utah, South Dakota, Wyoming and Idaho
- EG&G/WEPL Evaluation of State Taxation Impacts
- Study of Geothermal Legislation with Nevada Legislative Committee assisted by National Conference of State Legis-Latures.

Private Sector Actions:

- Integration of Phillips Petroleum Permitting Timetable with State Agency Agendas for Roosevelt Hot Springs, Utah
- Applications by Crescent Valley, Nevada, Developers for FCRC Funds and GLGP
- Well Drilled by Penny Hot Springs, Colorado

Community Sector Actions:

- Decision by City Council of Idaho Springs, Colorado, to Seek Funding for Feasibility Study for District Heating
- Successful Proposal by Pagosa Springs, Colorado, for DOE PON for District Heating System
- Request by City of Thermopolis, Wyoming, for Site Specific Development Analysis
- Application by City of Winnemuca, Nevada, to FCRC & GLGP for Alcohol Production Facility.

State Government Actions:

- Integration/Coordination of Resource Assessment and Commercialization Planning Projects in Certain States (Montana, North Dakota, New Mexico, Colorado and Arizona)
- Funding by Idaho Legislature for Engineering Design of Geothermal System for Capitol Mall
- Decision by North Dakota Governor's Office to Participate in DOE Commercialization Planning Project
- Decision by Colorado Department of Corrections to pursue the geothermal option at Canon City

Other Federal Agencies:

- BLM/USFS Lands Prioritization
- UDAG Funding Opportunities for Eligible Communities

2.2 Selected Significant Products of Specific State Team Tasks

Energy and Economic Data Collection:

- Prime Source of Data for NMEI Market Penetration Analyses
- Statistics for Press Releases by Governors and State Energy Offices
- Input for State Hydrothermal Commercialization Baseline Documents
- Information for Testimonies to State Legislative Committees
- Specialized State Geothermal Resource Maps by Idaho and New Mexico

Area Development Plans:

- Focus for Planning and Development Activity in Dona Ana County by New Mexico Energy and Minerals Department
- Stimulation of Public and Private Development Actions in San Luis Valley, Colorado
- Determination of Broad Applicability of Geothermal Energy for Commercial and Industrial Uses in Greater Phoenix Area
- Identification of Five Valleys in Montana for Expanded Resource Assessment Projects

Site Specific Development Analyses:

- Evaluation by Big Horn Basin Barley Growers Association of a Gasohol Plant in Cody, Wyoming
- Economic Feasibility Analysis for Retrofit of Idaho Capitol Mall Buildings
- Preliminary Economic Analysis for Lemmon, South Dakota
- Decision by Idaho Springs, Colorado, City Council to Obtain a Detailed Economic Analysis for District Heating System

Time Phased Project Plans:

- Coordination of Permitting Regulatory Actions by Phillips Petroleum and State of Utah
- Comprehensive Management Plan for City of Boise Geothermal Project
- Acceleration of Permit Applications by Pagosa Springs, Colorado

2.2.4 Institutional Analyses and Handbooks:

- Enacted or Proposed Legislation in All States
- Idaho Geothermal Handbook
- Decision by South Dakota Governor's Subcabinet Group to Disapprove Proposed Bills Unfavorable to Geothermal Energy
- State Institutional Handbooks for All States; 4 are Complete, 3 are in Draft Form and 3 are Underway.

Outreach and Technical Assistance:

- Contacts with Private Industry, Business and State Land & Federal Officials - About 50-100 Contacts in Each State
- Professional Public Relations Campaign in Arizona - Origin of "Mother Earth" and "GEO-rge THERMAL" Caricatures
- Aid to Jemez Springs (New Mexico) Well Leak Problem
- Award of DOE Region VIII Appropriate Technology Grant to Timberline Academy, Colorado
- Award of DOE Region VI Appropriate Technology Grant to Tom McCant, Animas, New Mexico
- Award of DOE Region IX Appropriate Technology Grant to City of Caliente, Nevada, Hospital

Special Projects:

- Prioritization of BLM/FS Lands for 1980 Leasing and Environment Assessment Schedules
- Determination of Prospective Community Applicants for UDAG Funds

Reporting:

- Weekly and Monthly Highlights to DOE
- Topical Reports
- Institutional Handbooks
- Hydrothermal Commercialization Baseline Documents
- Summary Report for First Year Southwest Regional Geothermal Operations Research Program
- Semi-Annual Progress Reports (by States)

3.0 SUMMARY OF FINDINGS

The identification and stimulation of geothermal commercialization projects requires the synthesis of three elements. The geothermal resource must be of a suitable quality and magnitude. A reasonably-proximate user must be available, either already co-located with the resource site or willing to locate at or near it. The site itself, including institutional, economic, demographic, environmental and other facets must be suitable for the proposed use. The tasks accomplished by the states were directed toward first revealing the opportunities to effect such three-way matches and then actively participating in implementation. The findings are reported below within the framework of those tasks.

3.1 Prospect Identification

The identification and categorization of geothermal prospects is a continuing process in each state. The most current information regarding the number of prospects, as summarized in Table 1, indicates that there are a total of 139 geothermal sites in the region that have electrical power generation potential. Fourteen of these sites have been classified as proven, 56 as potential, 69 as inferred. These numbers will continue to change as exploration and reservoir confirmation continues. Based on the exploration results, some areas are added and others are reclassified into another category. In some states, little interest has been expressed in electrical power generation, but federal lease applications have been submitted. As Table 2 shows, as of October, 1977, some 3,708 federal geothermal lease applications had been submitted. By 1979, only 1,058 federal leases had been issued. The lease interest may indicate a large inferred potential for high temperature resources. In any case, detailed investigations of leasing activity have indicated that the major part of that activity is directed toward the identification of sites for power generation. Too few leases have been issued and too few sites have been explored to conjecture how many sites will ultimately prove to be suitable for electrical power.

There are many locations where geothermal resources are a valuable source of energy for space and water heating and for commercial, agricultural and industrial uses. Table 1 shows that as many as 385 sites are suitable for these uses.

TABLE 1

Number of Geothermal Resource Sites

State	High Temperature Electric Prospects				Low Temperature Direct Thermal Prospects				Grand Total
	Proven	Potential	Inferred	Total	Proven	Potential	Inferred	Total	
Arizona	0	0	17	17	37	Included w/proven	--	37	54
Colorado[1]	0	3	0	3	1	52	NA	53	56
Idaho	0	13[2]	NA	13	0	55	0	55	68
Montana	0	0	0	0	4	7	62	73	73
Nevada[3]	2	35	42	79	3	3	17	23	102
New Mexico	1	4	10	15	7	13	12	32	47
North Dakota[4]									
South Dakota[5]	0	0	0	0	17	18	NA	35	35
Utah	1	1	0	2	6	7	35	48	50
Wyoming	0	0	0	0	0	9	20	29	29
Totals	4	56	69	129	75	164	116	385	514

1 This includes only those sites that have been inventoried by the Colorado Geological Survey.

2 Ten of these have some federal land involved.

3 More than 300 sites were identified but not all classified.

4 Not yet available.

5 The entire Madison Formation in the western part of South Dakota offers geothermal potential; this refers to those sites co-located with towns.

TABLE 2

Geothermal Leasing on Public Lands
Rocky Mountain Basin and Range Region

	Acres Leased			Number of Leases Issued			No. of Federal Lease Applications[1]
	State	Federal	Total	State	Federal	Total	
Arizona	1,844	18,341	20,185	2	4	6	89
Colorado	36,471	33,522	69,993	17	24	41	168
Idaho	375,470	313,530	689,000	NA	174	174	753
Montana	-0-	10,687	10,687	-0-	6	6	97
Nevada	NA	752,823	752,823	NA	455	455	1,434
New Mexico	62,974	225,710	288,684	145	123	268	508
North Dakota[2]	-0-	-0-	-0-	-0-	-0-	-0-	-0-
South Dakota[2]	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Utah	234,268	459,138	693,406	238	275	513	657
Wyoming	1,150	7,448	8,598	1	4	5	92
Totals	712,177	1,821,199	2,533,376	403	1,065	1,469	3,798

[1] Non-competitive and competitive Federal leases, as of October 1977 (Beeland, 1978).

[2] Not yet available.

SOURCES: EG&G, 1979, and State Geothermal Commercialization Teams.

Some generalizations can be made about each state and about the region concerning these geothermal prospects.

Arizona

Thirty-seven sedimentary basins in Arizona are known to store moderate temperature water at relatively shallow depths (less than 1200 meters). These are identified as proven and potential resources, with 17 sites identified as inferred intermediate to high temperature resources ($90^{0}C < T < 150^{0}C$). Leasing interest is greatest in the Clifton and San Bernardino Valleys. As of December 1979, federal leases totaled 21,541 acres and state leases totaled 1,844 acres (Hahman, et al, 1979). Given the economic bases of Arizona and the co-location of resources with the major cities, opportunities for direct application seem especially significant. Some prime prospective uses are mining, process heat for large industrial facilities, and space cooling. Rapid population growth enhances the development opportunities.

Colorado

In Colorado, 56 geothermal areas have been inventoried, for which geochemical subsurface temperature estimates have been made. Three of these are considered by the energy industry to have potential for power generation. Most are classified as "potential" resources, with only one, Pagosa Springs, considered to be "proven". Reservoir confirmation at the electrical power generation sites has been stymied by the inability of industry to obtain all the necessary leases.

In addition to those sites, Colorado's prime geothermal prospects are located near large resorts and other commercial facilities in recreation and tourist areas and in the San Luis Valley, a major target area for expansion of agriculture and agricultural processing activity.

Idaho

In Idaho, over 300 thermal springs and wells have been identified. A number of areas have electrical power generation potential and a large number have direct application potential. Idaho currently imports most of its energy resources even though geothermal energy underlies the State's most populated areas. About two thirds of the State's population is in areas of geothermal potential. An active food-processing industry is co-located with geothermal energy sites in the Snake River Plains Region of Southern Idaho.

Montana

Montana has identified 73 geothermal resource sites. Four are considered to be proven, 7 potential and 62 inferred. The entire Madison Aquifer underlying the eastern part of the state is a possible geothermal resource. Oil test wells that were unsuccessful or that are slated for abandonment could be significant geothermal prospects, as well. Although the prospects for power generation seem doubtful, nearly 100 federal lease applications were filed and 6 were issued, leading to speculation about the reasons for those filings. The major prospects for geothermal development seem to be greenhouse heating, aquaculture, and district heating.

Nevada

Nevada has more than 300 identified geothermal sites (Booth, 1978). One hundred of these have been classified as proven, potential or inferred. Twenty-one sites have temperatures over 300^{o}F; 94 have temperatures between 190 and 300^{o}F. Many times this number may be prospects, judging from the 1400 federal geothermal lease applications in Nevada (Beeland, 1978). In addition to the electrical power generation prospects, Nevada's sites are prospects for alcohol production and other industrial and agricultural processing, as well as for space and water heating and space cooling.

New Mexico

Most of New Mexico's geothermal resources are along the Rio Grande Valley and in the southwestern part of the state. Insofar as direct thermal applications are concerned, New Mexico has a fortunate coincidence of geothermal energy with the state's major population centers and economic activity. Sites are suitable for various industrial process uses and agriculture as well as space and water heating. Fifteen areas are considered to have power generation potential, while 32 are considered suitable for direct thermal applications. There were 123 federal leases issued as of December, 1979, covering 225,710 acres of land.

North Dakota

The geothermal resource prospects in North Dakota were inventoried by the North Dakota Geological Survey. The recently formed State Commercialization Team has divided the state into eight substate regions for investigation of the possible development prospects. Three of these are being analyzed now.

South Dakota

Since South Dakota has lacked a state-coupled geothermal resource assessment program, the identification of prospects has been difficult. The Madison Formation underlying western South Dakota is a confirmed geothermal reservoir, with temperatures up to 90°C. Because of these temperatures, it is not considered to have power generation potential. However, with the agricultural economic base in South Dakota, many sites seem capable of furnishing heat for agricultural processing, as well as for space and water heating.

Utah

At least two geothermal prospects in Utah are directed toward electrical power generation: Roosevelt Hot Springs and Thermo. The construction of a 20 MW plant at Roosevelt has just been announced (May 1980). Thermo may also be suitable for a primary power system. Electrical power sites are the largest of the geothermal projects in terms of both project size and energy use. More visible activity and a larger increase in the activity, however, have been directed toward the direct application of geothermal energy. The Cove Fort site, an unsuccessful electrical prospect, is being developed for an alcohol plant and a possible sulphur drying plant. Successful wells have recently been developed south of Salt Lake City for heating and process applications. Many other sites offer industrial, commercial and residential direct thermal applications.

Wyoming

Wyoming has no proven geothermal resources in the formal sense, although the Hot Springs at Thermopolis are well known. Nine potential sites and 20 inferred sites have been identified, with estimated subsurface temperatures of 130°C or less. Ninety-two federal lease applications had been filed and 4 issued as of October, 1977, which might indicate some possibility of power generation capacity. A number of prospects seem to be useful for agricultural, industrial processing or district heating.

Region Wide

Among the RMB&R states, there are many outstanding geothermal prospects. There are electrical power generation potential sites, with prime opportunities in Idaho, Nevada, New Mexico and Utah, prospective sites in Colorado, and possibly some sites in Arizona, Montana and Wyoming.

Some especially noteworthy direct application prospects are apparent. In Arizona, Idaho, New Mexico and Utah, the co-location of geothermal resources near major cities offers opportunities for a wide array of industrial as well as residential and commercial uses. In some cases, processing of agricultural products and natural resources near the production sites may be the most economical approach. Arizona's minerals, Idaho's food products, and Colorado's San Luis Valley agriculture are prime candidates for geothermal process heat applications. Nevada is a target for alcohol production plants and indeed has significant private sector development activity underway. Undoubtedly, many more such opportunities will reveal themselves as the State Commercialization Teams continue to investigate and stimulate such uses.

3.2 Area Development Plans

Most of the states have compiled Area Development Plans (ADPs) to assess the prospects for geothermal commercialization, as shown in Table 3.

Arizona

In Arizona, Maricopa Conty is the highest priority area because of its large population, estimated to be 1,463,000 people in 1979. Its industrial and commercial complexes offer an ideal opportunity for use of geothermal energy. Pima County is similar but lower on the scale. Opportunities for geothermal use in the copper industry, which is the largest industry in Pima County, are being explored in depth by the State Commercialization Team.

In Graham and Greenlee Counties and in Pinal County, the agriculture and mining industries provide opportunities for use of geothermal energy in processing. In Pinal County, the depth of the resource is somewhat greater and the rock less favorable for production than is the case at the other sites.

Colorado

In Colorado, the San Luis Valley in South Central Colorado is a prime candidate for processing of agricultural products. Such processing, combined with space heating, is estimated to offer an opportunity for using as much as 450×10^{10} Btu's of geothermal energy.

Idaho

The Idaho Commercialization Team has updated a previously-compiled data base report for five sub-state regions that coincide with Idaho's state economic development regions.

An analysis of the data by the New Mexico Energy Institute indicated that it will be economically competitive to explore for and develop the geothermal energy at about one-third of the sites in Idaho by the year 2020. (McClain and Eastlake, 1980).

Montana

Several Montana ADPs for three areas were described in previous reports.

TABLE 3
Summary
Area Development Plans
Prepared or Planned

Location	Possible Uses
Arizona	
Maricopa County	Commercial and industrial complexes, space cooling
Pima County	Copper processing, commercial and industrial complexes
Graham/Greenlee	Food processing, crop drying, copper processing
Colorado	
San Luis Valley	Agricultural processing, space heating
Montana	
Area 1 - Lewis & Clark, Broadwater & Jefferson Counties	Industrial processing, space heating
Area 2 - Madison County	Animal feed, space heat, aquaculture, greenhouses
Area 3 - Treasure, Rosebud, Big Horn, Custer, Powder River, Fallon and Carter Counties	Not indicated
Gallatin Park, Meagher Counties	Greenhouses, aquaculture, space heating
Nevada	
Carson City	Aquaculture, space heating greenhouses
Washoe	Electricity, process heat, greenhouses, space heating
New Mexico	
Dona Ana County	Agricultural processing
Greater Albuquerque	Industrial processing, space heating
North Dakota	
Roosevelt-Custer Region	Various direct heat applications

TABLE 3 (Continued)

Summary
Area Development Plans
Prepared or Planned

Location	Possible Uses
Utah	
Jordan Valley	Jordan Valley industrial space heating
Wyoming	
Fremont County	Agribusiness, oil & gas extraction, drying process lumber
Natrona-Converse	Space heating, energy impact area
Big Horn Basin	Ethanol plant

In a fourth area, an agrarian area, the primary applications for geothermal energy seem to be greenhouses, aquaculture and space heating, with an estimated potential of about 34.0×10^{10} Btu's by the year 2020. In the town of White Sulphur Springs interest is especially high since development has taken place, and it is expected that a geothermal heating district will be developed in the near future.

Wyoming

The Area Development Plan for Fremont County in Wyoming indicated that geothermal space heating could be competitive with alternatives. Uses identified for existing geothermal energy in this area include space heating, low-temperature processing, agriculture and greenhouse heating. The Big Horn Basin Area Development Plan includes an economic evaluation of district heating in Cody or Thermopolis, which indicates that geothermal energy would be competitve with other sources, if some interest-free grant funds were available to offset a portion of the initial system cost. The Natrona-Converse Counties Plan is underway; it shows preliminarily that geothermal space heating could greatly assist energy "boomtowns" in this area.

3.3 Site Specific Development Analyses

3.3.1 Completed Site Specific Development Analyses

Several states have prepared Site Specific Development Analyses for one or more sites. They are summarized in Table 4.

Arizona

Ten individual sites were analyzed by the Arizona Team, five in some detail. Space cooling and heating at Williams Air Force Base seems to be one of the better prospects for development. Since it is a federal facility, presumably federal funds could be made available and institutional barriers could be overcome to enhance the goal of energy conservation and dollar savings for such facilities. A second very attractive site is the Tucson area, where geothermal energy could be used for process heat and for space heating and cooling of industrial complexes. In this rapidly-growing metropolitan area the opportunities are abundant. Well locations are constrained, however, by the designation of federal withdrawn mineral ownership. Geothermal district heating and cooling in Green Valley, in southern Arizona is estimated to be possible before 1990. Copper dump leaching at Silver Bell could use about 8.16 million Btu/hr of geothermal energy with required temperatures of $50^{o}C$ to $80^{o}C$. Although the opportunities at some sites for mining applications seem promising, they need to be and are being further investigated.

TABLE 4

Summary

Completed Site Specific Development Analyses

	Potential Uses	Constraints	Incentives
Arizona			
Williams Air Force Base	Space cooling & heating	Not in Federal budget until 1981 at earliest	Energy conservation, cost reduction
Tucson	Space cooling & heating industrial complex	Withdrawn Federal ownership	
Green Valley	District cooling		
Silver Bell	Copper dump leaching		
Clifton	Power generation	Federal/State private ownership. Possible wild & scenic river designation	
Miami	In-situ solution mining/uranium and copper		
Springerville	Geothermal/coal power generation		
Picacho Mtns.	Central Arizona Project pumping	Not competitive given recent events	
Casa Grande	Steam turbine pumping	Economics still uncertain	
Yuma	Citrus concentrating	Not considered feasible	

TABLE 4 (continued)

Summary

Completed Site Specific Development Analyses

	Potential Uses	Constraints	Incentives
Colorado			
Idaho Springs	Commercial & residential space and water heating	Lack of front-end financing	Economically competitive
Glenwood Springs	Commercial & residential space and water heating	Lack of front-end financing	Economically competitive
Ouray	Commercial & residential space and water heating	Lack of front-end financing	Economically competitive
Durango	Commerical & residential space and water heating	Lack of front-end financing	Economically competitive
Idaho			
Fairfield	District heat		
Hailey	District heat	Water rights and resource ownership questions	
Stanley	District heat	National Recreation Area	
Weiser	Industrial park	Risk capital	Loan guarantee for geothermal ethanol plant
Wyoming			
Cody	Ethanol	Resource limitations	

Colorado

Four Site Specific Development Analyses were prepared for Colorado, for Glenwood Springs, Ouray, Idaho Springs and Durango. All four sites have active tourism and recreation industries with a high ratio of commercial to residential energy consumption. The first three communities are actively seeking funds for development of district heating systems. Without outside assistance, Ouray has already installed geothermal heat in a municipal garage. A boarding school north of Durango has, with the aid of a DOE Region VIII Appropriate Technology Grant, installed geothermal heat. Preliminary economic analyses show numerous uses to be competitive economically. Opportunities for energy savings by private owners of major restaurant, lodging and resort facilities could spur private investment in geothermal development.

Idaho

Four Site Specific Development Plans were prepared for Idaho for the towns of Fairfield, Hailey, Stanley and Weiser. All are small towns with little current energy demand. One of them, Weiser, however, does offer several locational advantages for establishment of an industrial park. An industrial park could include such processing as potato starch, ethanol, corn canning and onion dehydration. The agricultural production, transportation and energy are all readily available. Front-end financing mechanisms are needed.

Wyoming

A Site Specific Development Analysis was completed for the town of Cody in the Big Horn Basin. Interest among people in the area was high regarding a possible ethanol plant and it was hoped that geothermal fluid could fuel the plant. However, it appears now that the resource in inadequate for that use.

3.3.2 Candidates for Site Specific Development Analyses

Several sites are candidates or have been selected for Site Specific Development Analyses; as shown in Table 5.

Montana

Several candidate areas were identified for Montana's Site Specific Development Analyses. Boulder Hot Springs is a candidate because of its commercial greenhouse potential, with one greenhouse already constructed. White Sulphur Springs has a geothermal heated bank building and proposes to establish a heating district. A Bozeman spring/campground owner, is

TABLE 5

Summary
Candidate Site Specific Development Analyses

Sites	Potential Uses
Montana	
Boulder Hot Springs	Commercial greenhouse
White Sulphur Springs	District heat
Bozeman	Greenhouses, aquaculture
Nevada	
Caliente	District heat or industrial processing
Crescent Valley	Ethanol, livestock food production
Damonte Ranch	District heat
New Mexico	
Animas/Lighting Dock	Soil warming
Los Alturas	Industrial processing
Truth or Consequences	Space heat
Albuquerque	Space heat-heat pump
Jemez Springs	District heat
North Dakota	
Bismarck	Heat pumps for hotel and downtown buildings
South Dakota	
Lemmon	Agribusiness, space heating
Philip	Space heating
Edgemont	Space heating
Midland	Space heating
Utah	
Salt Lake City	Heat pumps for new downtown buildings

investigating the greenhouse and aquaculture potential. Hunter's Hot Springs is promising for a greenhouse and aquaculture system. Chico Hot Springs has a state grant for a demonstration project that includes heating a hotel with a heat pump using geothermal fluid and driven by locally generated hydropower. The opportunity for using oil wells in the Madison formation is still another possibility being investigated.

Nevada

Three sites in Nevada were selected for Site Specific Development Analyses. In the city of Caliente, two DOE Region IX Appropriate Technology Grants were used to convert buildings to geothermal space heat. They hope to develop a geothermal district heating system. A geothermal ethanol production plant is proposed for Crescent Valley, to be accompanied by a heated cattle and hog feed lot. The Damonte Ranch is a planned new community that would heat about 6,000 dwelling units and support buildings with geothermal energy.

New Mexico

Several sites are candidates for Site Specific Development Analyses. Animas Lighting Dock currently has two geothermally-heated greenhouses. The operators would like to use geothermal energy for an outdoor soil warming system. Proposed uses in the Los Alturas area include process heat at the Hanes L'eggs hosiery plant, heating of New Mexico State University buildings and other heating and processing. Truth or Consequences is developing the geothermal energy for heating the Senior Citizens Center and the Carrie Tingley Hospital. Proponents would like to use it in additional buildings. The rapid growth of Albuquerque provides an excellent opportunity to use the warm water in heat-pump assisted heating systems, especially for large facilities.

North Dakota

North Dakota has tentatively identified one site as a candidate for a Site Specific Development Analysis. This is a downtown Bismarck heating district, including renovation of housing for the elderly. Others will be identified as their work progresses.

South Dakota

Four sites in South Dakota were chosen for preparation of Site Specific Development Analyses. Lemmon is planning to use geothermal energy for agriculture and agricultural processing, as well as for space heating. Philip has a DOE cost-sharing contract to heat three school dwellings with geothermal energy. Edgemont and Midland are also good candidates for space heating projects.

Utah

At least 15 sites in Utah are candidates for Site Specific Development Analyses. Initial activity is an evaluation for the Salt Lake City Corporation of the utility of heat pumps in several planned new downtown office buildings.

Wyoming

A site specific analysis for the town of Thermopolis, in the Big Horn Basin, is underway.

3.4 Time-Phased Project Plans

3.4.1 Completed Plans

Time-Phased Project Plans were prepared for selected sites that have geothermal development well underway. These are listed in Table 6.

Colorado

A plan for Pagosa Springs, Colorado, described the initial activities leading to a PON-funded heating district. It discussed possible subsequent development including a proposed city-wide heating district, a suburban heating district, and a timber kiln, greenhouse and agriculture.

Idaho

A Time-Phased Project Plan for Boise, Idaho, is a description of the geothermal retrofit of the Capitol Mall. It illustrates the activities that must be accomplished to allow the project to be completed by 1983. An economic analysis that is part of the report indicates that either buying geothermal fluid from the Boise City system or constructing a separate system would be less expensive than continuing to heat with natural gas.

The Rexburg, Idaho, Time-Phased Project Plan, discusses the planned geothermal industrial processing as well as municipal space heating. A large Rogers Foods potato processing plant is a primary focus of the geothermal development plan, with Rexburg residents and the college also committed to use the energy for space heat. Production well drilling is scheduled to begin in May, 1980.

Montana

For Montana, two Time-Phased Project Plans were prepared. The plan for White Sulphur Springs describes in detail the development of a well and

TABLE 6

Completed Time-Phased Project Plans

Location	Potential Uses
Colorado	
Pagosa Springs	District heating
Idaho	
Boise Capitol Mall	Space heating
Rexburg	Food processing, space heat
Montana	
White Sulphur Springs	Space heating
Warm Springs State Hospital	Space heating and hot water heating
Utah	
Roosevelt Hot Springs	Power generation

TABLE 7

Time-Phased Project Plans
Candidates

Location	Potential Uses
New Mexico	
Truth or Consequences	Space heat hospital, senior citizens center
Taos	Solar-assisted greenhouse
Faywood	Solar-assisted greenhouse
Las Cruces	Solar-assisted greenhouse
Baca Location (west of Los Alamos)	Power generation
Animas Valley	Greenhouse heating
South Dakota	
Lemmon	Residential and commercial district heating
Utah	
Crystal Hot Springs	Commercial greenhouse Resort Prison heating
Salt Lake County	Commercial greenhouse
New Castle	Greenhouse
Hill Air Force Base	Space heat
Monroe	Space heat
Midway	Space heat

heating system for a bank building, with the aid of State financial assistance fo $43,500. The Warm Springs State Hospital is a retrofit project, with at least two buildings planned for conversion to geothermal heat. The White Sulphur Springs project was completed in slightly more than two years.

Nevada

In Nevada, there are two active demonstration projects, the space heating of the Sundance West Apartment complex at Moana Hot Springs, and the space and water heating for a laundry, motel and office building in Elko. Five developers are investigating the geothermal ethanol production potential at several sites in Nevada. The Brady Hot Springs and Elko sites are being considered for Time-Phased Project Plans.

3.4.2 Candidate Plans

Table 7 shows some of the sites for which Time-Phased Project Plans may be compiled.

New Mexico

New Mexico has nine projects that are candidates for Time-Phased Project Plans. Six of these are state-funded demonstration projects: The Carrie Tingley Hospital at Truth or Consequences will develop a geothermal heating system. Also at Truth or Consequences, the Senior Citizens Center will install geothermal space heating. A solar-assisted geothermal greenhouse at Taos is planned, as is a similar one at Faywood. The campus of the New Mexico State University at Las Cruces is proceeding with the implementation of a geothermal system to heat campus buildings. Finally, the L'eggs Hosiery Plant in Las Cruces is investigating the geothermal potential for their processing needs.

Two other sites are candidates for Time-Phased Project Plans. First is the Union Oil Company/Public Service Company of New Mexico power plant demonstration program which is located west of Los Alamas. Second is the Animas Valley, where two greenhouse owners are planning major expansions based upon geothermal energy.

North Dakota

All or some of the ten sites in North Dakota currently using geothermal energy are being considered for Time-Phased Project Plans.

South Dakota

The city of Lemmon may be considered for a Time-Phased Project Plan, once the Site Specific Development Analysis is completed. Public and private parties in Lemmon are moving aggressively to implement a district heating system for residential and commercial applications.

Utah

A Time-Phased Project Plan detailed the events leading to development of the Roosevelt Hot Springs electrical power generation site. Seven direct use projects are candidates for Time-Phased Project Plans. These are the Utah Roses greenhouse project at Crystal Hot Springs, the Utah State Prison project, Utah Roses in Salt Lake County, the New Castle greenhouse project, the Hill Air Force Base space heating project, the City of Monroe heating district, the Crystal Hot Springs Resort, and the Midway space heating use. Plans will be prepared only for those sites requiring development/regulatory assistance.

3.5 Aggregation of Prospective Geothermal Use

Although much is still unknown about the geothermal reservoirs in the RMB&R Region, as well as about the demand for the energy, the prospective geothermal energy use was preliminarily estimated for most of the states. North Dakota, South Dakota and Utah had too little information available to make reasonable estimates. The other states based their estimates on two primary sources: the analyses they have performed for areas and sites, and the analyses performed by the New Mexico Energy Institute.

As Table 8 shows, these preliminary estimates indicate that about 783 x 10^{12} Btu's could be on line by the year 2000, and 1,084 x 10^{12} Btu's could be on line by 2020, both in direct heat applications.

3.6 Institutional Analysis

All 10 states are contracted to perform analyses of their institutional settings for geothermal energy and to pinpoint problem areas and solutions. As a part of this activity, they also prepare Institutional Handbooks. These are designed for use by prospective participants in geothermal development, providing a step by step guide to the regulatory requirements. Arizona, Nevada and South Dakota have completed their analyses and handbooks in draft form, and Colorado, New Mexico and Wyoming have completed and submitted them to DOE-ID for publication. The Idaho Geothermal Handbook was completed earlier.

A comparison of various institutional elements is found in Table 9. Some of the noteworthy issues that deserve citation are as follows:

Arizona

Geothermal resources are exempt from state water law. The State Department of Revenue offers a 27.5% depletion allowance for geothermal wells and a deduction from gross income of all expenditures of a geothermal well.

TABLE 8

REGIONAL AGGREGATION OF
PROSPECTIVE GEOTHERMAL DIRECT HEAT USE (10^{12} Btu's)*

STATE	YEAR 2000	YEAR 2020
ARIZONA	132.5	176.3
COLORADO	157.7	244.4
IDAHO	125.9	178.3
MONTANA	43.4	51.1
NEVADA	45.9	75.6
NEW MEXICO	66.5	90.8
NORTH DAKOTA	40.7	51.0
SOUTH DAKOTA	13.2	15.5
UTAH	111.2	145.1
WYOMING	45.7	56.2
Totals	782.7	1084.3

* Economically feasible (high range).

Source: New Mexico Energy Institute, 1979.

TABLE 9

Institutional Characteristics of
Regulation in the Rocky Mountain Basin and Range Region

State	Geothermal Definition	Regulatory Agency of Geothermal Wells	Institutional Incentives	Institutional Constraints
Arizona	Hot water, hot brines, indigenous steam, heat in geothermal formations	Arizona Oil & Gas Conservation Commission	Depletion allowance, tax deduction, exemption from water laws.	
Colorado	Steam, other gases, hot water, hot brine, natural heat	Colorado Oil & Gas Conservation Commission	Property tax exclusion for alternative energy systems, income tax deduction for alternative energy costs over conventional systems.	Specifically excluded from mineral ownership except where stated in conveyance to be included. Is subject to water law.
Idaho	Neither water nor mineral but closely related to both	Idaho Department of Water Resources	Third party water finance precluded by valid water license; state funding of special projects.	Ownership questions, possible conflicts with water owners.
Montana	Natural heat energy of the earth, found beneath the earth, including minerals or other products obtained from the medium	Montana Department of Natural Resources	Exclusion from Major Facilities Siting Act of geothermal except power plants over 25 MW; state alternative energy grant program.	No geothermal wells on state lands except where there is overlapping competitive interest.
Nevada	Heated water steam, heat found beneath the surface of the earth.	Nevada Division of Water Resources	Authority for district heating systems, property tax exemption.	
New Mexico	Natural heat of the earth--below the surface of the earth but excluding oil, hydrocarbon gas and other hydrocarbons	New Mexico Oil Conservation Commission	Expanded state acreage lease and time allowances; state-funded demonstration and drilling programs.	

TABLE 9 (continued)

Institutional Characteristics of
Regulation in the Rocky Mountain Basin and Range Region

State	Geothermal Definition	Regulatory Agency of Geothermal Wells	Institutional Incentives	Institutional Constraints
North Dakota	None at this time	No statutory authority		No legislation directed toward geothermal energy and thus no leasing procedures, no definition. Are being developed currently.
South Dakota	No specific definition	Department of Water and Natural Resources		Moratorium on geothermal well permits.
Utah	No specific definition	Division of Water Rights		
Wyoming	Included in definition of underground water that has been exposed to the surface	State Engineer		

Colorado

The fact that geothermal is subject to water law and is exempted from mineral ownership except where specifically provided creates a condition for ownership conflicts.

Idaho

As in Colorado, the conditions for conflicts regarding ownership and water rights are inherent in the law; however, an in depth analysis of Idaho law has concluded that assurance against third party interference is secured through a valid water license.

In 1979, the Idaho State Legislature passed three major bills relating to geothermal resources:

Senate Bill 1062 - clarified existing law by defining "domestic water systems" to include space heating and cooling; provides authority for cities to revenue bond the construction of geothermal space heating system;

Senate Bill 1237 - appropriated from the Public Building Account to the Permanent Building Fund Advisory Council and the Division of Public Works the sum of $194,400 for the purpose of retrofitting the State Capitol Mall to geothermal heating;

House Bill 142 - allows counties to acquire and operate geothermal heating systems; however, the failure of HJR-2 makes House Bill 142 ineffective since counties do not currently have authority to go into debt for such systems. HJR-2 was a proposed joint resolution to amend the State Constitution to allow cities and other local units of government to acquire and operate energy systems and to finance them by issuing revenue bonds; HJR-2 was opposed by the state's major electrical utilities.

Montana

Geothermal development except for power plants over 25MW has been excluded from Montana's Energy Facility Siting Act, alleviating a major barrier.

Nevada

Nevada has established tax incentives and authority for geothermal development but faces possible water use conflicts.

New Mexico

In 1979, the State Legislature enacted the following items relating to geothermal energy:

House Bill 446 - extends the total state acreage limitation from 25,600 acres to 51,200 acres and extends the time limitation of the leases from five years to ten years.

House Bill 447 - clarifies procedures and powers regarding administration of the "geothermal resources conservation act" by the Oil Conservation Division of the Energy and Minerals Department.

North Dakota

No stationary authority or even definition of geothermal energy has yet been established, but corrective action is being stimulated by the State Commercialization Team working with other state agencies.

South Dakota

The absence of specific geothermal legislation in South Dakota prompted the State Department of School and Public Lands to promote several legislative initiatives in 1979. The initiatives would have subjected geothermal resources to the same leasing, rent, royalty and tax provisions as currently exist for hard minerals. The Governor's office has opposed this legislative initiative, but it surfaced again in 1980 and is likely to be an issue in 1981 also.

Utah

The State Division of Water Rights has tried unsuccessfully for the past two state legislative sessions to obtain a comprehensive state law defining geothermal energy and providing for specific regulatory authority. Resistance from the state's leading utility company has been substantial.

Wyoming

Wyoming law does not address geothermal energy directly but includes it in underground water and other topics of legislation. The Wyoming State Team expects to introduce specific legislation on geothermal resources into the 1981 State Legislature.

3.7 Public Outreach

Probably the most salient of the tasks of the State Commercialization Projects, at least within their own states, is the public outreach. This task requires the State Teams to spend a portion of their time marketing geothermal energy to encourage parties to evaluate, develop and use the resource. Without this activity all other efforts would be futile. Since the public outreach program began, expressions of interest in and proposals to develop geothermal energy have rapidly increased.

3.7.1 Mechanisms

Several different mechanisms were and are being used for this marketing effort to reach different audiences at different levels of interest. The news media were extensively used by some states to reach a broad audience. Presentations at professional meetings and college classes also reached a large but specialized audience while providing a mechanism for direct comments and questions. Meetings with officials and townspeople, including industry representatives in areas that have geothermal potential, have vastly expanded awareness of the value of geothermal energy. State Teams have met with geothermal energy company representatives, not to enhance their awareness but rather to learn from them more about industry needs and the ways that the State offices might be able to assist. State Teams have met with members of state and federal agencies to increase their awareness of geothermal resources and to determine ways that geothermal commercialization can be coordinated with their programs.

Tools prepared by the State Teams have been useful. These include brochures, maps and the aforementioned Institutional Handbooks. The plans and analyses prepared by the State Teams are also used in the outreach program. When their preparation begins, information is sought from officials, residents and industry in a prospective geothermal area, to assure the appropriateness and realism of a report. This enhances the initial interest in geothermal energy. As the study progresses and after its completion, findings are reported to the community to show the potential of geothermal energy and the steps needed to accomplish commercialization.

In some cases, the State Teams have been able to provide a high level of technical assistance to the prospective geothermal developers and users. They have prepared preliminary engineering and economic feasibility studies, have guided them through the development process, including the regulatory requirements, and have put them in communication with specialists for subsequent work. Furthermore, they have worked with state legislators to help improve the institutional climate for geothermal energy. In subsequent outreach activities, more emphasis will be placed upon industry contacts which might relocate as well as those already located near a geothermal area.

3.7.2 Summary of Contacts and Results

A wide range of geothermal project proposals have been stimulated in The Rocky Mountain Basin and Range Region, to a large extent by the Outreach (and other) activities of the State Commercialization Team. Among these are the planned and proposed projects on Table 10.

TABLE 10

PLANNED AND PROPOSED PROJECTS

Arizona

Williams Air Force Base - heating and cooling
Safford - heating and cooling
Wilcox - gasohol plant
Clifton - mineral processing
- Sigman meat processing plant

Colorado

Ouray - space and water heating
Glenwood Springs - space and water heating
Canon City - space and water heating
Idaho Springs - space and water heating
Haystack Butte - commercial greenhouse

Montana

Poplar - space and water heating
Baker - space and water heating
White Sulphur Springs - space and water heating
Hot Springs - space and water heating
Boulder - industrial park
Silver Star - ethanol plant
Broadwater Hot Springs - space and water heating
Hardin - livestock
Malta - space and water heating
Lost Trail Hot Springs - space and water heating
Chico Hot Springs - space and water heating

New Mexico

Animas - alcohol plant
Columbus - industrial park
Anapra - space heating
Berino-Mesquite - chili dehydration

TABLE 10 (continued)

PLANNED AND PROPOSED PROJECTS

New Mexico (continued)

Garfield - chili dehydration

Gila Hot Springs - space and water heating

Jemez Springs - space and water heating

Truth or Consequences - space and water heating

Mesilla - space and water heating

Socorro - space and water heating

Nevada

Caliente - space and water heating

Winnemucca - ethanol plant

Lyon County - ethanol plant

Carson City - space and water heating

Elko - space and water heating

Hawthorne - space and water heating

North Dakota

Bismarck

St. Mary's School - space and water heating

Patterson Hotel - space and water heating

Town of Bismarck - space and water heating

South Dakota

Pierre - space and water heating

Polo - space and water heating

Edgemont - space and water heating

Lemmon - space and water heating

Utah

Cove Fort - alcohol plant

Plymouth - space and water heating

Crystal Madsen's Hot Springs - space and water heating

TABLE 10 (continued)

PLANNED AND PROPOSED PROJECTS

Utah (continued)

Milford - alcohol plant

Watsatch Hot Springs - space and water heating, prawn-raising

Midway - space and water heating

Logan - space and water heating

Wyoming

Powell - agribusiness

Midwest - industrial park

Thermopolis - space and water heating

Midwest-Edgerton - space and water heating

East Thermopolis - space and water heating

4.0 FINDINGS AND RECOMMENDATIONS

In the following state by state project reports, all the states have clearly demonstrated significant potential for geothermal energy development and use. They have documented a wide variety of prospective uses, including:

- Electrical power generation
- Alcohol production
- Swine shelter warming
- Cattle feedlots
- Copper leaching and other mineral extraction
- Food processing
- Timber and wool products processing
- Milk pasteurizing and cooling
- Greenhouse heating
- Aquaculture
- Industrial, commercial and residential space and water heating
- Space cooling

Use of geothermal energy in these and other applications can have a significant impact on the demand for fossil fuels. In many instances, it can significantly promote the economic development of the Region.

Additionally, the states have documented the increased interest and activity in geothermal commercialization. Without exception, however, they indicate that commercialization could progress much more rapidly with certain significant barriers removed. Following are their recommendations for stimulating greater and more rapid geothermal commercialization:

- Remove institutional barriers. The difficulty of obtaining leases and permits on Federal lands is a principal barrier to geothermal development. It remains a significant barrier for sites with power generation potential. Some states have state legislative and regulatory barriers. Several are attempting to make improvements. The National Conference of State Legislatures provides significant assistance to the states in these efforts.

- Continue to increase visibility of and interest in geothermal commercialization, especially among industry and commerce. This is being accomplished primarily by the State Commercialization Teams. More information and publicity from the national level would broaden the coverage and the acceptance. More marketing to major prospective user industries is required.

- Expand technical assistance. The difficulty of obtaining a thorough, although preliminary, engineering and economic assessment of a prospective project slows commercialization. Without reasonable assurance that a project is economically sound, developers and users are extremely reluctant to proceed. Many of them cannot finance this work themselves.

- Expand reservoir confirmation work. Probably the most pervasive of limitations is the lack of sufficient geothermal reservoir information. Given the situations of most prospective developers and users, they often cannot assume the risk of reservoir assessment and confirmation themselves. In many instances they could fund the development phase themselves or could obtain assistance from other financial sources. Reservoir confirmation assistance should be directed toward those areas that are shown to have the greatest market potential as well as the greatest ability to stimulate further development. The states and their constituents are hopeful that the DOE User-Coupled Reservoir Confirmation Drilling Program will be a major incentive and action.

- Expand funding for geothermal assessment, exploration and development. Although the states recognize the budget limitations of the national geothermal program, expanded funding remains a critical need, one that perhaps will ultimately be addressed by the U.S. Congress.

By removing institutional barriers, by enhancing the acceptability and visibility of the resource, and by reducing the risk and uncertainty through technical assistance and reservoir confirmation, commercialization could indeed be accelerated. Given the current scarcity of private or public funds for evaluation, exploration or development, geothermal energy may continue to lie dormant while U.S reliance upon imported oil continues or grows.

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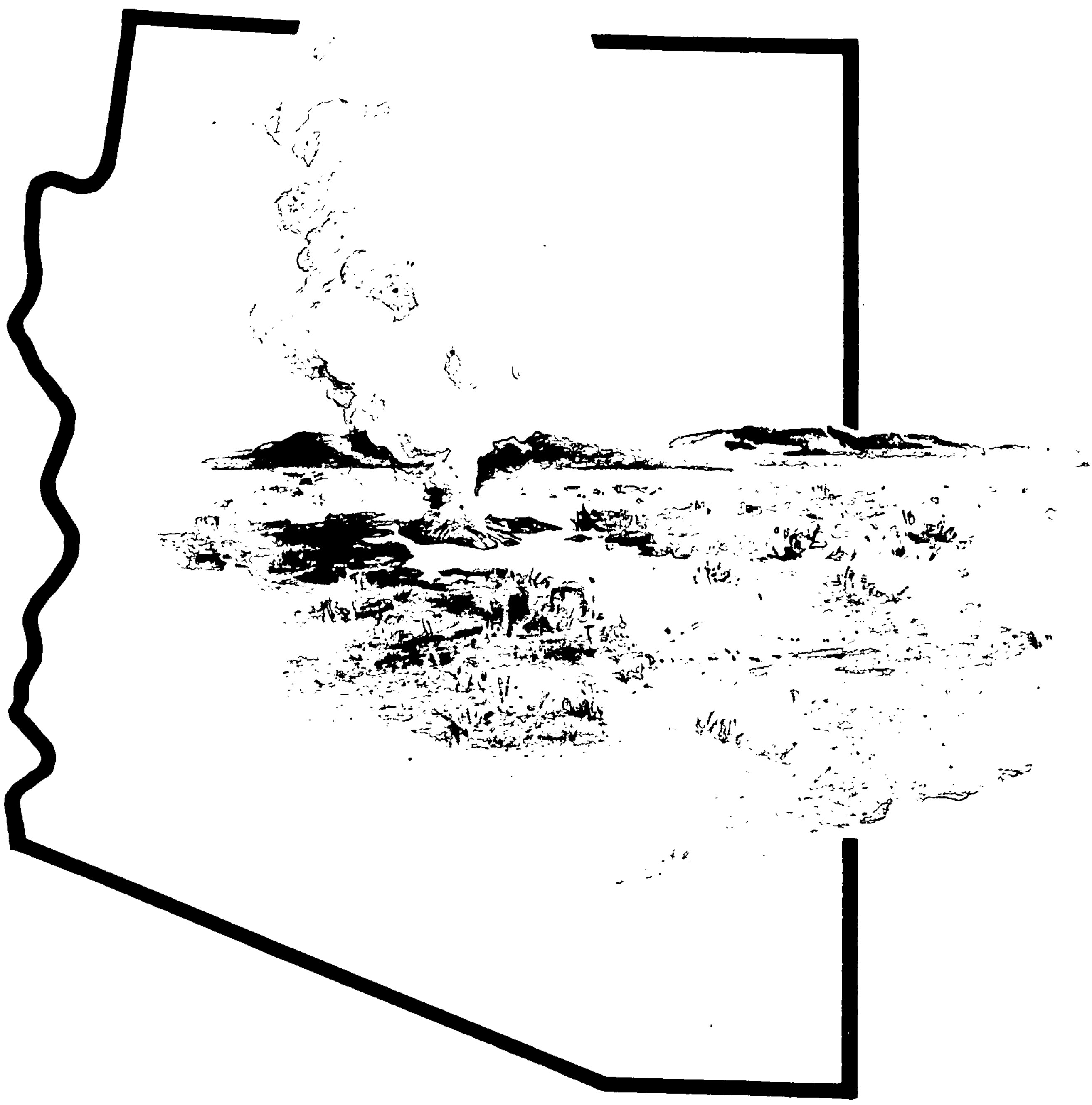
Chapter 2

Arizona Teams Geothermal Planning Project



ARIZONA TEAM GEOTHERMAL PLANNING PROJECT

SEMI-ANNUAL PROGRESS REPORT

July - December, 1979

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Work performed under Contract No. DE-FC07-79ID12015
with Arizona Solar Energy Commission
Subcontract 0199 with
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TABLE OF CONTENTS

1.0 INTRODUCTION

The Arizona Geothermal Planning Team, at the University of Arizona has been working under contract to the DOE via Arizona Solar Energy Commission for over two years (since June 12, 1977). During the first year, an appraisal of potential geothermal resources and uses was undertaken. Efforts were directed toward a survey of the geology of the state, the identification of potential resources, and twenty-two possible applications of geothermal energy specifically suited for Arizona. In the second year, the Arizona Team took the planning phase one step further. Nine geothermal applications were considered in detail, four regions of the State were studied as Area Development Plans, an institutional analysis was undertaken and an outreach program was initiated.

The Arizona Team consists of three key personnel, two senior level advisors, three support personnel and eight additional temporary personnel. Key personnel are: 1) Dr. Frank Mancini, Project Monitor. His responsibilities include: a) monitoring the progress of the project, b) serving as a liason between the Arizona Geothermal Team and the DOE. 2) Dr. Don H. White, Team Leader. His responsibilities include: a) coordinating and monitoring all the efforts of workers on the project, b) suggesting and analyzing ADPs, c) suggesting and analyzing geothermal applications, d) editing all reports written for this project. 3) Richard Hahman, Sr., Resource Advisor and Director of Outreach. His responsibilities include: a) providing geothermal resource advice, b) suggesting and analyzing ADPs, c) suggesting and analyzing geothermal applications, d) directing outreach activities. The senior level advisors are: 1) Dr. Helmut Frank, Energy and Economics Advisor. His responsibilities include: a) providing energy and economic data on Arizona, b) advising on energy and economic planning. 2) Dr. David Wolf, Technical Advisor. He is responsible for analyzing and providing advice on the geothermal applications.

The other personnel and their names and tasks are listed in the organization chart of the Arizona Geothermal Team in Figure 1-1.

Arizona is the fastest growing state in the United States. Therefore, the planning of its future growth is a task which could have a broad impact on the economic stability and quality of life within the State. The availability and development of geothermal energy could aid in the orderly growth of Arizona, as well as offset the effect of oil and natural gas importation.

2.0 SPECIFIC TASK DESCRIPTIONS AND PRODUCTS

After identifying twenty-two possible applications for geothermal energy during the first year, nine of these applications were examined in more detail in the current year. Work on these applications plus data gathering for various planning areas led to completion of four Area Development Plans and an Institutional Handbook. Resource data was updated as well. Some of the key results from the work to date are outlined below.

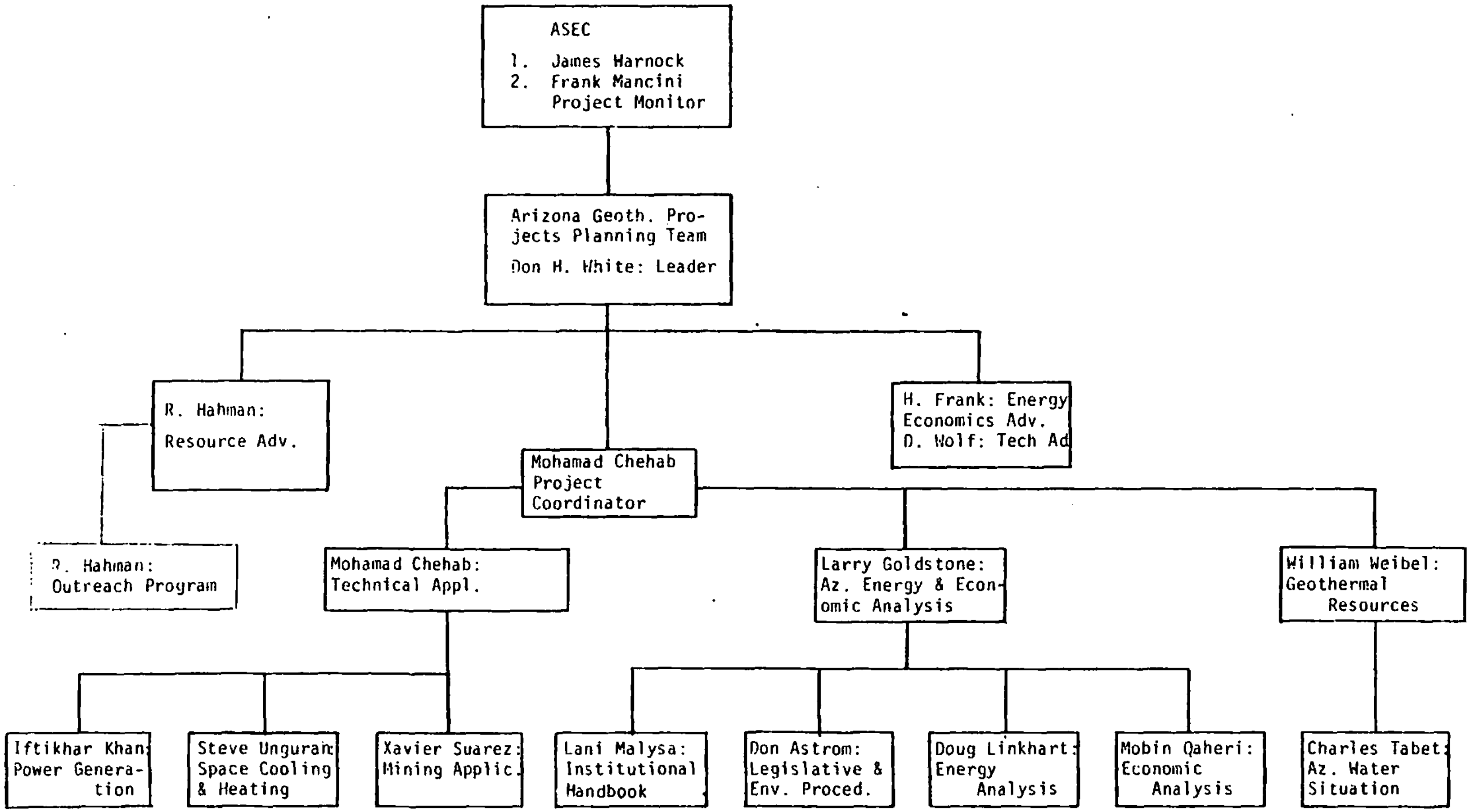

Figure 1-1: Organizational Chart for the Arizona Geothermal Team for 1979.

2.1 GEOTHERMAL PROSPECT IDENTIFICATION

The effort expended to delineate Arizona's known geothermal resources has been concentrated upon the Basin and Range physiographic area, characterized on the surface by alternating mountain ranges and broad valleys. Most of the valleys overlie structural basins somewhat smaller than the area of the valleys themselves. The Basin and Range constitutes the southwestern - most two-thirds of the state and is also characterized by higher than normal heat flow on the average. Some of these basins are filled with deep piles of reasonably porous sediment, most of which has eroded from adjacent mountains since their formation between 13 and 5 million years ago. These sedimentary piles are generally between about 600 and 1200 meters deep, and a few basins contain thick evaporite masses, e.g., anhydrite, halite, or gypsum. Deposited before, and thus lying beneath, the evaporites are usually conglomerates intermixed with volcanics. Where observed on the land surface, these porous conglomerates often are found to be deposited directly on igneous basements.

Thirty-seven of these sedimentary basins are known to store warm to hot (35-85^{o}C) water at relatively shallow depths (less than 1200 meters) and are thus proven direct thermal resources. Figure 2-1 shows these basins as boxes, numbered by county; locations and estimates are given in Table 2-1. The circled, stippled areas on this figure represent potential and inferred geothermal prospects, keyed to Table 2-1 and 2-2, where higher temperatures (>90^{o}C) may be discovered as determined by J.C. Witcher of the State Bureau of Geology. The Bureau is investigating areas near Tucson, Phoenix, Hyder Valley, Tonopah, Willcox, Springerville, Yuma, Kingman and the Safford-San Simone basin. Leasing interest has been greatest in the Clifton and San Bernardino Valleys, and many applications currently await processing. These areas of great leasing interest also exhibit the geologic properties most favorable for geothermal electrical generation in the state.

Leasing of State and Federal lands in Arizona for prospective geothermal development has resumed in 1979 after several years of no leasing activity. As of December 1979, Federal leases totalled 21,541 acres and the State leases totalled 1,844 acres,

2.2 AREA DEVELOPMENT PLANS

2.2.1 State Geothermal Planning Areas

The 14 counties of the state have been organized into seven regional areas for purposes of planning the future use of geothermal energy. Work to date has been concentrated in the southern portion of Arizona, especially within Maricopa and Pima counties where the majority of the state's population resides. Figure 2-2 shows the divisions within Arizona for planning purposes. With respect to Arizona's seven planning areas, four have been analyzed during 1979.

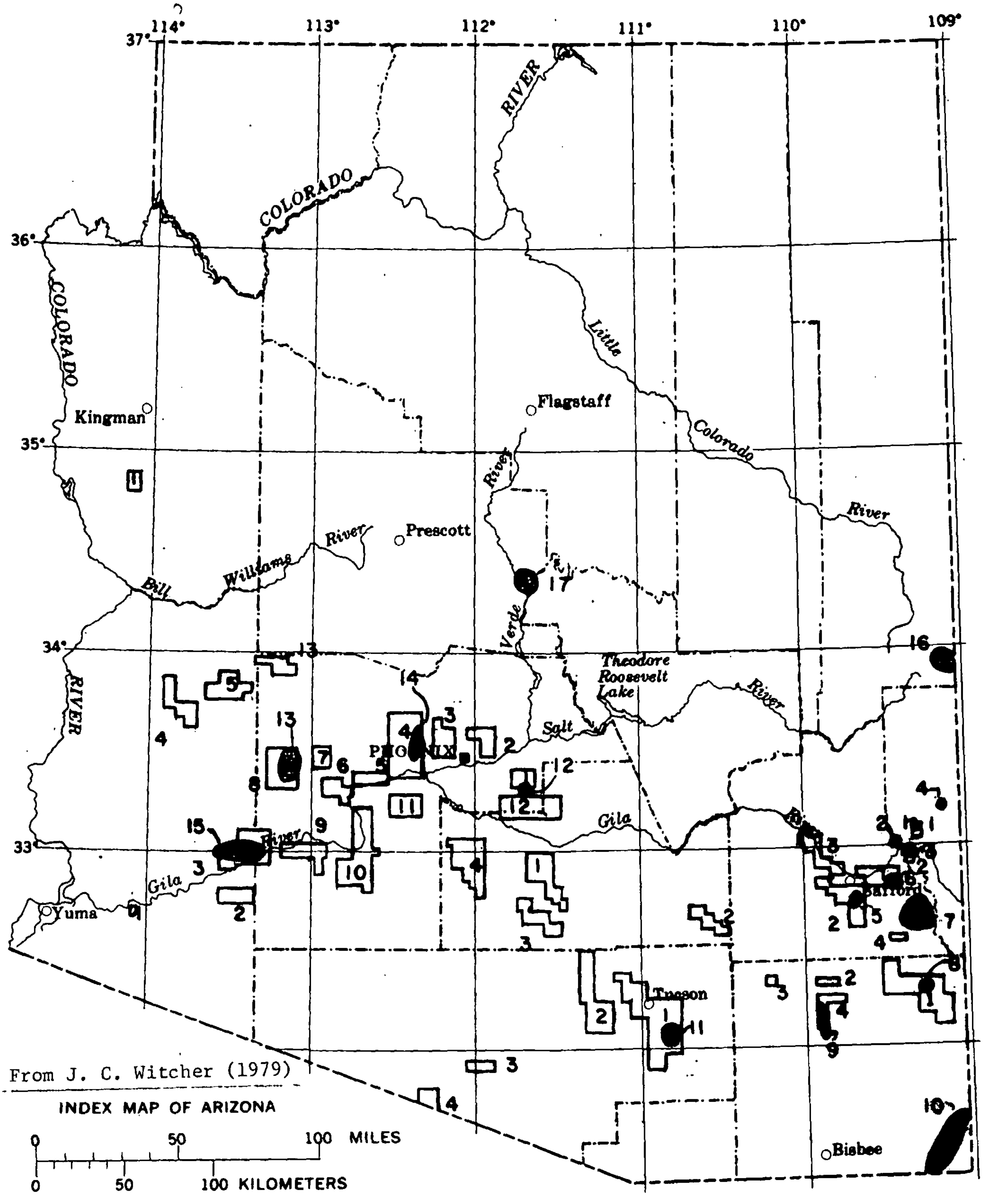

Figure 2-1: **Arizona's proven, potential, and inferred resources.**

TABLE 2-1: PROVEN AND POTENTIAL GEOTHERMAL RESERVOIRS LESS THAN 1.2 KM DEPTH
Modified from (Witcher, 1979)

Tr - Average temperature of the reservoir

County/Area	Location	Volume km^3	Measured °C Temperature	Depth (Feet)	Tr °C	Geothermometry Temperature °C	Method	Source
Greenlee 1	T4S, R30E	18.6	30 - 67	Surface	80	130 - 180	Quartz Mixing Model, 2Na-K-Ca/mg corr.	7
Greenlee 2	T5S, R30E	18.6	30 - 83	Surface	80	130 - 140	Quartz, Na-K-Ca	6
Graham 1	T6-7S, R26-28E	61.9	30 - 50	<1000	75	70 - 115	Quartz, Na-K-Ca	7
Graham 2	T7-9S, R24-26E	111.5	30 - 45	<2000	70	30 - 90	Quartz, Na-K-Ca	7
Graham 3	T4-6S, R23-25E	71.2	30 - 60	<3500	60	70 - 90	Chalcedony, Na-K-Ca	7
Graham 4	T10S, R28-29E	61.9	30 - 40	<2000	60	90 - 110	Quartz, Na-K-Ca	7
Cochise 1	T12-15S, R28-31E	204.3	30 - 40	<1000	60	60 - 85	Chalcedony, Na-K-Ca	6,8
Cochise 2	T13, R24-25E	15.5	30 - 50	<2500	60	60 - 70	Chalcedony	3,8
Cochise 3	T12-13S, R21E	12.4	30 - 50	Surface	60	50 - 90	Quartz, Na-K-Ca	6
Cochise 4	T14-15S, R24-25E	80.5	30 - 40	<1000	70	80 - 110	Quartz, Na-K-Ca	3
Pima 1	T12-17S, R12-15E	287.9	30 - 50	<2500	60	50 - 65	Chalcedony, Na-K-Ca	7
Pima 2	T12-15S, R10-11E	157.9	30 - 45	<2000	60	30 - 60	Chalcedony	8
Pima 3	T17S, R3-5E	30.9	35 - 40	< 700	55	50 - 60	Chalcedony	8
Pima 4	T19-20S, R31E	40.3	30 - 45	<1000	65	50 - 80	Chalcedony	8
Pinal 1	T5-8S, R7-9E	126.9	30 - 45	<2500	55	40 - 80	Chalcedony	8
Pinal 2	T8-10S, R16-18E	61.9	30 - 45	<1000	60	50 - 70	Chalcedony	8
Pinal 3	T8-9S, R6-8E	80.5	30 - 45	<2500	55	40 - 80	Chalcedony	8
Pinal 4	T4-7S, R2-4E	164.1	30 - 40	<1500	55	-	Reservoir Temp. for gradient = 35°C/km	-
Yuma 1	T8-9S, R19W	3.1	50 - 60	< 50	60	60 - 70	Quartz	6
Yuma 2	T7-8S, R11-12W	65.0	30 - 40	< 700	65	40 - 70	Chalcedony	2
Yuma 3	T4-6S, R10-12W	148.6	30 - 45	<1500	70	60 - 80	Chalcedony	8
Yuma 4	T3-6N, R14-16W	83.6	30 - 45	<1500	60	40 - 70	Chalcedony	8
Yuma 5	T5-6N, R11W-13W	123.8	30 - 40	<1500	50	30 - 40	Chalcedony	8
Mohave 1	T17N, R17W	18.6	30 - 35	-	50	40 - 50	Quartz	8
Maricopa 1	T1N, T1S, R6-7E	46.4	30 - 40	< 500	60	50 - 60	Chalcedony	8
Maricopa 2	T2-3N, R3-5E	68.1	30 - 45	<1500	60	30 - 60	Chalcedony	8
Maricopa 3	T2-3N, R1-2E	55.7	30 - 45	<2000	60	35 - 60	Chalcedony	8
Maricopa 4	T1-4N, R1-2W	222.9	30 - 60	<2000	60	30 - 70	Chalcedony	8
Maricopa 5	T1N, T1S, R3-4W	37.1	30 - 40	<2000	55	30 - 40	Chalcedony	8
Maricopa 6	T1-2S, R5-6W	52.6	30 - 35	<1500	70	40 - 70	Chalcedony	8
Maricopa 7	T1-2N, R6-7W	49.5	30 - 50	< 700	75	45 - 85	Quartz, Na-K-Ca/Mg corr.	Jones pers. comm.
Maricopa 8	T1S, 1-2N, R8-10W	148.6	30 - 40	<2000	65	30 - 110	Chalcedony	8
Maricopa 9	T4-6S, R7-9W	74.3	30 - 40	<1000	60	30 - 80	Chalcedony	8
Maricopa 10	T2-7S, R3-6W	182.7	30 - 50	<2000	60	30 - 65	Chalcedony	8
Maricopa 11	T2-3S, R1-2W	74.3	30 - 40	<1500	60	30 - 70	Chalcedony	8
Maricopa 12	T2-3S, R5-8E	123.8	30 - 40	<1000	60	40 - 60	Chalcedony	8
Maricopa 13	T6-7N, R8-10W	61.9	30 - 40	2000	55	30 - 40	Chalcedony	8

TABLE 2-2: INFERRED INTERMEDIATE TO HIGH TEMPERATURE (<90°C) GEOTHERMAL RESERVOIRS LESS THAN 2.5 KM
Tr - Average Reservoir Temperature

	Name	County	Location	Depth km	Volume km^3	Tr °C	Inferences based on
1.	Clifton Hot Springs	Greenlee	T4S, R30E	2.0	2.5	170	1, 5
2.	Eagle Creek Hot Springs	Greenlee	T4S, R28E	2.0	2.5	130	1, 5
3.	Gillard Hot Springs	Greenlee	T4S, R30E	2.0	2.5	140	1, 5
4.	Martinez Ranch	Greenlee	T3S, R31E	2.0	2.5	130	1, 5
5.	Cactus Flat-Artesia	Graham	T7-9S, R26E	2.0	2.5	110	1, 3, 5
6.	Buena Vista	Graham	T6-7S, R27-28E	2.0	2.5	120	1, 3, 5
7.	Whitlock Mountains Area	Graham	T8-10S, R28-30E	2.0	2.5	110	1, 3, 5
8.	San Simon	Cochise	T13-14S, R29-30E	2.0	2.5	120	2, 3, 5
9.	Willcox Playa	Cochise	T14-15S, R24E	2.0	2.5	110	1, 3, 5
10.	San Bernadio Valley Area	Cochise	T20-24S, R29, 31E	2.5	2.5	150	1, 3, 4, 5
11.	Tucson Basin	Pima	T14-15S, R14-15E	2.5	2.5	130	2, 3, 5
12.	Power Ranch Area	Maricopa	T1-2S, R6E	2.5	2.5	130	2, 3, 5
13.	Harquahala Plain	Maricopa	T1S, T1N-2N, R8-10W	2.5	2.5	110	1, 3, 5
14.	Luke-Litchfield	Maricopa	T1-4N, R1-2W	2.0	2.5	110	3, 5
15.	Hyder Area	Maricopa	T4-6S, R10-12W	2.0	2.5	110	1, 3, 4, 5
16.	Alpine-Nutrioso	Apache	T5-7N, R30E	2.0	2.5	120	3, 4, 5
17.	Verde Hot Springs	Yavaipai	T11N, R6E	2.0	2.5	130	1, 3, 5

(1) Geothermometry
(2) Deep well tests
(3) Geophysics/heat flow
(4) Young volcanism
(5) Structure

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Priorities

I) Maricopa
II) Pima
III) Graham/Greenlee
IV) Pinal
V) Yuma
VI) Cochise/Santa Cruz
VII) Northern Counties (1,3,4,8,9,13)

County Names

1. Apache
2. Cochise
3. Coconino
4. Gila
5. Graham
6. Greenlee
7. Maricopa
8. Mohave
9. Navajo
10. Pima
11. Pinal
12. Santa Cruz
13. Yavapai
14. Yuma

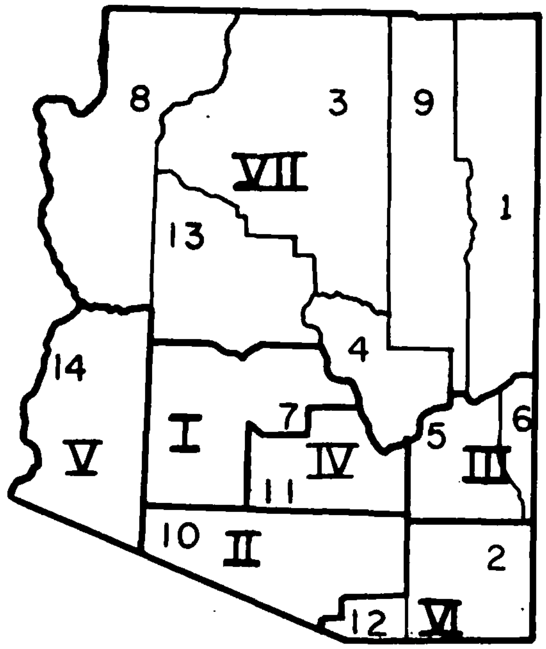


Figure 2-2: Geothermal Planning Areas

2.2.2 Specific ADPs - Completed

a) Maricopa County

On the basis of geophysical inference, thirteen basins have been delineated on Figure 2-1 which contain thick Cenozoic deposits suitable for geothermal development in the low-to-moderate (<90°C) temperature range. Five of these basins are near greater Phoenix. Higher temperature resources may be discovered in the deeper subsurface by drilling beneath the areas shown as stippled circles on the map. Two of these areas lie in close proximity to Phoenix. More than one hundred wells exist in the Phoenix area whose reported discharge exceed 30 degrees centigrade.

Maricopa County ranks first in priority for Arizona primarily because it supports over half of the states population. The 1979 estimate of population for Maricopa County is placed at 1,463,000 people (Ref. 2-1) Future growth for the county is placed at between 2% and 3% per year.

Manufacturing of high technology products is the principal contributor to the economy, accounting for 91,000 jobs in 1979 (Ref. 2-2). Maricopa County's economy also depends strongly upon tourism and agriculture. Growth in Maricopa County is expected to occur primarily in the Phoenix area. Future urban expansion is expected to occur to the north, southeast and southwest of the city. During 1979, a street map of Phoenix was compiled which illustrated sites of large commercial or industrial complexes either existing or proposed. All of these facilities are considered large enough candidates for geothermal commercialization. Most significant is that nine out of ten proposed new facilities will be located near a potential geothermal resource. These facilities are located either to the west or southeast of Phoenix proper.

Energy use patterns within Phoenix are characterized by high demand for electricity during the summer months. Figure 2-3 illustrates a typical annual load curve for a Phoenix utility. This annual peak in electrical consumption resulting from the high summertime demand for space cooling in southern Arizona is significant. Geothermal space cooling will hopefully be able to reduce this annual peak in electrical consumption via direct thermal use or heat pump applications.

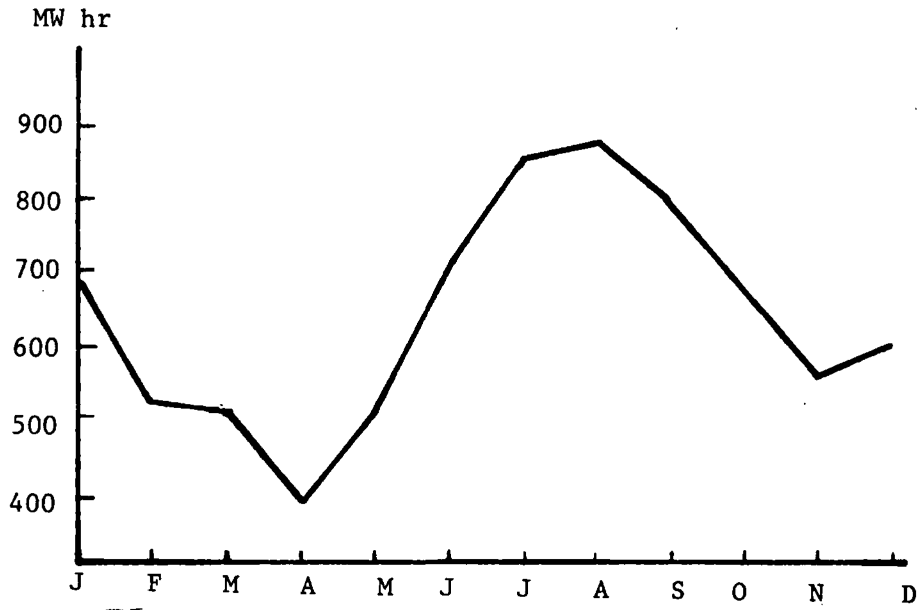


Figure 2-3: Monthly Electric Power Sales by Salt River Project in Maricopa County (1978).

b) Pima County

The most important resource in this ADP is the Tucson Basin. Tucson is surrounded by mountains and underlain by a structural basin that thickens toward the south, as inferred from gravity and seismic surveys. A 3,832 meter-deep oil test well drilled in the deepest area of the basin penetrated over 3,600 meters of sediments with some volcanics, before encountering "basement". This deepest section of the hole is most probably mid-tertiary boulder conglomerate with granitic clasts. The basement may be hundreds of meters deeper. The oil well's bottom was recorded to have a 146.7°C temperature. Thus Tucson has a geothermal energy source that could be developed to provide space cooling in the southern part of the area and space heating in much of the urban area.

Besides near Tucson, only shallow water wells have been drilled in this ADP. On the Papago Indian Reservation, warm (45°-47°C) water issues forth from two wells on the Great Plain (Pima 4 on Figure 2-1) from less than 200 meters depth. Soil warming, fermentation, and fish farming are suitable uses for this water without further well investment.

Pima County is the second largest population center in Arizona, with a 1979 population of 506,100. (Ref. 2-3). Tucson, the principal city in the county, accounts for over 90% of the county population. Pima County and Tucson have experienced rapid growth over the last ten years, and growth is expected to continue at a rate of 4.3% per year. Principal growth will probably take place to the southwest, northeast and the southeast of the city. Copper production is the largest industry in Pima County, followed by manufacturing and tourism. As was done with Phoenix, locations of large commercial and industrial facilities both existing and proposed were matched to potential geothermal resources near Tucson. The results were not as promising as in Phoenix but future growth is in the direction of potential geothermal resources.

Energy use patterns in Pima County are similar in nature to those in Maricopa County reflecting high demand for space cooling during the summer months. Further, Pima County experiences intense daily peaks (Figure 2-4),

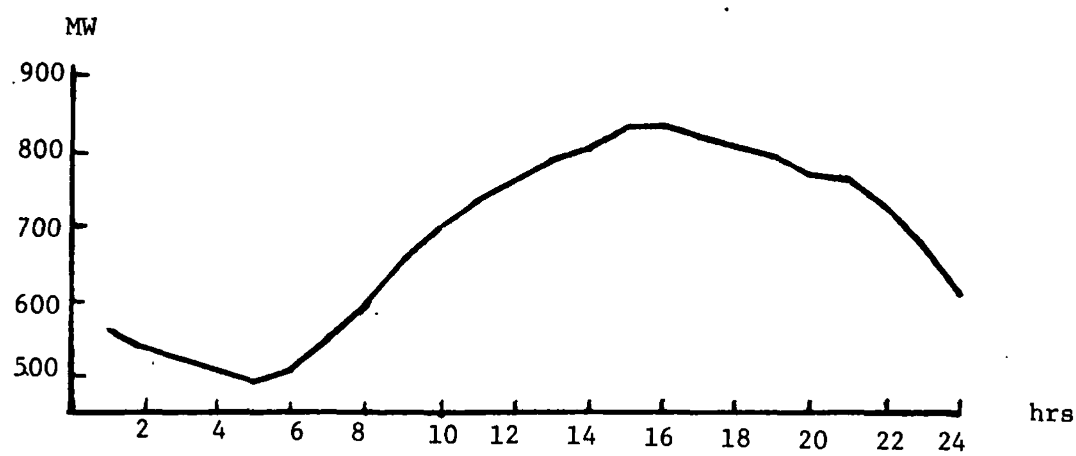


Figure 2-4: Daily Load Curve. Tucson Electric Power Co. July 19, 1978. Peak Load - 833 MW.

reflecting the heavy use of electricity for space cooling. Both the daily and annual peaks in electrical consumption can hopefully be reduced by introducing direct thermal use of geothermal resources for space cooling.

c) Graham/Greenlee Counties

The northern half of this ADP lies within the transition between the Colorado Plateau and Basin & Range geologic provinces. This transition has qualitites of each province. The southern half of the ADP lies within the Basin & Range province. The two counties have more hot springs than any other ADP in the state (see Figure 2-5) and 7 areas of inferred reservoirs >90°C (see Figure 2-1). Safford itself is surrounded by proven and potential geothermal reservoirs <90°C and the center of the Safford Basin may be as deep as 3 kilometers. Clifton will be the site of heat flow drilling by the Bureau of Reclamation in the coming year; the resulting stratigraphic data will be of great help in appraising the area's suitability for geothermal power production. Clifton is inferred via geochemical thermometry to be underlain by a reservoir in the 170°-190°C range (see Table 2-2), but the existence of a reservoir rock is still in question.

Graham and Greenlee Counties rank third in priority because of this geothermal potential. The 1979 combined population for the two counties is estimated to be 33,600. Future population growth is expected to be 0.65% for Graham County and 1.5% for Greenlee County. The principal industries in Graham County are farming and ranching, followed by tourism and recreation. Possible geothermal uses include food processing and crop drying. The principal industries in Greenlee County are copper mining and smeltering, ranching and tourism. Mining is by far the leading industry located in the Clifton/Morenci area. Figure 2-5 illustrates that geothermal energy might be quite useful in the dump leaching process. This is one of the more favorable scenarios for geothermal development, and has received much attention during the year.

Graham County exhibits electrical load curves similar to those of Pima and Maricopa Counties. Most electricity sold in Graham County is for residential use or irrigation, and peaks arise during the months of heavy irrigation. Clifton and Morenci, the two main towns in Greenlee County, experience a much more level annual electrical load curve, due to the effect that high elevation has on cooling the climate, thus reducing demand for space cooling and increasing demand for space heating.

d) Pinal County

Pinal County has four areas of proven <90°C resources (see Figure 2-1) and no obvious potential for electrical production from geothermal resources. Piccacho Basin, where two oil tests have been drilled, is over 3 kilometers deep with water temperature near this level shown on Figure 2-6. The thermal gradient for these wells is calculated to be

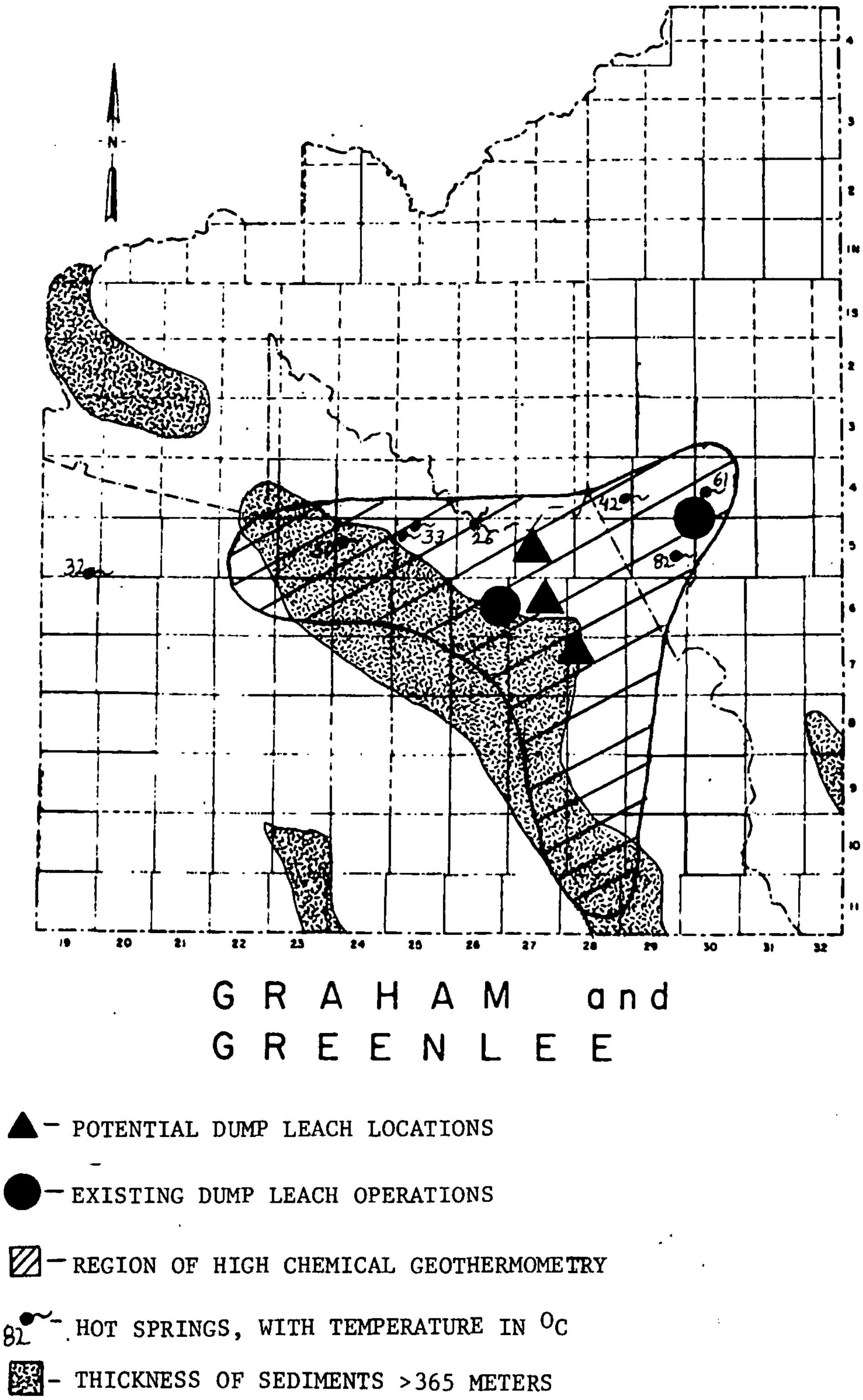
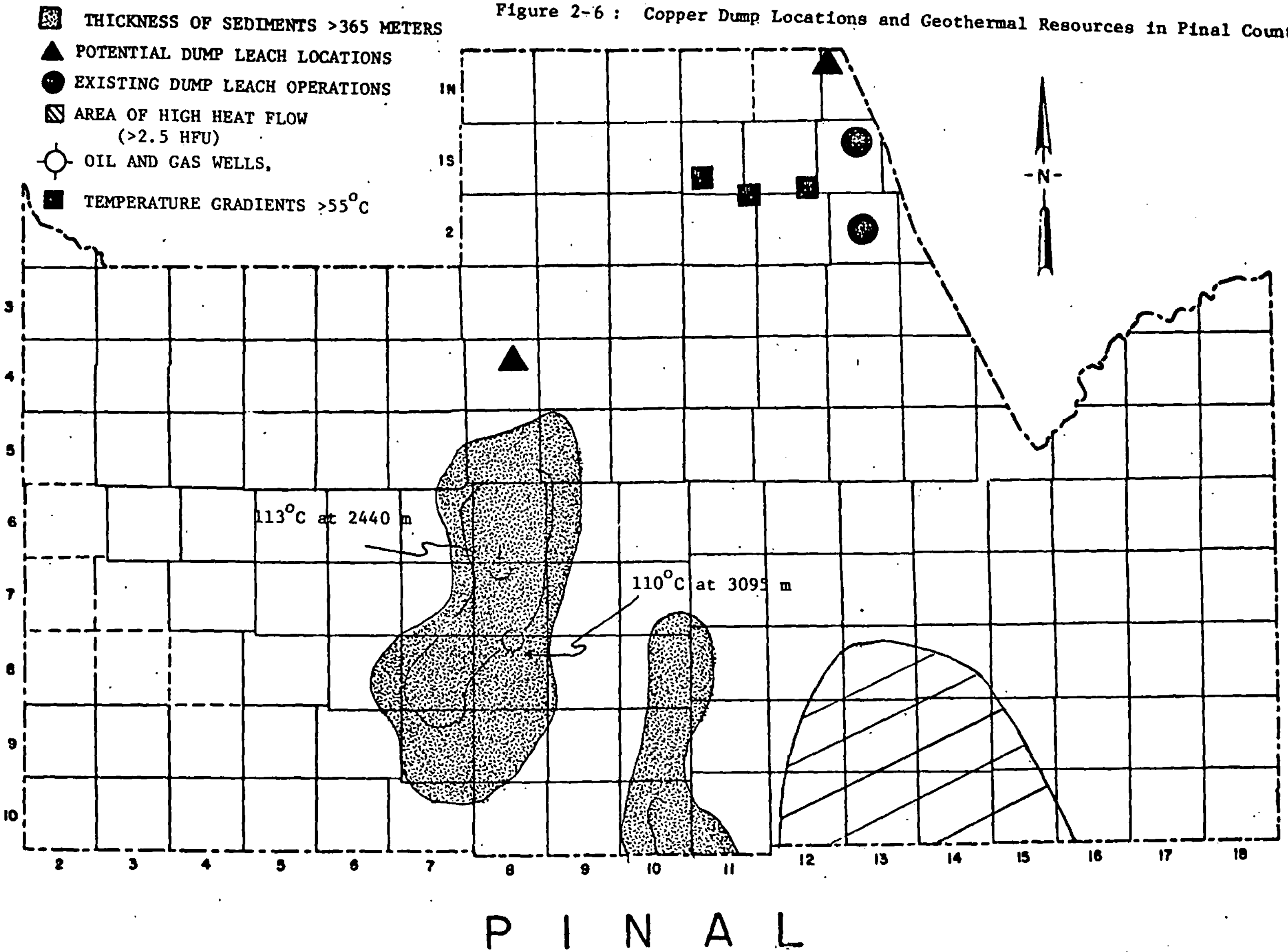


Figure 2-5: Potential for Integration of Geothermal Energy and Copper Dump Leaching.

Figure 2-6 : Copper Dump Locations and Geothermal Resources in Pinal County



between 28 and 38°C/km, about normal for the Basin & Range province within which this ADP lies. One well penetrated over 1.8 km of bedded anhydrite, a rock not favorable for hydrothermal production (evaporites occur from 712 to 2536 meters depth). The floor of this basin lies at the lowest elevation of any basin known in the state, 2,034 meters below sea level.

Situated between Pima and Maricopa Counties, Pinal County exhibits many similarities in growth and climate. The 1979 population of Pinal County is estimated at 91,500. The population is anticipated to grow at a rate of 1.6% per year through the year 2000. Most growth will probably occur within the principal cities of Casa Grande, Apache Junction and Coolidge. Principal industries within the County are farming and ranching copper mining, tourism and manufacturing. As was the case in Maricopa and Pima Counties. Pinal County experiences both annual and daily peaks in electrical demand. A load curve for Pinal County would be similar to those already presented for Pima and Maricopa Counties.

2.3 SITE SPECIFIC DEVELOPMENT PLANS

Based on the recommendations of last year's preliminary study and recent developments in the state; ten site specific development plans (SSDP) were chosen as candidates for further evaluation. It is important to note that none of these proposed applications are under actual development at the present time.

2.3.1 Candidate Geothermal Site Specific Applications

Five SSDPs were completed during this year. The technical, economic, environmental and institutional aspects of each of these five SSDPs were studied. The results of these evaluations are presented in section 2.3.2. The other five SSDPs were evaluated in less detail and are presented in summary form in section 2.3.3. A list of the ten site specific applications is given in Table 2-3. A map showing the locations of the proposed application sites is presented in Figure 2-7.

2.3.2 Completed SSDPs

The five SSDPs discussed in this section were evaluated in detail. The following is a brief summary of the results.

A) Space Cooling & Heating for Williams Air Force Base - Chandler, Arizona

Williams Air Force Base, is located in south-central Arizona, nine miles east of Chandler and 35 miles southeast of Phoenix. During 1979, the Department of Energy along with E.G. & G. Idaho, Inc., Williams Air Force Base personnel and the Resource Advisor of the Arizona Geothermal Planning Team conducted a study on the technical and the economic feasibility of using geothermal energy for space cooling and heating of the base. The resultsof the study were encouraging and the project is being pursued further by the Air Force.

Table 2-3: List of Candidate SSDP'S

Site	Application	Resource Data		Est. of Energy Consumption (MW, 1 year)
		Est. Surface Temp. (°C)	Pot. Usable Energy (MW, 30 yrs.)	
Chandler	Space cooling and heating	184	76	5.3
Tucson (Southeast)	Space cooling and heating	137	22	4.0
Green Valley	District cooling	140	100.2	45
Silver Bell	Copper dump leaching	70	5	2.0
Clifton	Geo. power plant	180		
Miami	In-situ solution mining	90	50	3.0
Springerville	Geo./coal power plant	90	40	3.0
Picacho Mtns.	CAP pumping	130	13	1.0
Casa Grande	Steam turb. pump.	132	10	2.0
Yuma	Citrus concentrate	175	100	1.0

The study prepared by E.G. & G. Idaho Inc., considered three sources of energy (geothermal, solar and coal) to power a centralized unit which could provide space cooling and heating for the base area. The total installed load in the major buildings in the central base area was determined to be 4,300 tons of cooling and 86.5 MMBtu/hr for heating. An economic evaluation was conducted for different scenarios using the three energy sources. The results indicated that one of the geothermal options which required two new production wells was the most cost-effective scenario. The total cost of this project would be about $7,828,000 as opposed to $42,532,500 for a similar solar system. The earliest this project could be included in the Federal budget would be in the year 1981. If approved, environmental assessments and environmental impact statements must be completed prior to the drilling and construction phases.

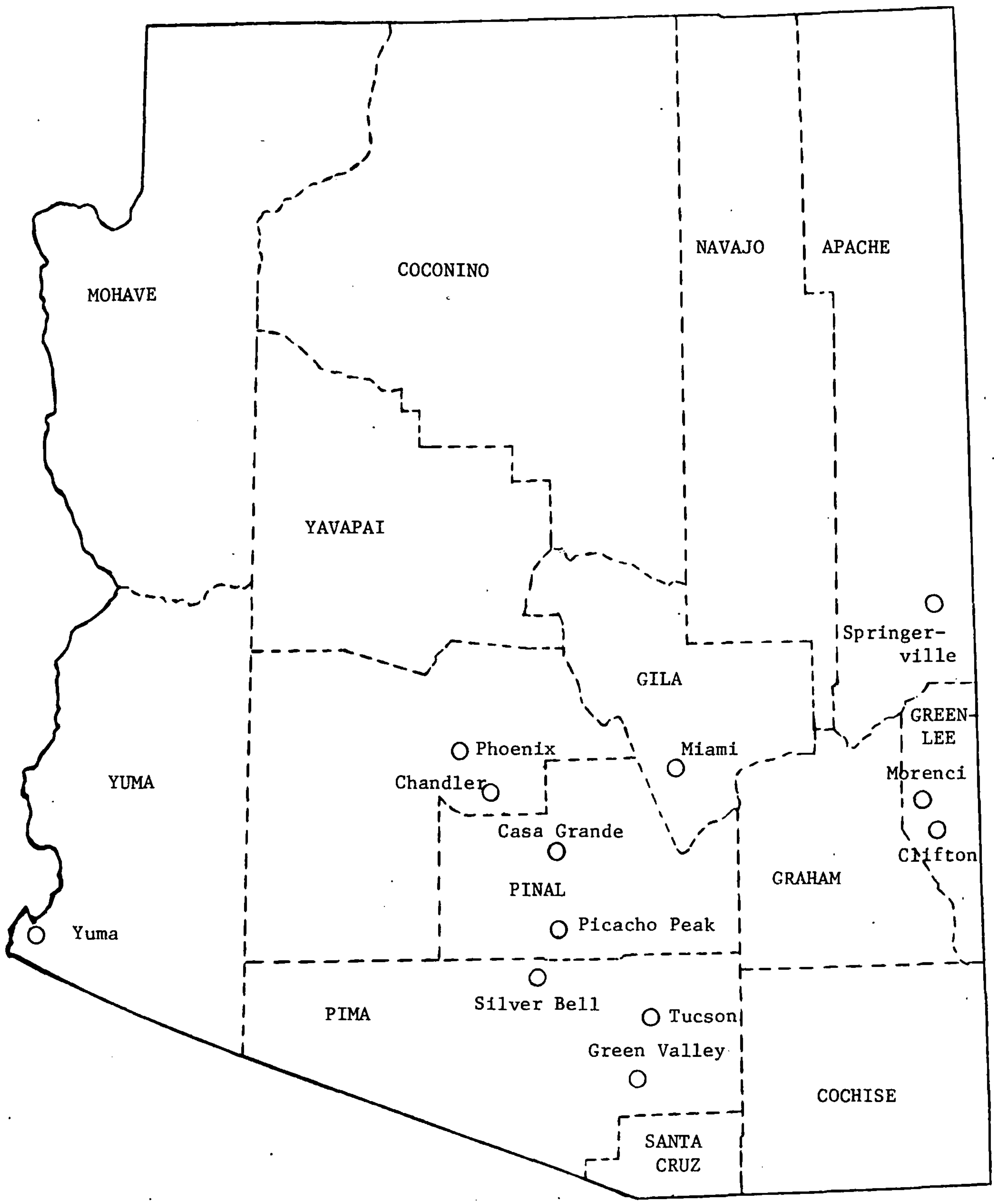


Figure 2-7: Locations of Proposed Application Sites

B) Space Cooling and Heating of an Industrial Complex - Tucson, Arizona

This SSDA considers the feasibility of using a specific geothermal resource to provide space cooling and heating for an industrial complex near the Tucson area. After interaction with E.G. & G. Idaho, Inc. it appears that attitudes are in favor of developing geothermal if studies prove that it will be beneficial from both energy conservation and economics stand points. The required cooling load of the complex is 2700 tons while the heating load is somewhat smaller.

A barrier to geothermal development would occur if this industrial complex chose to drill a geothermal well on private land with federally-held mineral rights. According to Public Law 87-747 (enacted by Congress in 1962), certain private land with Federal mineral rights surrounding the Tucson area (the geographic boundaries are delineated in the law) are withdrawn from subsurface development. This industrial complex falls within this withdrawn area. Consequently, any subsurface drilling would be prohibited on such private land with Federal mineral rights. The earliest construction could feasibly begin would be 1981.

C) District Heating and Cooling - Green Valley, Arizona

Rapid population growth in southern Arizona is triggering the planning and establishment of new communities. For example, in 1961 plans were adopted to establish a community in Green Valley and by the year 1979 the population of Green Valley was 8500. This analysis provides an example of the use of geothermal energy for district cooling and heating for a planned community.

The application site is located on privately owned land, which is presently undeveloped. The water temperature in the reservoir is probably in the range of 123^{o} - 158^{o}C. Each house requires an average cooling load of 170MMBTU/hr. and an average heating load of 30,000 BTU/hr. Under the conditions of our analysis and current energy prices, we could expect the energy on line to occur before the year 1990.

D) Geothermal Assisted Copper Dump Leaching - Silver Bell, Arizona

Arizona is the largest copper-producing state in the nation, accounting for 65% of all domestically produced copper in 1978. Theoretical studies have shown that the rate of extraction of copper increases with the increase in the temperatures of the leaching fluid. The result of this concept of geothermal - assisted copper dump leaching would be a more efficient copper recovery from low grade leach materials.

Silver Bell was chosen for this analysis due to the availabily of data on its mining operations and the compatibility of the geothermal resource. (It should be noted that this application would apply to a number of mining operations in southern Arizona.) Required resource temperatures for this application range from 50°C to 80°C. Heat demand for a theortical dump leach process would be 8.16 MMBTU/hr, with an 80% recovery of copper being desired. Results of an economic evaluation prepared in collaboration with New Mexico Energy Institute shows that an investment tax credit of 10% yields a 20% rate of return in 1987 and a 30% investment tax credit yields a 20% rate of return in 1985.

E) Geothermal Power Plant - Clifton, Arizona

Geologic studies have shown that some geothermal prospects in Arizona are likely to have fluid temperatures above 150°C and might be suitable for use in power production. Two possible locations that seem to have such potential are the Clifton hot springs area and the San Bernardino Valley.

This analysis presents a theoretical evaluation of a hypothetical 50MW geothermal power plant in the Clifton area of Greenlee County. Gross capacity of the power plant is about 61MW. Assuming a heat level of 145,135.8 BTU/sec, and a flowrate of 140,000 kg/hr for each production well, the required number of production wells is sixteen. Two potential barriers to development do exist. First, extensive leasing time would be required due to the mixture of Federal, State, and private land in the area. Second, the Forest Service may designate the area a wild and scenic river which could hinder development.

2.3.3 PARTIALTY COMPLETED SSDP'S

Five SSDP's were analyized and partially completed. Only a brief summary of the results of each SSDP are presented here.

F) Geothermal Assisted In-Situ Solution Mining - Miami, Arizona

During the year 1979, the Arizona Geothermal Team evaluated the feasibility of the integration of geothermal resources with the in-situ leaching of uranium (first priority) and copper (second priority), utilizing the existing sulfuric acid capacity and existing commercial technology of chelating agents in liquid-liquid extraction to recover these valuable metals from very impure solutions.

The main advantages of integration with geothermal energy are as follows:

a. Extraction rate increase with the increase in the temperature of the leaching fluid, thus reducing the overall time required to extract the metal from the ore body.

b. Reduced pollution of the environment.

c. Recovery of metals from low-grade ores, unsuitable for conventional mining.

d. Eliminates the necessity of geothermal reinjection wells.

e. Geothermal energy could be used in some other processes, with the "waste geothermal" then being used for this application.

f. Conserves valuable groundwater in Arizona.

G) Geothermal/Coal Fired Power Plant - Springerville, Arizona

A study of the technical and economic feasibility of combining both geothermal and fossil-fuel energy in a power plant was recently completed by the City of Burbank. This hybrid power plant would have two independent sources of energy, those being geothermal and coal. The main use of geothermal energy would be to pre-heat the feed water to a certain temperature and then coal would be used to convert this preheated feed water to steam. The result of this hybrid power plant would be to conserve coal and obtain an overall efficiency that is higher than the efficiency of both geothermal and coal-fired power plants when operated separately. Future coal-fired power plants are planned for the Springerville and Willcox areas. If proposed sites for future coal-fired power plants overlap significant geothermal anomalies, this concept of combining the two sources of energy may prove to be of paramount importance.

H) Geothermally-assisted Central Arizona Project Pumping

This SSDA involved evaluating the possibility of using geothermal energy to provide the electricity needed in the pumping stations for the Central Arizona Project (CAP). Recently, the U.S. Bureau of Reclamation acquired a 24.3% share (547MW) of the capacity of the Navajo Power Plant in Page, Arizona. As a consequence of this recent action, this proposed geothermal application is no longer feasible.

I) Geothermal Steam Turbine Pumping - Casa Grande, Arizona

Arizona's agriculture is based on irrigation since most of the state has an arid climate, whereby about 90 percent of the rain is lost by evapotranspiration. Thus, most of the irrigation water in use today is ground water stored over the ages. A considerable amount of this underground water is being pumped up to the surface and used. This irrigation requires a substantial amount of natural gas and electricity for pumping. Geothermal energy might be used in some of these agricultural areas to power the pumps.

The use of alternate sources of energy like solar and geothermal energy have been studied in New Mexico and Arizona, and an evaluation of these studies is needed to assess the actual feasibility of such a geothermal application. It is believed that a modified system of one geothermal well serving a larger area of several irrigation pumps might be economically feasible.

J) Integrated Citrus Juice Concentrate/Peak Power/ Irrigation Pumping Geothermal System - Yuma, Arizona

The intention of this analysis was to illustrate in a simplified form an integrated use geothermal system. Basic criteria deemed necessary for the success of this application were defined as part of the analysis. However, due to the inability to fulfill all of the criteria, analysis of this specific application was dropped. It is anticipated that another industry will be chosen in the future for this type of integrated system.

2.4 Time Phased Project Plans

Geothermal projects in Arizona have not yet progressed to this point.

2.5 State Aggregation of Prospective Geothermal Utilization

This section attempts to aggregate all work reported in the previous two sections in terms of energy supply and demand for the reported ADP's and SSDP's. Table 2-4 projects how much energy could be provided by geothermal energy and how much would be demanded under private development for residential and industrial sectors. The supply figures were developed with the help of the New Mexico Energy Institute and reflect their modelling capabilities.

Table 2-4: Projected Geothermal Supply/Demand
(Billion BTU)

ADP	Counties	1979	1985	2000	2020
I	Maricopa	0/143,830	7700/165,440	45300/232570	77100/373,00
II	Pima	0/52,390	0/59,250	816/78,690	6061/116520
III	Graham/Greenlee	0/2296	134/3892	232/4522	3200/5574
IV	Pinal	0/10,897	249/12,370	10,470/16,600	13,150/25930
	Total	0/209,413	8083/240,952	56,818/333,652	99,511/521,024

It should be noted that the supply figures do not include any space cooling, whereas, the demand figures do include space cooling energy consumption.

Table 2-5 presents a summary of energy on line as a result of our Site-Specific Development Plans. It is highly unlikely, due to long lead times, that any of the proposed applications will be on line prior to 1985. However, most would be feasible before 1990.

Table 2-5: Projected Goethermal Energy Supply for Candidate SSDP's (Billion BTU)

SSPD	County	1979	1985	2000	2020
1	Maricopa	0	0	530	795
2	Pima	0	0	335	503
3	Pima	0	0	1775	2700
4	Pima	0	0	71.5	108
5	Greenlee	0	0	4556	6833
	Total	0	0	72,67.5	10,939

It should be noted that a 50% expansion of geothermal systems is assumed after 20 years of operation.

2.6 Institutional Analysis

Arizona State Law broadly defines a geothermal resource to include hot water, hot brines, indigenous steam, heat found in geothermal formations and minerals exclusive of fossil fuels and helium gas which may be present in solutions or in association with geothermal steam (A.R.S. 27-651).

The Arizona State Land Department has statutory authority to designate "known geothermal resource areas" (KGRA's) and to lease State lands for geothermal development purposes through competitive bidding. The Arizona Oil and Gas Conservation Commission regulates the drilling of wells for geothermal development on State, Federal, Indian and private land. The Corporation Commission has regulatory and enforcement authority over public utilities. The Arizona Solar Energy Commission collects, analyzes, and provides information and data relating to solar energy technology and other renewable energy sources.

Several key provisions add an incentive to the commercialization of geothermal as a potential future energy source. First, the State of Arizona does not require environmental assessments and environmental impact statements. Second, geothermal resources are exempt from State water laws due to A.R.S. 27-667 and administrative rulings. Lastly, the State Department of Revenue offers a 27.5% depletion allowance for geothermal resource wells (A.R.S. 42-154) and a deduction from gross income of all expenditures paid for the development of a geothermal resource well (A.R.S. 43-123.30).

2.7 Public Outreach Program

2.7.1 Outreach Mechanisms

An extensive Outreach Program was conducted during CY 1979 within the State of Arizona. The Arizona Geothermal Planning Team's approach to the task of outreach was three-fold. First, numerous phone calls were made to potential developers, potential users, and State officials which served to increase their awareness of the potential geothermal resources in Arizona. Secondly, the Judi Kirby Public Relations Firm was hired with the purpose of assisting the Arizona Geothermal Team (hereby named the Geothermal Project) in a coordinated effort towards educating the public and providing a broader base of understanding of geothermal energy. The third approach to outreach involved the use of all forms of the media and direct meetings with interested State and community leaders. The Arizona Outreach Program was responsible for approximately 25-30 newspaper releases, three television interviews, five radio talk shows, a number of articles published in professional journals and newsletters, speaking engagements at 10 professional meetings, and speaking at the Governor's Commission on Arizona Environment. In addition to these, the geothermal display and sound-slide show have been shown at various places around the state.

The proposed outreach activities for CY 1980 will follow along these same areas with the objective of further stimulating interest in geothermal energy in Arizona. Thirty-second public service announcements are being prepared for use on radio and television stations throughout Arizona. Press releases and feature stories will continue to be disseminated to all statewide media. An attempt will be made to further inform and possibly lobby state lawmakers for favorable geothermal legislation. More speaking engagements are planned with key civic, social, business, and governmental organizations. Also, more outreach work is planned with the public school systems throughout the state. Lastly, approximately three public hearings are planned in conjunction with the U.S. Bureau of Reclamation on a proposed geothermal desalinization plant near Springerville.

2.7.2 Summary of Contacts and Results

The Arizona Geothermal Planning Team has been approached by many individuals and organizations with inquiries relating to the feasibility of some type of geothermal application. The most promising inquiry to date has been Williams Air Force Base near Chandler, Arizona. The Department of Energy in collaboration with E.G. & G., Idaho Inc., Williams Air Force Base personnel and the Resource Advisor of the Arizona Geothermal Planning Team conducted a study on the technical and economic feasibility of using geothermal energy for space cooling and heating. The results of this study were encouraging and the project is being pursued. Another inquiry has come from a major manufacturing company in Tucson interested in the possibility of using geothermal energy for space cooling and heating.

The Arizona State team has been interacting with Mr. Dave Perkins, Greenlee County Manager, on the feasibility of building a small geothermal power plant in the Clifton area. The State team has also been working with a Safford city offical on the feasibility of using geothermal for hog processing. Such a company is considering locating in the Safford area.

In addition to these, the Arizona State Team has been approached by a California man interested in using geothermal water to raise shrimp (aquaculture), a Phoenix home developer interested in using geothermal to district cool and heat a new subdivision of homes, a Phoenix company interested in using geothermal to cool and heat an industrial park, a Phoenix man interested in using geothermal in cottonseed oil processing, a lumber company interested in kiln drying and several mining companies. The Arizona State Team will continue to follow-through on these inquiries during CY 1980.

2.7.3 Overall Prospective for Future Geothermal Activity

Based on the monthly increase in interest since the conception of the geothermal Outreach Program, the Arizona Geothermal Planning Team expects interest to increase during 1980.

2.8 References

2-1 Inside Phoenix 1979 (Phoenix Newspapers Inc., 1979) p. 5

2-2 Pop. Emp. & Income Projections for Arizona Counties 1977-2000, (Dept. of Econ. Security, July 1978), p. 90

2-3 Dept. of Planning, City of Tucson 1979.

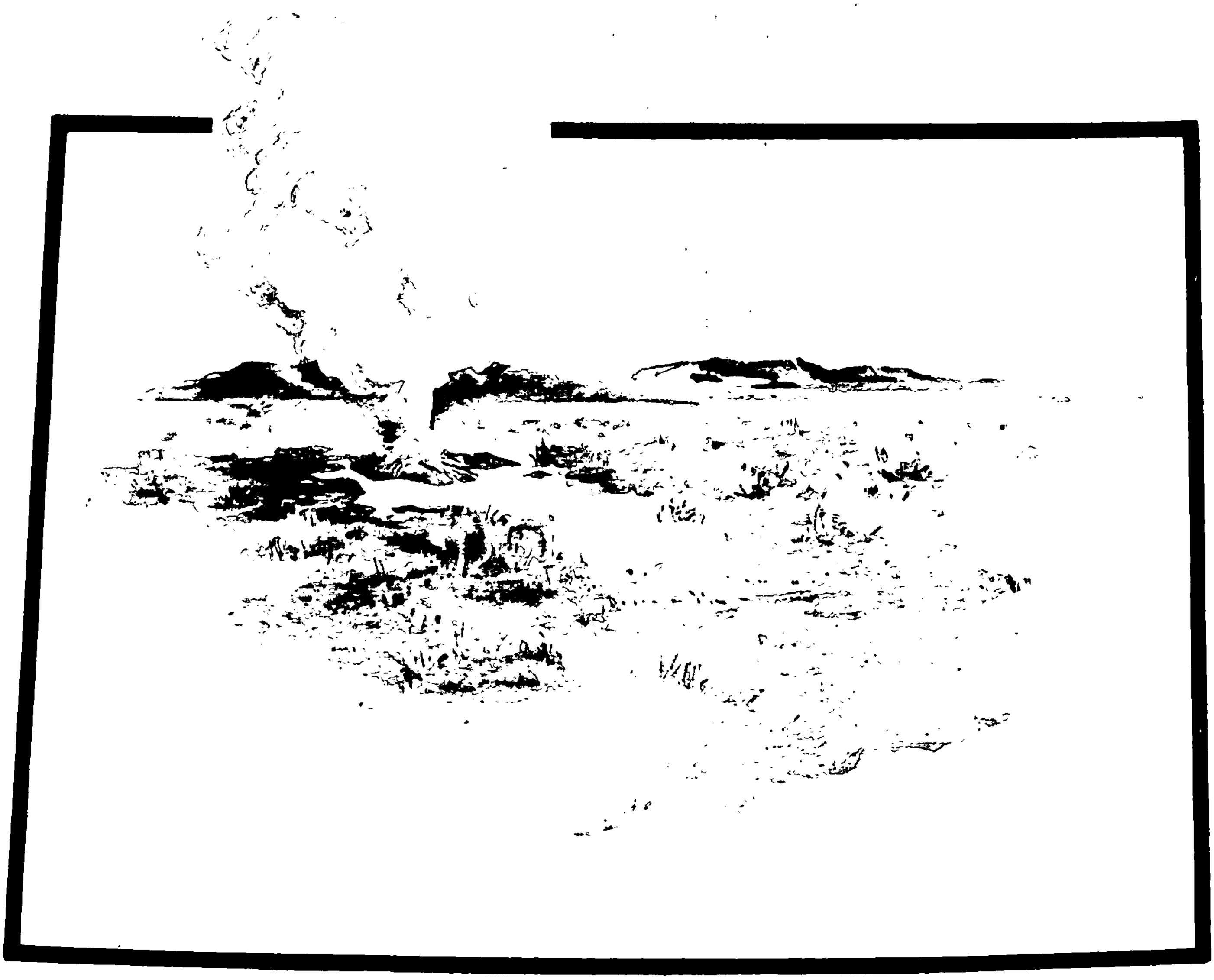
2-4 Sullivan, T.D. "Chemisty of Leaching Chalcocite" U.S. Bureau of Mines, Tech. Paper 473, 1930.

3.0 Summary of Major Findings and Recommendations

In conclusion, a number of significant results have come out of the work of the Arizona Geothermal Planning Team. During 1979, five counties were analysed in detail in order to define their resource characteristics, the nature of their economies, their energy use patterns, and expected growth patterns. Specific applications of geothermal energy arose out of each county's economic and energy use characteristics. These applications were analysed and evaluated for technical and economic feasibility. Further, an institutional handbook was prepared which will aid in the development process. In addition, our work and that of the Arizona Bureau of Geology and Mineral Technology and the Arizona Solar Energy Commission have resulted in private sector interest in geothermal energy and governmental awareness of this potential energy source. As a result, the benefits of geothermal commercialization to the State of Arizona are close to realization.

Chapter 3

Colorado Geothermal Commercialization Project



COLORADO GEOTHERMAL COMMERCIALIZATION PROJECT

SEMI-ANNUAL PROGRESS REPORT

July - December, 1979

Prepared by:

Barbara A. Coe

Colorado Geological Survey
Department of Natural Resources
Denver, Colorado

Work performed under Contract No. DE-FC07-79ID12018
U. S. Department of Energy
Idaho Operations Office

This report describes the accomplishment of the Colorado Team for the Rocky Mountain Basin and Range Geothermal Commercialization Planning Project for the year ending December 31, 1979. The project is funded by the U.S. Department of Energy and the Four Corners Regional Commission. Mr. Richard Pearl, Chief, Groundwater Investigations Section, is the Team Leader for the project.

NOTICE

Acknowledgements

The persons who provided information and assistance leading to this compilation are numerous. Sincere appreciation is extended to all those who participated. A special thanks to Richard H. Pearl, for his freely contributing from his store of knowledge of geothermal resources in Colorado; to Dr. Richard T. Meyer, for his most capable leadership and to Gladys Peters and Becky Andrews for their untiring manuscript typing.

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1.0 INTRODUCTION

The State of Colorado is known to have significant geothermal energy potential Indeed, several successful geothermal facilities are located in the state already. A prior study showed that about 500 megawatts of electricity could be produced in Colorado with geothermal energy and that about 30 communities could use geothermal for their direct thermal energy needs (Coe, 1978).

A more specific indication of the potential was necessary, however, for several reasons. First, tax dollars are allocated by the Federal government to aid the research and development of various energy forms, including geothermal energy. The extent to which the expenditure of public funds is justified depends upon the extent of the probable benefits to the public. In the case of geothermal energy, these benefits are measured in units of energy on line at an affordable price and without intolerable negative impacts.

Secondly, providing ideas and information about the geothermal energy potential may help stimulate local communities, users, and developers to develop a valuable, but so-far virtually-untapped resource. Finally, a description of constraints limiting geothermal energy development was necessary is that recommendations could be made for measures to overcome those constraints. This study was conducted under a contract from the U.S. Department of Energy and the Four Corners Regional Commission.

The approach to conducting this study was a "grass roots" one, initiating dialogues with residents, developers, and key officials in each area to be investigated. The analyses, however, also rely heavily upon published sources for required background information. Quantitative analyses were performed when necessary to forecast or estimate energy demands, population, energy availability, or other elements.

Team members for the project were Richard H. Pearl, Chief, Groundwater Investigations Section, administrator of the project, and Barbara A. Coe, Project Chief. Two research assistants, Nancy Forman and Judy Zimmerman were employed during 1979 to assist with particular investigations and analyses.

2.0 TASK DESCRIPTIONS AND PRODUCTS

The results of several geothermal development analyses that were conducted for the State of Colorado during calendar year 1979 are summarized below.

2.1 Geothermal Prospect Identification

2.1.1 Geothermal Resources - Geothermal prospect identification began with the identification of the geothermal resource sites. A recent inventory located 56 thermal wells and springs in the state. As shown on Figure 1, most are on the western part. Surface temperatures and chemical content of the geothermal fluid at these sites were also recorded (Barrett and Pearl, 1978). Subsurface temperatures, reservoir volumes, and energy content were estimated by Pearl (1979). Some selected data are shown on Table 1. As shown, these hydrothermal systems are estimated to contain between 4 and 13 quads of energy altogether. This is theoretically enough to heat 3,000,000 homes based on an annual demand of 89,000,000 BTU's per home (Coe, 1979). Several additional areas have become known since the inventory was conducted and still others have been reported to CGS personnel, but are not yet verified. The full extent of the hydrothermal resource may be much vaster than is apparent from existing surface expressions and other available data.

2.1.2 Ownership - The ownership of the land under which geothermal resources are located influences the ability to develop the land and the procedures and time required for that development. Federal lands cover more than one-third of the land area in Colorado (Colorado Division of Planning, 1978). Most of the identified geothermal areas are on or near federal property.

2.1.3 Leases - Still another clue to the location of possible geothermal development is the leasing that has occurred. As shown on Table 2, three competitive Federal Leases are active on 5035 acres (Known Geothermal Resource Areas) in Colorado. Twenty-one non-competitive federal leases are active on 28,487 acres (Table 3). On State property, 17 leases are active on 36,471 acres (Table 4).

TABLE 1

Characteristics of Hydrothermal Reservoirs in Colorado

Site	Highest Measured Surface Temperature (°C)	Estimated Probable Subsurface Temperature (°C)	Estimated Probable Heat Content (Btu's x 10^{15})
01 Juniper	38	50-75	.016
02 Craig	39	40-70	.033
03 Routt	64	125-175	.111
04 Steamboat	39	125-130	.049
05 Brads Ranch	42	42-55	.004
06 Hot Sulphur	44	75-150	.070
07 Haystack Butte	28	50	.006
08 Eldorado	26	26-40	.015
09 Idaho HS	46	NA	.171
10 Dotsero	32	32-45	.005
11 Glenwood	51	NA	.038
12 South Canyon	49	100-130	.002
13 Penny	56	60-90	.166
14 Col. Chinn	42	NA	.018
15 Conundrum	38	40-50	.004
16 Cement Creek	25	30-60	.013
17 Ranger	27	30-60	.002
18 Rhodes	24	25-35	.043
19 Hartsel	52	NA	.047
20 Cottonwood	58	105-182	.389
21 Mt. Princeton	56	150-200	1.062
Wright	72	150-200	
Hortense	82	150-200	
Woolmington	39	150-200	
22 Brown's Canyon	25	50-100	.226
23 Poncha	71	115-145	.141
24 Wellsville	33	35-50	.009
25 Swissvale	28	35-50	
26 Canon City	40	NA	.003
27 Fremont	35	35-50	.010
28 Florence	28	35-50	.008
29 Don K Ranch	28	NA	.035
30 Clark	25	25-50	.008
31 Mineral	60	70-90	.949
32 Valley View	37	40-50	.056
33 Shaws	30	30-60	.015
34 Sand Dunes	44	NA	.155
35 Splashland	40	40-100	.155
36 Dexter	20	20-50	.034
37 McIntyre	14	20-50	
38 Dutch Crowley	70	70-80	.026
39 Stinking Springs	27	40-60	
40 Eoff	39	40-60	.017
41 Pagosa	58	80-150	.023
42 Rainbow 40	40	40-50	.047

TABLE 1 CONT.

Site	Highest Measured Surface Temperature (°C)	Estimated Probable Subsurface Temperature (°C)	Estimated Probable Heat Content (Btu's x 10^{15})
43 Wagon Wheel Gap	57	NA	.063
44 Antelope	32	35-52	.011
45 Birdsie	30	35-52	
46 Wannita	80	175-225	.061
47 Cebolla	40	NA	.070
48 Orvis	52	NA	.028
49 Ouray	69	70-90	.226
50 Lemon	33	NA	.015
51 Dunton	42	50-70	.007
52 Geyser	28	60-120	.007
53 Paradise	46	NA	.023
54 Rico	44	NA	.174
55 Pinkerton	32	75-125	.010
56 Tripp/Trimble	44	45-70	.036

SOURCES: Barrett and Pearl, 1976 and Pearl, 1979.

TABLE 2

FEDERAL ACTIVE COMPETITIVE GEOTHERMAL LEASES AS OF AUGUST, 1979
(KGRA'S)

LESSEE	ACRES	TOWNSHIP & RANGE	DATE ISSUED
The Anschutz Corporation	915	49 N, 8 E	1975
Phillips Petroleum Company	2484	45 N, 8 E	1975
Phillips Petroleum Company	1636	45 N, 9 E	1975
	5035		

*Designated Known Geothermal Resource Areas by Federal Government

SOURCE: Bureau of Land Management, Denver, Colorado

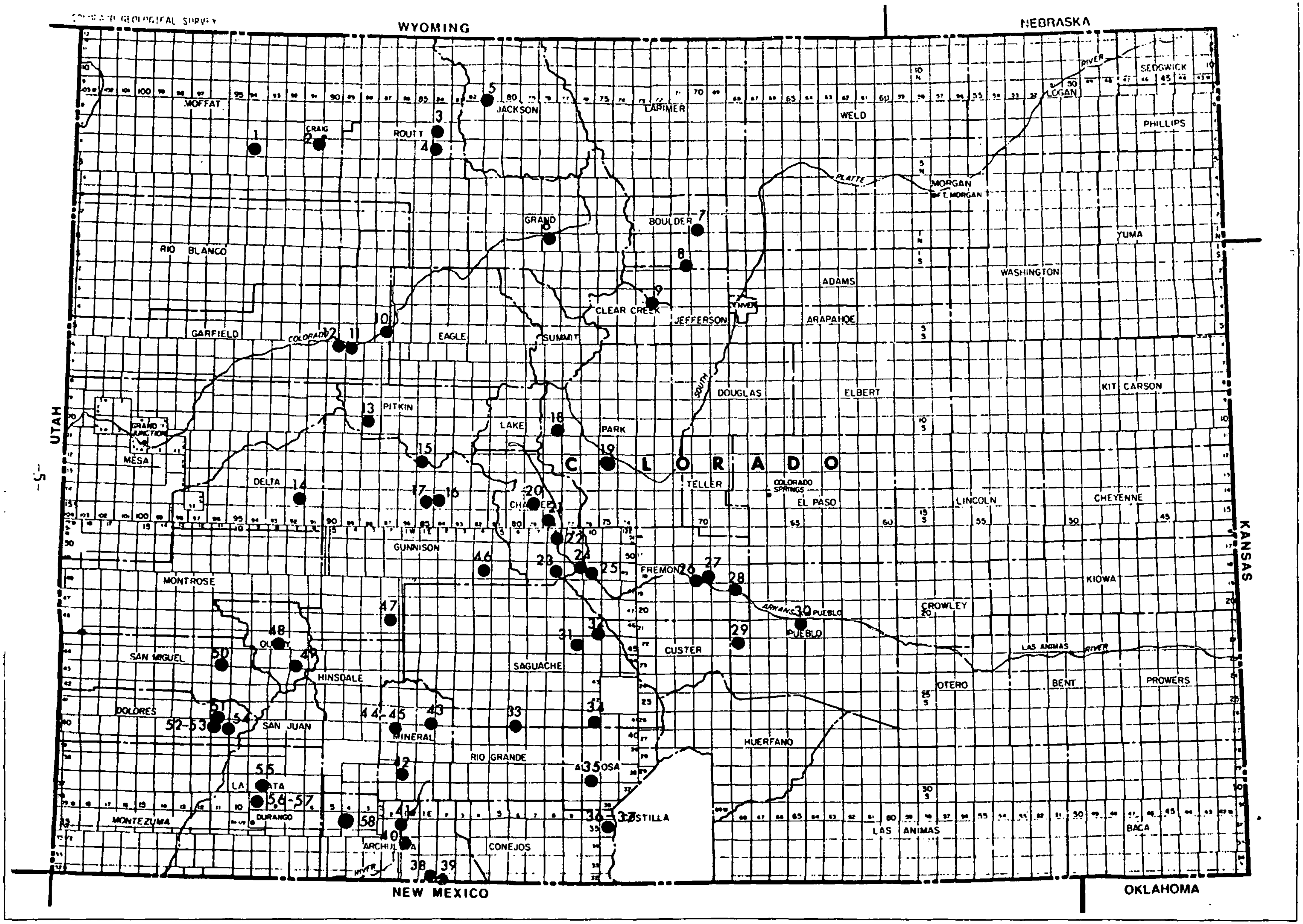

Figure 1.--Location of thermal springs and wells in Colorado. Numbers identify thermal areas.

Among the 56 sites inventoried in Colorado, potential for electrical power generation may exist at 3 sites according to representatives of the energy companies holding leases at Poncha Springs, Chalk Creek, and Cebolla. These representatives indicate that high temperatures had been inferred from some preliminary exploration data at these three sites.

The inability to obtain leases on National Forest lands for which applications were submitted in 1974 has stymied exploration in at least two areas, Chalk Creek and Poncha Springs. The U.S. Forest Service has been preparing an environmental assessment report for the Chalk Creek area (William Dolan, pers. comm.).

In one area, Cebolla, necessary leases on private land have been thus far unobtainable (David Butler, pers. comm.). If leases were issued, exploratory wells could be drilled and the potential of these areas further defined.

These potential power generation sites represent only a small part of the geothermal development potential. Because of the low and moderate temperatures of the geothermal resources in Colorado, the greatest potential for use of the energy is for direct uses, such as those shown on Table 5.

To put the energy to use, a market is required. Several criteria identify potential geothermal market areas. The first of these is the location of the residents in Colorado.

2.1.4 <u>Demography and Economic Conditions</u> - Major population centers in Colorado are along the Front Range of the Colorado Rocky Mountains in the central part of the State. However, 23 communities are within 10 miles of inventoried geothermal sites and 16 are virtually on site (Coe, 1978).

As Table 6 shows, the largest employment sector in the State is wholesale and retail trade, with government next and services third. All categories except agriculture show an increase in employment from 1970 to 1977. Service categories reflect the strong emphasis of tourism in the State. Determining the industries relevant to direct use of geothermal energy requires the examination of the industrial patterns and potential near geothermal resource areas.

TABLE 3
FEDERAL ACTIVE NON-COMPETITIVE GEOTHERMAL LEASES
IN COLORADO
August, 1979

LESSEE	ACRES	TOWNSHIP & RANGE	DATE ISSUED
Buttes Resources Company	781.32	46 N, 2 W	1977
	2,226.88	46 N, 1 & 2 W	1977
	1,804.57	46 N, 1 W	1977
	1,040.04	46 & 47 N, 2 W	1977
	1,970.30	46 & 47 N, 2 W	1977
Chevron Oil Company	1,867.94	46 & 47 N, 2 & 3 W	1977
	2,127.56	46 & 47 N, 3 W	1977
	645.74	47 N, 3 W	1977
Earth Power Corporation	1,000.00	46 N, 10 E	1976
Geothermal Kinetics, Inc.	1,000.00	37 N, 12 E & 38 N, 13 E	1975
	1,106.00	29 W, 73 W	1975
	827.31	38 N, 13 E & 29 S, 73 W	1975
	1,042.47	29 S, 73 W	1975
Occidental Petroleum	80.00	49 N, 8 E	1975
	1,280.00	49 N, 3 E	1975
	2,113.30	49 N, 7 & 8 E	1975
	1,286.17	51 N, 8 E	1975
Phillips Petroleum Co.	320.00	46 N, 10 E	1975
	1,120.00	45 N, 10 E	1975
	1,644.50	46 N, 10 E	1975
	329.50	46 N, 11 E	1975
	28,487.51		

SOURCE: Bureau of Land Management, Denver, Colorado

TABLE 4

COLORADO STATE ACTIVE GEOTHERMAL LEASES
AUGUST, 1979

LESSEE	ACRES	TOWNSHIP & RANGE	COUNTY
General Geothermal, Inc.	9,639.90	41 N, 6 E	Saguache
		45 N, 9 E	
		46 N, 10 E	
	8,183.33	39 N, 11 E	Alamosa
		40 N, 12 E	
	360.00	49 N, 8 E	Chaffee
	640.00	35 N, 2 W	Archuleta
	640.00	12 S, 75 W	Park
	480.00	11, 12 S, 75, 76 W	
	560.00	35 N, 1 W	Archuleta
Occidental Oil Co.	640.00	49 N, 4 E	Gunnison
Petro-Lewis	2,004.85	14 S, 78 W	Chaffee
	3,692.31	15 S, 78 W	
	1,280.00	15 S, 78 W	
		14 S, 79 W	
	3,226.61	50 N, 8 E	
	1,560.00	49 N, 7 E, 9 E	
		50 N, 8 E	
	40.00	14 S, 78 W	
Phillips Petroleum	1,764.40	48, 49 N, 4, 5 E	Gunnison & Saguache
Underwood, C. A.	640.00	46 N, 10 E	
			Conejos, & Saguache
	1,120.00	33 N, 8 E	
TOTAL	36,471.40		

TABLE 5
SOME POTENTIAL USES FOR GEOTHERMAL RESOURCES IN COLORADO

SPACE HEATING AND COOLING	MILK CHILLING AND PASTEURIZATION
WATER HEATING	MUSHROOM GROWING
REFRIGERATION	SODIUM CHLORIDE PRODUCTION
BIOMASS PROCESSING	SOIL STERILIZATION AND WARMING
FEEDLOT AND LIVESTOCK PEN WARMING	MINERAL EXTRACTION AND PROCESING
CROP DRYING	WOOL DRYING
FISH FARMING	TROPICAL GARDENS
FRUIT AND VEGETABLE AND FREEZE-DRYING	GREENHOUSE HEATING
WOOD PRODUCTS AND CHEMICALS MANUFACTURE	LUMBER CURING
PAPER AND PULP MANUFACTURE	BATHS AND SWIMMING POOLS

TABLE 6

STATE OF COLORADO ANNUAL AVERAGE EMPLOYMENT DATA*

	Resident Labor Force		
	1970	1975	1977 (estimate)
Total Employment	873.4	1,088.8	1,158.8
Agriculture	55.5	50.2	50.0
Mining	8.8	18.3	22.1
Contract Construction	40.1	56.8	55.8
Manufacturing	117.7	134.9	145.7
Transportation & Public Utilities	51.6	59.8	63.0
Wholesale and Retail Trade	173.1	236.2	255.4
Finance, Insurance & Real Estate	39.3	56.1	61.1
Services	135.1	183.3	204.0
Government	165.6	210.2	218.2

(totals will not add due to rounding & omission of "other" category)

*All numbers are in thousands.

Source: Research and Analysis Section, Colorado Division of Employment and Colorado Business/Economic Outlook Committee (from Colorado Division of Planning, 1978.)

Most of the prime agricultural land in Colorado lies in the eastern plains. Agricultural areas are, however, scattered around the West Slope and concentrated in the San Luis Valley, in south central Colorado, an area that seems to have especially high potential for agricultural processing (Colorado Division of Planning, 1978). Other areas where production levels are sufficiently high to warrant plant construction may have such potential as well. Additionally, if sufficient timber continues to be produced from National Forests, manufacture of wood products could offer an opportunity for use of geothermal energy.

Manufacturing is another significant industry in Colorado. Almost two-thirds of the 245 new industries that were announced between 1970 and 1976 were planned for the Front Range, however, with about 92 percent located near a community of 20,000 population or more (Colorado Division of Planning, 1976). Most communities near geothermal areas in Colorado are much smaller. However, where small communities such as Ouray are attempting to encourage the initiation of light industrial units, geothermal energy has a potential industrial market, (George Gault, pers. comm.).

Construction also contributes significantly to Colorado's economy. New structures can accommodate geothermal energy more economically than can existing ones. Several major construction sites planned near geothermal sites are stimulated by recreation and energy demands.

Colorado is rapidly becoming an energy resource center. Extensive deposits of coal, uranium, and oil shale, as well as some oil and gas, are found in the State, with much of the energy fuels and metallic minerals reserves located near geothermal areas. Population influxes generated by development of these resources require expansion of utility systems including heating. Use of the geothermal energy for heating in such areas as Gunnison County can help alleviate negative socio-economic impacts of energy and mineral development.

Probably the best known economic resources in Colorado, however, are its environmental features that attract both permanent settlers and visitors. In particular, forested mountains with 54 peaks over 14,000 feet high attract outdoor recreation activities including hiking, fishing, hunting, skiing, boating, and sight-seeing. Many communities, especially on the Western Slope, rely heavily upon tourist dollars (Division of Planning, 1978). Lodging and food establishments require large amounts of heat and hot water. Communities such as Durango, Pagosa Springs, Ouray, Steamboat Springs, and Glenwood Springs seem to afford good opportunities for commercial use of geothermal energy as well as accompanying residential use.

Historical and existing economic patterns are not the only determinants of probable economic development. However, those conditions that led to current patterns are not likely to change dramatically. The Federal land ownership, rugged terrain, short growing seasons, and remoteness, as well as the interest in retaining the existing environment, preclude the development of major industrial complexes in many Western Colorado communities. Some scattered, small industrial and agricultural facilities will, however, afford opportunities for industrial use of geothermal energy.

2.1.5 Interest - Interest in use of the geothermal energy is another key indicator of potential prospect areas. Table 7 shows the geothermal development activity that has been identified during the past year. Inquiries have been made about some additional areas.

2.1.6 Geothermal Energy Demand - Finally, a primary indicator of the market demand for geothermal energy is price. Preliminary economic studies showed that in 22 communities in Colorado geothermal energy will be competitive with natural gas by the year 1985 and that by the year 2020, in 165 cities geothermal energy will be competitive. Furthermore, cities such as Idaho Springs, Hot Sulphur Springs, Ouray, Pagosa Springs, and Steamboat Springs could develop the energy right now for less than the cost of their alternative sources, according to the studies (Cunniff, et al, 1979).

2.2 Area Development Plans

2.2.1 State Geothermal Planning Areas - An area development Analysis was completed during calendar year 1979 for the San Luis Valley Region in south central Colorado. It includes the six counties of Alamosa, Conejos, Costilla, Mineral, Saguache, and Rio Grande.

2.2.2 Area Development Plan - The analysis for the San Luis Valley Region showed that unlike most areas of the State, a primary potential use is

TABLE 7

GEOTHERMAL DEVELOPMENT ACTIVITY IN COLORADO

Site	Suggested Use	Activity
07 Haystack	Greenhouses	Engineering and feasibility study
08 Eldorado	Pre-heat for lodge	Information collection
09 Idaho HS	District heat	Investigate source of funds
10 Dotsero	Highway snow melting	Drilling thermal gradient holes
13 Penny	Clinic and greenhouse heat	Drilling well
23 Poncha	Agribusiness	Leases obtained, seeking funds for exploration
26 Canon City	Prison space heat and processing	Soil mercury and geophysical tests by CGS
31 Mineral	Swine pen heat and methane production	Developing facilities
41 Pagosa	District heat	Preliminary engineering Has DOE/cost-share contract
50 Ouray	District heat and commercial and industrial use	economic development consultant is seeking funds
55 Pinkerton	Heat boarding school	Consulting system with DOE grant
56 Trimble	Heat lodge and district heat	Property purchased, preliminary planning with private funds
Non site specific	Alcohol and agriculture	Site investigation

agribusiness. Current uses of the energy such as livestock pen warming and agriculture could be expanded and new uses such as greenhousing and agricultural processing could be introduced. The primary challenge is to locate prospective entrepreneurs who will establish these kinds of facilities. Residential and commercial space and water heating fuel could be supplied as well. Development of such systems is also limited by the lack of funds and by the lack of homeowner interest in conversion. Were funds available and savings in energy costs demonstrated, communities in the San Luis Valley could develop geothermal energy estimated to be as much as 450×10^{10} Btu's.

2.3 Site Specific Development Plans

2.3.1 Candidate Geothermal Sites/Applications - During the calendar year 1979, scenarios were prepared for all hydrothermal sites that had been identified in Colorado. As detailed data were obtained, more detailed analyses were prepared for some sites. Sites were chosen because some initial development activities, such as preliminary investigations and attempts to obtain funds and technical assistance were apparent.

2.3.2 Site Specific Development Analyses - Site specific development analyses were prepared for four sites, Glenwood Springs, Idaho Springs, Ouray and Durango. Analyses show a high potential geothermal energy demand for commercial and residential space and water heating.

All four cities have active tourist and recreation industries, with large numbers of motels, restaurants, resorts, and retail stores relative to their populations. Commercial energy consumption is nearly 100 percent of the residential consumption or 50 percent of the total consumption rather than the 80 percent of residential or 40 percent of the total found statewide (Public Utilities Commission, 1977). Geothermal energy could supply most of these thermal energy demands.

Preliminary economic analysis estimated that these cities could develop a geothermal heating district for as little as $2.49 per million Btu, which compared favorable with the cost of natural gas. (Cunniff, et al, 1979). three of the four sites, Glenwood Springs, Idaho Springs and Ouray, the lack of funds not only for development but even for feasibility studies and reservoir confirmation is stalling development. In the Durango location, the Timberline Academy is installing a geothermal system with the help of a small DOE grant.

2.4 Time Phased Project Plans

2.4.1 Active Demonstration/Commercialization Projects - Two geothermal sites in Colorado are currently being developed. One is the Mineral Hot Springs site in the San Luis Valley where Weisbart's Inc. is constructing a geothermally-heated swine pen for 30,000 head of swine, as well as a methane plant to produce methane for operating a power generator (Gary Weisbart, pers. comm.). The complex is expected to be in operation at Mineral Hot Springs during 1980.

2.4.2 Time Phased Project Plans - The other project is the Pagosa Springs project, for which a Time Phased Project Plan for Pagosa Springs was prepared during calendar year 1979. Funds were obtained from DOE to help finance a district heating system to heat about 60 buildings in the Pagosa Springs central business district. The plan for Pagosa Springs describes the planned, proposed and potential geothermal development and a possible development schedule. Although the primary energy demand is for residential and commercial uses, some potential industrial and agricultural uses of geothermal energy include a timber kiln, greenhouse heating and agriculture. Approximately 5×10^{10} Btu's of geothermal energy are expected to be on line by 1981, including the existing development in Pagosa Springs.

The geothermal program funded by DOE was instrumental in stimulating development. With the help of DOE funding, Pagosa Springs is now designing its district heating system. It is highly improbable that the City would have progressed this far were it not for DOE programs.

2.5 State Aggregates of Prospective Geothermal Utilization

Following is the amount of geothermal energy that is currently estimated to be developable in Colorado by the year 2020. These estimates will be revised as more information becomes available.

TABLE 8

Electric Power Generation Sites

Site	Potential Energy on Line by the Year 2020
Chalk Creek 21	100 MWe
Poncha Springs 23	200 MWe
Cebolla 47	200 MWe
	500 MWe

Direct Thermal Sites or Areas

	10^{10} Btu's
San Luis Valley #31/32/33/34/35/36-37/43/44/45	422.0
*Pagosa Springs #41	189.0
Glenwood Springs #11	129.0
Hartsel #19	4.0
Waunita #46	12.0
Routt/Steamboat #3,4	25.0
Hot Sulphur #6	14.0
Haystack Butte #7	3.0
Eldorado #8	2.0
Idaho #9	8.0
Ouray #49	15.0
Dunton/Geyser/Paradise #51,52,53	5.0
Juniper/Craig #1,2	12.0
Brand's Ranch #5	.7
South Canyon #12	2.0
Penny #13	10.0
Colonel Chinn #14	4.0
Cement Creek/Ranger #16,17	3.0
Wellsville/Swissvale #24,25	2.0
Canon City, Fremont #26,27	3.0
Don K. Ranch, Florence #28,29	19.0
Clark #30	2.0
Wagon Wheel Gap #43	4.0
Orvis #48	6.0
Rico #54	4.0
Pinkerton/Mound #55	2.0
Tripp/Trimble #56	7.0
TOTAL	909.7

2.6 Institutional Analysis

During 1979 the state, local and federal laws and regulations that govern geothermal energy development in Colorado were investigated. They are described in the institutional handbook entitled, The Regulation of Geothermal Energy in Colorado. (Coe and Forman, in prep.).

2.7 Public Outreach Program

2.7.1 Outreach Mechanisms

2.7.1.1 Existing - The outreach program was designed to help accelerate geothermal energy development. The following methods for promoting the use of geothermal energy in Colorado were used.

Media Publicity - news media, including TV, radio, newspapers, and business weeklies provided coverage.

Meetings and Telephone Interviews - Meetings with groups or individuals as well as telephone conversations were held to describe the energy, potential development activities or related topics. Information interchange was emphasized. Meetings or interviews included those with industry, government agencies and communities, and individual users.

Lectures - Formal talks concerning the geothermal resource potential were presented on several occasions. Such talks provided contacts with a specialized group, and at the same time included an opportunity to obtain feedback.

Displays, Brochures, and Papers - Brochures were prepared and widely distributed to county officials, energy fairs, other energy offices, and individuals. A display showing resource areas, equipment, and uses was shown at energy fairs. Papers discussing the potential for geothermal development were submitted to various organizations and publications. A list of contacts and results is found in Appendix A.

2.7.1.2 Recommended Mechanisms - Since media presentations reach the largest number of people, increased emphasis in the form of more frequent releases is suggested. Meetings, too, are especially helpful in that questions can be answered and feedback obtained regarding the acceptance of geothermal energy, the level of development interest, and constraints to development.

Lectures and talks are especially beneficial, since large audiences can be reached and at the same time, feedback can be obtained, emphasis on reaching industrial and professional groups is recommended.

2.7.2 Overall Prospectives for Future Geothermal Activity

Investigations and discussions concerning geothermal energy indicate that the interest in development is likely to continue to grow. If constraints can be lifted, several opportunities for geothermal development are obvious. If additional leases can be obtained, three areas--Mt. Princeton, Poncha Springs, and Cebolla--may be further explored, possibly resulting in the construction of power plants. Recreation-and tourism-oriented communities may use geothermal energy to supply both high commercial and residential demands for space and water heating. The San Luis Valley may develop an extensive agribusiness complex using geothermal energy. High-growth areas that are stimulated by either recreation or energy development may develop geothermal energy to help reduce energy costs and restrain the burden on traditional energy supplies. Furthermore, geothermal energy may encourage new industry to locate in rural areas.

3.0 SUMMARY OF MAJOR FINDINGS AND RECOMMENDATIONS

3.01 Findings - This study reveals geothermal energy development opportunities in Colorado, current constraints to that development and ways those constraints might be removed.

Colorado does have geothermal energy potential. Although additional resource areas will be discovered and more information about known ones compiled, the 56 sites already inventoried contain from 4 to 13 quads of energy (Pearl, 1979). Several areas in Colorado have active geothermal leases, and if additional leases in those areas can be obtained, further exploration and development can occur.

Because of the low and moderate temperatures, the greatest potential for development of geothermal energy in Colorado is for direct thermal uses. At least 23 small communities within 10 miles of geothermal resource areas could use the energy. Some opportunities for industrial use of geothermal energy are apparent. A few small manufacturing plants are found near already-identified geothermal resource areas. Agriculture and extractive industries can use geothermal energy in such areas as the San Luis Valley and in timber, energy and mineral resources areas.

The prime opportunity for development of Colorado's geothermal areas is, however, tourism and recreation. High demands for hot water and space heating of motels, restaurants, and resorts could stimulate development. Areas of high population growth generated by energy extraction afford an opportunity to develop geothermal energy, too, without the burdensome costs of retrofitting.

Interest has been shown in geothermal development in at least 22 areas in Colorado. The bulk of the interest has come from potential users, either individuals, small businesses, or communities. Most share one constraint--the lack of funds. Communities have bonding limits and political constraints upon obtaining loans. More importantly, their needs are large relative to their revenues. For many needs, communities rely upon federal grants or revenue sharing. Small business and prospective individual users generally lack the means to generate sufficient front-end capital. Interest is keen from both private and public prospective geothermal energy users in grant funds for development of geothermal energy for direct use, but few sources have so far been available.

A second constraint is the lack of information. Numerous requests are heard for technical assistance including assessments of the economic feasibility of development and the capacity of the geothermal reservoirs. Lacking sufficient information, prospective users cannot or will not risk large capital outlays. They would be more likely to obtain capital for construction if economic and resource information were available.

Also, geothermal energy has lacked extensive publicity. Among the general population as well as high-level decision makers, the words "geothermal energy" have seldom been heard.

Technological problems, especially problems resulting from corrosion and scaling, have discouraged development in the past. Information that new methods are available for dealing with those problems must be disseminated, often to skeptical audiences. Site-specific conditions often require site-specific system designs and treatments, adding to the complexity and cost of development.

Large energy companies who have the expertise and capital to develop these resources have shown little interest in them. The primary reason for this lack of interest is the apparent lack of opportunity to obtain a sufficient total return on investment. While a prospect may be economically feasible, it may not be sufficiently profitable. Widespread energy company interest in direct use of geothermal energy is deterred, too, by the need to market and distribute the energy.

Some small geothermal development companies have been formed and are focussing on areas with potential for agricultural or industrial processing or large commercial uses. Investment capital for their projects has not been readily available (Jay Dick, pers. comm.).

Although new construction offers a good opportunity to introduce geothermal energy, builders so far apparently lack interest or fail to perceive financial gains resulting from geothermal development.

To summarize, energy developers show some interest in geothermal development for agricultural, industrial and some large commercial uses. The economic incentives may not be sufficient to stimulate their development of geothermal district heating systems. Energy users, both private and public, who can save money on their energy bills, are one group that could be helped to develop the energy. Public or quasi-public entities lack front-end funds but could repay investments in new heating systems through utility bills. Builders might also be encouraged to develop geothermal energy through sufficient incentives. In both cases, engineering and economic feasibility studies and reservoir confirmation drilling to reduce the uncertainty may be the critical missing factors.

3.02 Recommended Actions - A number of actions are recommended to eliminate or alleviate geothermal development barriers or to provide incentives to geothermal development.

1) Issuance of federal leases to encourage further exploration of potential high temperature sites.

2) Stimulation of geothermal exploration by providing technical and financial assistance for preliminary evaluations and reservoir confirmation. This could

show that indeed the energy is available for use. Such efforts should, however, be concentrated in areas that have the highest market potential for the energy.

3) Increased levels of preliminary engineering assistance could help reduce the uncertainty among potential users about the use of geothermal resources, especially where mineralization is considered to be a problem. Such studies could help encourage subsequent private or other non-DOE or non-federal investment.

4) The mention of the words "geothermal energy" in national energy plans, energy speeches by high-level officials and national educational programs could establish geothermal energy in the minds of the general public as a legitimate and useful resource.

5) Expanded funding of federal geothermal programs could assure the widespread development of the energy resources. Were grant funds to be widely available not only for demonstration projects but for development of more tested uses as well, there is little doubt that geothermal energy development would be accelerated.

If research and development programs, especially for economic studies and reservoir confirmation were expanded, or redirected to the highest market potential areas, greater geothermal development could indeed be stimulated. By thus enhancing the acceptability and visibility of the energy resource, and reducing the uncertainty, future development could be spurred. Given the current scarcity of private or public funds for either exploration or development, geothermal energy is likely to continue to lie dormant while other resources with greater development incentives will capture the attention of energy developers.

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APPENDIX A

SUMMARY LISTING OF CONTACTS AND RESULTS

Contact	Prospective Application	Comments
INDUSTRY		
Eaton Develop. Corp., Archuleta County	heat commercial facilities, including athletic center	Interested, but construction will start soon. Have natural gas. Could convert later, after use demonstrated.
Denver Business Week	general	article in weekly
Denver Business World	general	article in weekly
Rocky Mountain Journal	general	article in weekly
Riverbend Estates, Development	heat homes	said would drill here, but have not yet
Petroleum Information Denver, Colo.	general	report on geothermal activities
Willard Owens, Consultant Wheatridge, Colo.	heat homes in new subdivision	doing feasibility study for heat-pump application
Hazen Resources Golden, Colo.	general	Discussed geothermal resource potential in Colorado.
Grand Junction Sentinel Grand Junction, Colo.	general	
Indian Springs Resort (in town of Idaho Springs)	heat resort	Got tech assistance from EG & G. May not be economical to develop.
Landowner, Chaffee County	general	interested in value of geothermal resource
Public Service Company of Colorado	general	interested in possible involvement for PSC
Acme Plumbing & Heating	space heat	Do hot water and heat pump systems. Could do geothermal.
Coury & Assoc. Lakewood, Colo.	agribusiness, San Luis Valley, space heat, Pagosa Springs	Coordinate efforts to encourage geothermal development.

Lawrence Ross, Consulting Engineer	heat Glenwood Springs bank	may submit PRDA proposal
Energy Materials, Inc.	general	have plastic pipe useful in geothermal systems
Rudy Bear Durango, Colo.	resource information	owns Trimble springs, will develop resort, probably distribute energy to wide area, ultimately
Tony Sarver Durango, Colo.	space and water heat for houses in new subdivision (Rockwood Estates)	building near Pinkerton Hot Springs north of Durango
Art Pringle	agribusiness, space heat for new town	resort owner, wants to expand energy use
Clark Millison, Consulting Geologist Colorado Springs, Colo.	district heat	did review of Glenwood Springs geology
Whetstone, Inc., builders	heat homes	interested, need information about resources, grants
LOPA Hydrotheraphy	heat additional structures	need engineering help, grant
Stan Wadsworth, Tamarron Resort	space and water heat for resort, condos	has forced air heat with electrified source
Rico Argentine Mine Rico, Colo.	mineral extraction, heat company homes	Interested in developing. Have wells already. Mine and mill may be sold. Cannot invest money until option is either exercised or dropped.
John Schenk Glenwood Springs, Colo.	new luxury condos	building in Glenwood Springs, have well with 68°F water at 50 feet
Solar Pathways	district heating	might submit PRDA
Dr. Barnarr Johnson Carbondale, Colo.	health resort, clinic uses	owns Penny Hot Springs, needed direction to proceed

<u>AGRIBUSINESS</u>

Gary Weisbart Mineral Hot Springs	swine houses, methane, plant, fish culture	constructing pens, having engineering done for methane plant

Doug Sutton	greenhouse	need front-end funds
Vicki Hays Pagosa Springs, Colo.	greenhouse	need front-end funds
Executive Director, Colorado Flower Growers Association.	heat greenhouses	said studied previously, not feasible
Cindy Warner, Carnation Grower	heat greenhouse	Said energy problem, but energy conservation measures help. Said imports are a bigger problem.
Rainbow Trout Farm	fish culture	Said market good for catfish. Trout need low temperature water. Their trout market is primarily for stocking.
Roger Sherman	greenhouse	needs grant, technical assistance
<u>INDIVIDUALS</u>		
Linda Newhall	heat homes	said well doesn't have enough flow, clogs pipes
Ouray Citizen's Committee Ouray, Colo.	district heat, industrial or agricultural processes	need clarification of legal aspects, resource assessment, well, feasibility study, funds, but can't match federal grants
Glenwood Springs Citizen Committee	district heat, industrial or agricultural processes	Need resource assessment, well, clear definition of geothermal rights in Glenwood Springs, front-end financing for system. Said minimal opportunity for industry.
<u>FEDERAL GOVERNMENT</u>		
Regional office, U.S. Dept. of Commerce Denver, Colo.	general	Requested reports as published. As governor, the director had promoted geothermal energy.
Regional office, U.S. Housing and Urban Development Denver, Colo.	general funding	

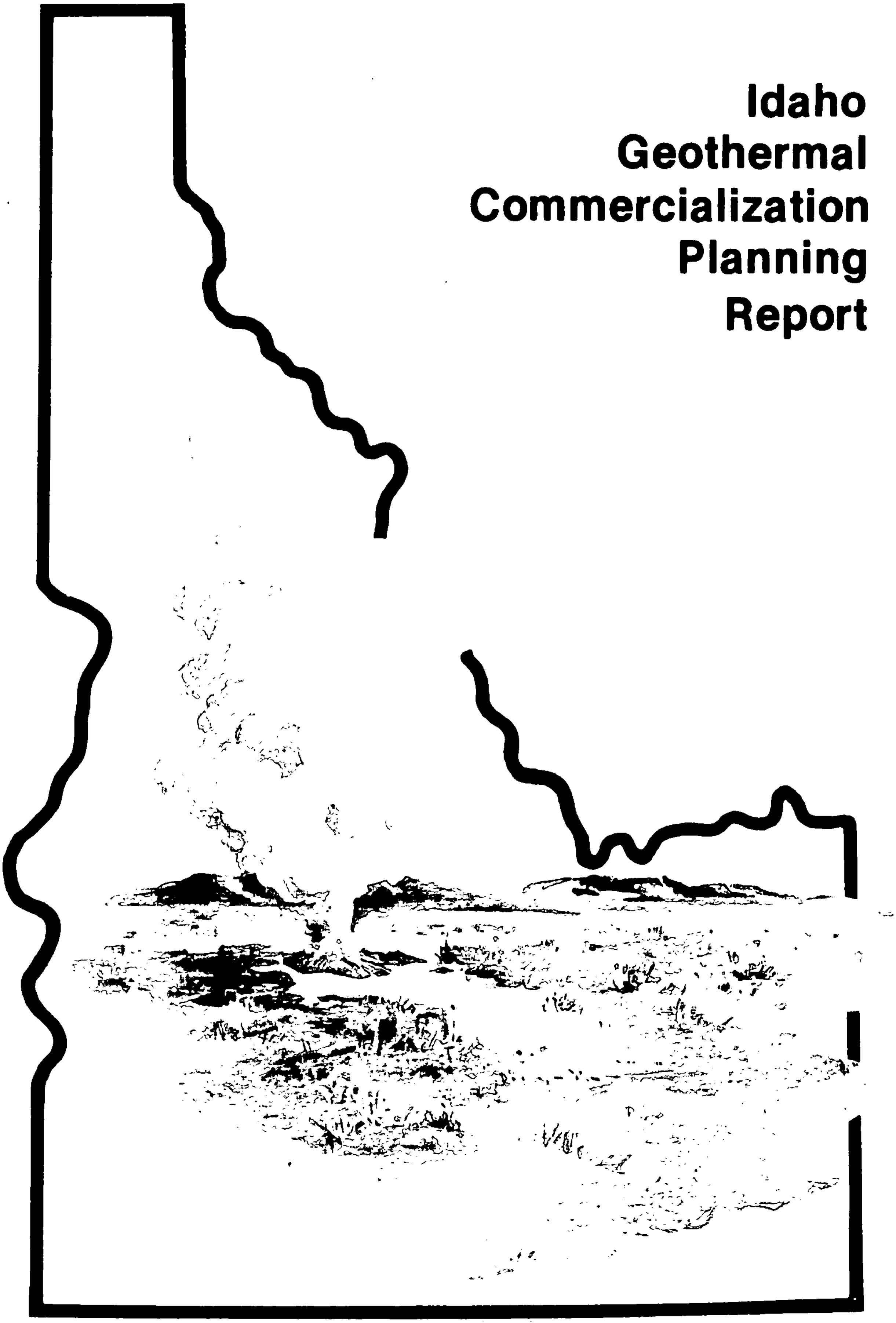
Farm Home Administration, Dept. of Agriculture Denver, Colo.	general funding	hospitals grant and loan guarantee, appropriate technology and small grants programs.
DOE Solar Energy Research Institute Golden, Colo.	industrial processes	Discussed energy demand studies & needs
U.S. Forest Service	general	
Bureau of Land Mgmt.	general	

<u>COLORADO STATE GOVERNMENT</u>

State Legislature Denver	general	
Div. of Commerce & Dev. Denver	process	
Four Corners Regional Commission, Denver	process	
Economic Development Planning, Denver	process	
Division of Housing Denver	heat low-cost housing	
Oil & Gas Conservation Commission, Denver	general	
State Land Board Denver	general	
State Engineers Office Denver	general	
Energy Conservation Office Denver	alternative energy	
Dept. of Institutions Colo. Springs	heat new prison, use for prison industries	Joint CGS/Institutions exploration project
Director's office, Dept. of Natural Resources, Denver	general	
Governor's Office Denver	general	

Chapter 4

Idaho Geothermal Commercialization Planning Report



IDAHO GEOTHERMAL COMMERCIALIZATION PLANNING

SEMI-ANNUAL PROGRESS REPORT

July - December, 1979

Prepared by:

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Idaho Office of Energy

Work performed under Contract No. DE-FC07-79ID12010
U. S. Department of Energy
Idaho Operations Office

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1.0 INTRODUCTION

Idaho has a significant but largely undeveloped geothermal energy potential. Idaho Department of Water Resources has identified over 300 thermal wells and springs in Idaho. Most of the known geothermal resources in the State are below 150° C (302° F) temperature. Although at this time it is impractical to generate electric power from these resources, low to moderate temperature geothermal resources have significant potential in Idaho for direct applications such as food processing and space heating.

All of Idaho's petroleum products, natural gas, coal, and a substantial part of its electrical power are imported from other states and nations. Hydroelectric power, solar energy, and geothermal energy are Idaho's major native energy resources. Much of the high-head hydroelectric potential in Idaho has already been developed or is protected by wilderness classification.

Geothermal energy is Idaho's major undeveloped energy resource. Idaho is fortunate that its geothermal resources underlie the areas of highest concentration of people, industry, and commerce. Approximately two-thirds of Idaho's population lives in areas with geothermal energy potential. Twenty-two of Idaho's major food processing plants are located along the Snake River Plain in areas with geothermal resource potential.

The Idaho Office of Energy, in a cooperative agreement with the U.S. Department of Energy, Idaho Falls Operations Office, has completed an overview of geothermal resource development potential and institutional barriers to development. This report is a summary of the 1979 Operations Research Program in Idaho. After twelve months of research, it is the conclusion of this program that there is significant opportunity, interest, and potential for geothermal resource development throughout the State of Idaho. Development potential is most significant along the Snake River Plain Region of southern Idaho, while opportunities for development are more limited in the interior mountainous regions of the State.

This summary report outlines the major objectives and results of the 1979 Idaho Operations Research Program. In the course of the last twelve months, the Office of Energy has examined the regional market potential for geothermal resource development in Idaho; conducted selected site specific development analysis for four sites; researched the institutional factors affecting geothermal development; and conducted an outreach program to assist in geothermal resource development.

2.0 Specific Task Description and Products

It was the joint objective of the U.S. Department of Energy and the Idaho Office of Energy to accomplish four major tasks during the 1979 contract period. The tasks to be accomplished were as follows:

1. Area Development Plans for State Planning Regions
2. Site Specific Development/Commercialization Plans
3. Institutional and Economic Assessments
4. Establish an Outreach Program

The following report summarizes each specific task and the products of each task for the contract period of January 1, 1979 through December 31, 1979. Individual detailed task reports are available from the U.S. Department of Energy/Idaho Falls Operation Office, Geothermal Division.

2.1 Geothermal Prospect Identification

A. Electric Power Prospects:

The Idaho Department of Water Resources has recently completed an extensive water chemistry analysis of thermal springs and wells in Idaho. Those prospective sites with the highest geochemical temperatures with potential for electrical generation are listed in Table 2.1.1. The land ownership of these sites is listed in Table 2.1.2.

B. Industrial Prospects:

Table 2.1.3 lists the potential geothermal industrial park sites. These sites were identified by the Idaho Office of Energy as prospective hydrothermal reservoir sites which have significant economic potential for developing geothermal industrial parks. The forty largest industries in Idaho were inventoried during this contract period for their energy demand, compatability to utilization of geothermal resources directly in the plants and their location with respect to prospective resources.

C. District Space heating Prospects

Table 2.1.4 lists all communities in Idaho within five kilometers (3 mi) of a 20° C (68° F) or higher thermal spring or well. All of these sites are considered potential space heating locations. The total population of these sites is 272,736 people. This represents 33 percent of the state's total population and approximately 50 percent of the urban/community population. Two of these sites, Boise and Rexburg, have been selected for time phase project plans. Boise and Ketchum currently have operational geothermal heating systems.

TABLE 2.1.1

High Temperature Geothermal Prospects

Geothermal Site	County	Location	Land Ownership	Measured Temp* °C	Best Estimate* Subsurface °C	Types of Development Speculated and Notes
Battle Creek H.S.	Franklin	T. 15 S., R. 39 E., Sec. 8	Private	84	250	Electrical Generation (Wet Steam), Industrial Food Processing, Gasahol.
Big Creek H.S.	Lemhi	T. 23 N., R. 19 E., Sec. 22	U.S.F.S.	91	175	Electrical Generation (Wet Steam), Institutional Restrictions.
Blackfoot Reservoir	Caribou	T. 6 S., R. 41 E., Sec. 19	Private, BLM, BIA	42	240	Electrical Generation (Possible), Based on dry oil exploration well.
Bonneville H.S.	Boise	T. 10 N., R. 10 E., Sec. 31	U.S.F.S.	85	142	Development not considered possible, Remote, Institutional Restrictions.
Crane Creek H.S.	Washington	T. 11 N., R. 3 W., Sec. 7	Private, BLM	92	176**	Electrical Generation (Wet Steam), Industrial Processing, Gasahol.
Cove Creek H.S.	Washington	T. 10 N., R. 3 W., Sec. 9	Private	74	172	Electrical Generation, Industrial, Agriculture (Livestock).
Indian Creek H.S.	Valley	T. 17 N., R. 11 E., Sec. 16	U.S.F.S.	88	142**	Wilderness Area.
Magic Reservoir	Blaine-Camas	T. 1 S., R. 17 E., Sec. 23	Private, BLM	72	174	Electrical Generation (Binary), Industrial Processing.
Raft River	Cassia	T. 15 S., R. 26 E., Sec. 23	BLM	147***	147	Electrical Binary Plant under construction, Gasahol.
Roystone H.S.	Gem	T. 7 N., R. 1 E., Sec. 8	Private	54	150	Electrical Generation (Binary), Industrial Processing.
Vulcan H.S.	Valley	T. 14 N., R. 6 E., Sec. 11	U.S.F.S.	84	147	Development not considered possible, Remote, Environment and Institutional Restrictions.
White Licks H.S.	Adams	T. 16 N., R. 23 E., Sec. 33	U.S.F.S., Private	65	145**	Electrical Generation (Binary), Space Heating, Industrial.
Weiser H.S.	Washington	T. 11 N., R. 6 W., Sec. 10	Private	78	156**	Electrical Generation (Binary), Industrial Processing, Food and Gasahol, Space Heating.

* Idaho Department of Water Resources, Bulletin 30, 1979.

** Quartz Temperatures.
All others are Na-K-Ca Temperatures.

*** Pump Test Temperatures at the Raft River Geothermal Test Site.

TABLE 2.1.2

OWNERSHIP OF GEOTHERMAL AREAS IN IDAHO MOST FAVORABLE FOR HIGH TEMPERATURE RESOURCES:

Site	County	
Private Ownership:		
Battle Creek H.S.	Franklin	
Cove Creek H.S.	Washington	
Crane Creek H.S.*	Washington	
Magic Reservoir*	Blaine-Camas	
Roystone H.S.	Gem	
Weiser H.S.	Washington	
White Licks H.S.*	Washington	
BLM Ownership:		
Crane Creek KGRA*	Washington	
Magic Reservoir*	Blaine-Camas	
Raft River KGRA	Cassia	
USFS Ownership:		
Big Creek H.S.	Lemhi	
Bonneville H.S.	Boise	
Indian Creek H.S.	Valley	
Vulcan KGRA	Valley	
White Licks H.S.*	Adams	
*** Mixed Ownership**		
Crane Creek	Washington	Private and BLM
White Licks	Adams	Private and USFS
Magic Reservoir	Blaine	Private and BLM
Blackfoot Reservoir and Grays Lake	Caribou	Private, BIA, BLM

TABLE 2.1.3

POTENTIAL GEOTHERMAL INDUSTRIAL PARKS

Weiser Hot Springs:	Natural Gas, Railroad, Power, Private Land, Temp. 78-156°C*.
Battle Creek H.S. Preston, Idaho :	Natural Gas, Railroad, Power, Private Land, Temp. 84-250°C*.
Crane Creek H.S. :	Railroad, Private Land, Temp. 92-176°C*.
Cove Creek H.S. :	Private Land, Temp. 74-172°C*.
White Licks H.S. :	Private Land, Temp. 65-145°C*.
Roystone H.S. :	Private Land, Railroad, Power, Temp. 54-156°C*.
Magic Hot Springs :	Private Land, Near Railroad, Temp. 72-174°C*.
Bruneau KGRA :	Mix Ownership, Private-Federal, Natural Gas, Temp. 70°-140°C*.
Raft River KGRA :	Mix Ownership, Private-Federal, Temp. 147°C**.
Rexburg, Idaho :	Private Land, Railroad, Power, Natural Gas, Present Industrial, Resource undetermined.
Pocatello, Idaho :	Private Land, Railroad, Power, Natural Gas, Present Industrial, Resource undetermined.
Nampa, Idaho and Caldwell, Idaho :	Private Land, Railroad, Power, Natural Gas, Present Industrial, Resource undetermined.
Payette, Idaho :	Private Land, Railroad, Power, Natural Gas, Present Industrial, Resource undetermined.
Mountain Home KGRA:	Mix Ownership, Private-Federal, Power, Resource undetermined.

* Temperatures Range is shown as measured temperature and best estimate of subsurface temperature.

** Known temperature.

TABLE 2.1.4

Towns in North Idaho Within 5 km of a 20^{o} C. or Higher Thermal Spring or Well

Town	Population	Known Surface T.^{o}C.	Best Estimate Subsurface T.^{o}C.	Present Use	Ownership	Location
Burke	30	27.6	?	Mine Waste	Private	T48N, R5E, Sec.10
Burgdorf	10	45	120	Pool	Private	T22N, R4E, Sec.1
Kellogg	3,811	32	?	Mine Waste	Private	T48N, R3E, Sec.6
Lewiston	31,554	20	?	Municipal Emergency Supply	City	T35N, R5W

Towns in North East Idaho Within 5 km of a 20^{o} C. or Higher Thermal Spring or Well

Town	Population	Known Surface T.^{o}C.	Best Estimate Subsurface T.^{o}C.	Present Use	Ownership	Location
Ammon	3,360	20	?	Domestic	Private	T3N, R39E, Sec.30
Ashton	1,181	41	116	Unused	Private	T9S, R42E, Sec.23
Challis	850	40	69	Natatorium	Private	T14N, R19E, Sec.23
Clayton	41	41	99	Natatorium	Private	T11N, R17E, Sec.27
Ellis						
Newdale	285	32	93	Municipal	City	T7N, R41E, Sec.35
Rexburg	9,761	26	?	Irrigation	Private	T5N, R40E, Sec.36
Stanley	52	41	76	Unused	Private	T10N, R13E, Sec.3

Towns in South Central Idaho Within 5 km of a 20° C or Higher Thermal Springs or Well

Town	Population	Known Surface T.°C.	Best Estimate Subsurface T.°C.	Present Use	Ownership	Location
Hailey	1,804	59	100	Space Heating	Private	T2N, R18E, Sec.18
Ketchum	1,780	71	101	Space Heating	Private	T4N, R17E, Sec.15
Twin Falls	23,616	29	66	City Pool	City	T10S, R17E, Sec.14
Oakley	698	47	90	Natatorium	Private	T14S, R22E, Sec.7
Albion	372	60	89	Irrigation	Private	T11S, R25E, Sec.11

Towns in South East Idaho Within 5 km of a 20° C. or Higher Thermal Springs or Well

Chubbuck	4,095	40	185	Irrigation	Private	T6S, R34E
Lava Hot Springs	512	45	82	Space Heating Natatorium	Private State	T9S, R38E, Sec.21
Malad	1,848	25	61	Unused	Private	T14S, R36E, Sec.27
McCammon	619	20	?	Domestic	Private	T9S, R36E, Sec.3
Pocatello	42,565	41	62	Domestic	Private	T5S, R34E, Sec.26
Preston	3,284	84	150	Unused	Private	T15S, R39E, Sec.17
Soda Springs	3,487	28	54	Tourism Geyser	City	T9S, R41E, Sec.12
Weston	229	23	92	Irrigation	Private	T16S, R38E, Sec.24

Towns in Southwest Idaho Within 5 km of a 20°C. or Higher Thermal Spring or Well

Town	Population	Known Surface T. °C.	Best Estimate Subsurface T. °C.	Present Use	Ownership	Location
Cascade	916	43	66	Pool	City	T14N, R3E, Sec.36
Council	850	22	?	Irrigation	Private	T16N, R1W, Sec.15
Garden Valley (Crouch)	200	55	80	Pool, Space Heating & Greenhouse	Private	
Idaho City	200	41		Natatorium	Private	T6N, R5E, Sec.1
Meadows	650	43	96	Unused	City	T19N, R2E, Sec.22
Boise	92,901	71	96	Space Heating	City & Private	T3N, R2E, Sec.12
Caldwell	15,643	28	70	Irrigation	City	T4N, R3W, Sec.28
Cambridge	451	26	76	Unused	Private	T14N, R3W, Sec.19
Emmett	3,943	20	?	Domestic	Private	T6N, R2W, Sec.14
Glenns Ferry	1,387	38	68	Natatorium	Private	T5S, R10E, Sec.32
Hollister	63	36	81	Irrigation	Private	T12S, R17E, Sec.31
Midvale	447	23	68	Public Supply	City	T13S, R3W, Sec.8
Mountain Home	6,755	23	?	Public Supply	City	T3S, R6E, Sec.26
Mtn. Home AFB	6,000+	21	?	Irrigation	Private	T4S, R5E, Sec.26
Parma	1,879	28	70	Public Supply	City	T4N, R3W, Sec.35
Weiser	4,607	70	156	Natatorium	Private	T11N, R6W, Sec.10

2.1 Geothermal Prospect Identification - Continued

D. Geothermal Leasing In Idaho

Approximately 689,000 acres of state and federal lands have been leased in Idaho for geothermal exploration. This is a substantial increase in leasing activity compared to the same period last year. Since October, 1978, federal competitive leases have shown no change in status. The number of noncompetitive acres leased has increased by 5 percent since October, 1978. The number of state acres leased has increased 600 percent during the same period of time. The substantial increase in state leasing is due to the rescinding of a moratorium of leasing state lands which has been in effect since 1975. Leasing activity is expected to slow after the initial application period. Table 2.1.5 summarize the status of geothermal leasing in Idaho.

Although leasing activity and total acres leased in Idaho is increasing rapidly, the drilling activity has not kept pace. The major exploration activity in Idaho is currently for oil and gas in the Overthrust Belt in southeast Idaho. Because this area is also geothermally active, these exploration holes could prove a geothermal resource.

E. Geothermal Development Potential Map

A map was compiled from data collected for the purpose of identifying geothermal development prospects. This map displays State and Federal leasing data, the location of all high temperature or prospective high temperature resources, potential industrial park locations, and communities with significant potential for space heating. Copies of this map are available from the Idaho Office of Energy.

2.2 Area Development Plans

The compilation of all available information on factors which are expected to affect geothermal development in Idaho began in 1978. The Geo-Heat Utilization Center and this author conducted an extensive survey of available information regarding geothermal resource potential, market conditions, and institutional conditions in Idaho. This data base was published by the Geo-Heat Utilization Center, Oregon Institute of Technology in July, 1979. That report is the data base for the Idaho Area Development Plans.

This year's task was to refine and update the data base for five sub-state areas which coincide with Idaho's state economic development regions. The updated information base was then supplied to New Mexico Energy Institute (NMEI) for the purpose of assessing long and short range market potential for geothermal development.

TABLE 2.1.5

TOTAL ACREAGES OF GEOTHERMAL RESOURCE LEASES IN THE STATE OF IDAHO

(December 1979)

Federal Leases

Total Acreages of Competitive Leases in KGRAs: All BLM	41,887
Total Acreages of Noncompetitive Leases BLM: 277,737.07 Forest Service: 2,560	291,385.15

State Leases:

Total Acreages of State Leases	355,680
Total of All Acreages State and Federal Leased for Geothermal Resources	688,952

STATE OF IDAHO
Geothermal Leases

		Total Acres Leased
Issued Prior to 1975 Moratorium		59,504 acres
Issued Since November, 1978, and as of April, 1979		320,098 acres
	Subtotal	379,602 acres
Declined/Released by lessee as of May, 1979		23,922 acres
	Total Acres Under Geothermal Lease by State	355,680 acres

2.2 Area Development Plans - Continued

The Office of Energy supplied NMEI the following types of data:

a) Location and geochemistry of all known thermal wells in Idaho.
b) Population and employment statistics for all counties in Idaho.
c) Climatic data for all communities and resource areas in Idaho.
e) Location of major industrial sites and detailed industrial energy consumption data by fuel type per industrial plant.
f) PUC rate tariffs for all regulated energy forms.
g) Historical and projected energy growth rates and price rates.
h) Estimated transmission distances between resource locations and potential market sites.
i) Estimated drilling depths for each geothermal resource location, based on heat flow data, geothermal gradients and well logs.
j) Assumed resource temperatures for each resource location, based on geochemistry, and heat flow.

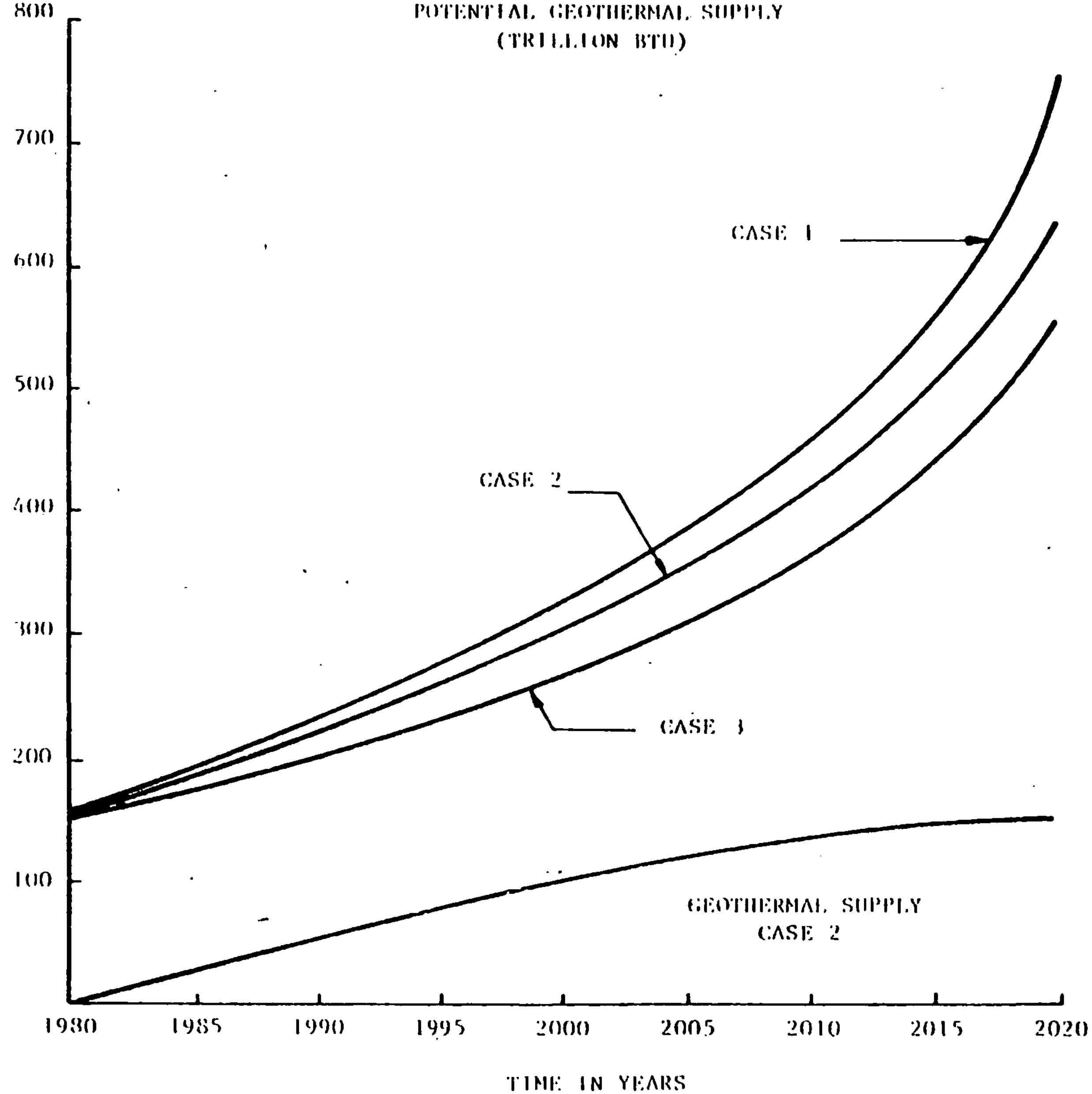
With this data base, NMEI conducted a computer analysis, which estimates the potential for market penetration by geothermal resources. The CASH program was used to estimate the cost of development at each location and the number of wells needed to supply the energy demand base. An energy demand forecast was also calculated. The geothermal development cost was compared with projected conventional energy demand and prices to obtain the timeframe when geothermal exploration and development will become cost competitive with current conventional energy forms. The information for each site was aggregated for the whole state to obtain a statewide market penetration estimate for geothermal energy.

A three case energy demand forecast was conducted using NMEI's computer program. The demand forecasts are based on natural gas consumption and pricing in Idaho. Table 2.2 lists the major parameters used to establish real price growth in Idaho's natural gas market. Figure 2.2 illustrates the projected growth in Idaho's total energy demand for the three cases outlined in Table 2.2 The Idaho Office of Energy considers Case 2, the Northwest Energy Policy Project forecasting model, to be the most accurate model for Idaho's projected total energy demand between 1980 and 2020.

A market penetration analysis was run using the Case 2 demand projections. This analysis compared the cost of geothermal resource development with the projected real price and demand growth rate for energy in Idaho under the Case 2 forecast. Figure 2.2 illustrates the potential for geothermal supply to provide a percentage of Idaho's energy demand under the Case 2 demand projections.

Figure 2.2 illustrates the degree of energy market penetration which appears to be economically feasible. Figure 2.2 does not estimate the amount of geothermal resource. Figure 2.2 only illustrates, that under the Case 2 (moderate growth) scenario, it will be economically competitive to explore for and develop geothermal energy supply at approximately one-third of the energy consuming sites in Idaho by the year 2020.

FIGURE 2.2
IDAHO
TOTAL ENERGY DEMAND
VS
POTENTIAL GEOTHERMAL SUPPLY
(TRILLION BTU)



2.2 Area Development Plans - Continued

If all the resource sites used in the CASH model could be successfully developed, the maximum market penetration possible in Idaho would be approximately 100 trillion BTU's per year. Reservoir confirmation investment costs were estimated under the CASH program to be approximately 3.9 to 4.0 billion dollars, with a potential consumer savings of approximately 20 billion dollars in fossil fuel use.

TABLE 2.2

IDAHO NATURAL GAS COMPOUND
REAL PRICE GROWTH

	Growth Factor	Period	Remarks
Case 1	0.02302	1975 - 1985	EIA
	0.0219	1986 - 2020	Case C
Case 2	0.057	1975 - 1992	Northwest Energy
	0.0365	1993 - 2020	Policy Project
Case 3	0.057	1975 - 1070	
	0.08	1980 - 1985	Current Historic
	0.0561	1986 - 2020	Trend

2.3 Site Specific Development Plans

2.3.1 Candidate Geothermal Sites/Applications

Specific sites which are candidates for Site Specific Development Plans are listed in Table 2.3.1. Site Specific Development Plans apply only to proven and potential resources and to applications that are planned or potential. Locations selected for Site Specific Development Plans during the 1979 contract period were Weiser Hot Springs, Hailey, Fairfield, and Stanley, Idaho. These sites were selected based on resource potential and local development interest.

2.3.2 Site Specific Development Plans

Site Specific Development Plans were completed for Fairfield, Hailey, Stanley, and Weiser, Idaho. Copies of detailed site specific analyses are available from the Idaho Office of Energy and the U.S. Department of Energy, Idaho Operations Office.

The following are abstracts of these reports:

TABLE 2.3.1

Candidate SSDP Geothermal Sites

Site	Potential Use	Resource Data	Comments
Fairfield	Space Heating Industrial	71° C Surface	Propane and electricity are the current energy supplies. Area is considering exploration for a new industrial park.
Stanley	Space Heating	41° C Surface	Community is considering geothermal district heating system.
Hailey Hot Springs	Space Heating	70° C Surface	Geothermal resource was used for space heating the Hiawatha Hotel, in Hailey until fire destroyed the building in 1978. Community is interested in expanding the system
Weiser Hot Springs	Industrial Park Space Heating	78° C Surface 156° C Na-K-Ca	Located close to railroad. Site currently used for a natatorium. No major industries in the area. Site located 8 km west of Weiser, Idaho. Developers interested in ethanol and onion dehydration.
Crane Creek Hot Springs	Feed Lot Industrial	92° C Surface 176° C Na-K-Ca	No current use, no adjacent communities or industries. Owner is interested in ethanol, located close to railroad.
Bruneau KGRA	Feed Lot Industrial	70° C Surface 140° C Na-K-Ca	No current use, no adjacent communities or industries.
Big Creek Hot Springs	Electrical Power Generation	93° C Surface 175° C Na-K-Ca	No current use, no adjacent industries, isolated.
Sun Valley Ketchum	Space Heating	70° C Surface 80° C Subsurface	Geothermal space heating currently serves 30 customers.
Twin Falls College of Southern ID	Space Heating	130° C Subsurface (estimated)	Exploration well currently being drilled by the college on the campus.
Preston	Space Heating Industrial	84° C Surface 250° C Na-K-Ca	No current use, located close to community and railroad
Malad	Space Heating	23° C 133° C Subsurface	New high school currently under construction will consider geothermal heat. Exploration will be completed 1979.
Pocatello	Industrial	Inferred Resources	Current heavy industrial sites.
Payette	Industrial	Inferred Resources	Current heavy industrial sites.
Nampa	Industrial	Inferred Resources	Current heavy industrial sites.
Caldwell	Industrial	Inferred Resources	Current heavy industrial sites.

2.3.2 Site Specific Development Plans - Continued

Fairfield

The Fairfield area was selected for a site development analysis because: the State Water Resources Department has classified the area as a Geothermal Resource Area, the City has requested assistance from the Idaho Office of Energy regarding potential for space heating public buildings; and Camas County, through the Wood River Resource Council, requested assistance from the Office of Energy regarding an evaluation of potential resource locations for industrial applications.

Fairfield, Idaho is a small agricultural community located on the Camas Prairie in central Idaho. The community is located at an elevation of 1543.8 meters (5,065 ft.) and has 8,575 heating degree days.

Camas County is interested in developing the area's geothermal resources for space heating public buildings and for locating a new industrial park. Other potential applications include greenhouses and controlled breeding conditions for livestock. The following section describes the estimated cost of exploration at several potential sites in Camas County.

Three areas near Fairfield appear to offer excellent to good chances for geothermal exploration. Resource development costs were estimated for five potential drilling locations within the resource areas. Four wellhead sites were evaluated as potential industrial park locations. In each of the four industrial cases the wellhead cost of geothermal energy was very low compared to alternative fuel costs. Even though these costs do not include a disposal system, they are so low as to suggest that any commercial or industrial establishment able to locate at the heat source would derive huge benefits in terms of fuel savings from use of geothermal fluids. For Site #5, space heating of Fairfield, it also appears that even with the possible inclusion of additional costs for possible disposal or management fees, geothermal space heating would be a tremendously attractive proposition.

Based on a city population estimate of 450 by the Idaho State Division of Budget, Policy, Planning, and Coordination and an average family size of just

2.3.2 Site Specific Developments Plans - Continued

Fairfield - Continued

over three persons, the projected number of households in Fairfield is 150. Assuming an average home uses about .2 X 10^9 BTU's per year, total heating demand for Fairfield is about 3 X 10^{10} BTU's per year. Fairfield has 8575 heating degree days. The annual heat load translates into a design heat load of 1.17 X 10^7 BTU's per hour , the peak heat load any heating system must satisfy.

With an expected water temperature of 100° C (212° F), the temperature drop to be expected is 14°C (57° F). With that temperature drop and the expected flow of 500 gallons per minute, the heat delivered by the water is 1.43 X 10^7 BTU's per hour or 1.25 X 10^{11} BTU's per year. Thus, available heat from the geothermal water is expected to be sufficient to meet the Fairfield space heating demand.

Hailey:

The Hailey site was selected for site specific development analysis because there has been a historical use of the thermal water for space heating the Hiawatha Hotel in Hailey for over forty years. The feasibility analysis evaluated major factors having a direct bearing on the potential for expanding the use of geothermal space heating in the City of Hailey. Hailey, which has 8070 heating degree days, has a total heat demand of 4.12 X 10^7 BTU's per hour.

Annual savings in operating costs for geothermal heating versus natural gas heating amount to $317,115 in the first year and rise over time with natural gas prices. The internal rate of return, which equates a 20-year stream of savings to capital costs for a geothermal system, is a favorable 13.33% for a public system, versus a low -3.36% for a private system.

The major constraints to developing a Hailey district heating system which utilizes Hailey Hot Springs are the questions of water rights and resource ownership at the Hot Spring. It is apparent from the available public information that there are no major constraints to groundwater development in Democrat Gulch. The question of current water claims, implied or recorded, is confined to diversion of surface waters for irrigation. To what extent the surface diversion of Hailey Hot Springs will restrict the development of ground water resources is unknown. This is because the question of surface water rights to Hailey Hot Springs is unclear.

It is apparent from this analysis that the city owned district heating system has the highest potential for successful economic development.

2.3.2 Site Specific Development Plans - Continued

Stanley:

At the reqest of the City of Stanley, Idaho, the Idaho Office of Energy conducted a Site Specific Analysis of the potential for developing the geothermal resources at Stanley into a district heating system.

Stanley, an isolated mountain community which has 10,739 heating degree days, has significant hot springs with surface temperature of 41° C (105° F) located within 1 km (.6 mi). The analysis considered resource evaluation, site specific application, and the development process. Annual savings in operating cost of a geothermal system versus the alternative fuel, propane, would be $78,796 in the first year, and increasing thereafter. This represents an extraordinary 67% internal rate of return over a 20-year life of the system. Major barriers to development are institutional.

The mineral entry withdrawal of all federal lands within the Sawtooth National Recreation Area will restrict exploration to private lands. The Geothermal Steam Act of 1970 (CFR 43-3201.1-6) specifically forbids the development of geothermal resources on federal lands within National Parks, National Recreation Areas and National Wildlife Refuges.

Weiser:

The Weiser Hot Springs site was selected for site specific development analysis because the site has a number of geographical aspects which are critical locational criteria for industrial development. The geothermal prospect is located close to the state's major east-west railroad, a natural gas pipeline, major power transmission lines and the interstate freeway. These support facilities are necessary for industrial development and with the unique combination of a nearby geothermal energy source, the Weiser site is a logical location for a new geothermal-industrial park.

The Weiser Site Specific Development Plan describes the institutional, logistical and economic parameters which will affect the development of a new industrial park based on geothermal energy. The development concept involves locating one or more industrial facilities at the railroad located 4,877 meters (16,000 ft.) south of the proposed wellfield.

The resource temperatures are expected to range from a minimum of 90° C (194° F) to a maximum of 140° C (284° F) based on the geochemistry of the water. The types of processes

2.3.2 Site Specific Development Plans - Continued

Weiser:

considered for the industrial park were based on local and regional raw products. The types of processing envisioned are: potato starch, ethanol distillation, corn canning and processing, and onion dehydration.

A well program was developed for three possible depths to obtain a realistic range of drilling costs. Three possible distribution systems to deliver the resource to the point of use and the pump and power requirements necessary to deliver the resource were also developed to obtain an estimated deliverable energy cost. For all cases considered, geothermal energy was found to be competitive with other deliverable energy sources.

The Weiser site has considerable potential for developing a geothermal industrial park. The Weiser Hot Springs geothermal area has an excellent location with respect to transportation and utility corridors. The area has abundant agricultural production and could supply the raw product needs of the types of processes outlined in this report. Development interests who are working without federal assistance are currently studying the feasibility of a geothermal-ethanol plant at this location.

Better funding mechanisms are needed for direct application projects to obtain risk capital for exploration. Also, a loan guarantee program is needed for construction of a hybrid geothermal-ethanol plant. A prototype plant is needed to demonstrate the feasibility of geothermal-ethanol production.

2.4 Time Phased Project Plans

2.4.1 Active Demonstration/Commercialization Project

Two sites in Idaho are currently developing geothermal demonstration projects---Boise, and Madison County, Idaho. Major government and developer actions required to achieve the energy and time goals of these projects were reviewed. A detailed review of the Boise Geothermal Project and a timetable review of the Madison County Geothermal Project were conducted. The State of Idaho has an operational geothermal space heating demonstration which is separate from the Boise Geothermal Project. Two major State office buildings, the Idaho Agriculture - Health Laboratory and the Department of Agriculture Office Building, are currently heated with geothermal water. The Agriculture Health Laboratory was retrofitted to geothermal heat in 1976 from natural gas. The Department of Agriculture Office Building was completed in 1979 and was designed for geothermal heat.

2.4.2 Time Phased Project Plans

Boise:

The Idaho Office of Energy prepared a preliminary analysis of the Boise Geothermal Project. The report consists of two major sections: Part I, an economic feasibility analysis of retrofitting and heating the seven state buildings in the Capitol Mall; Part II, is a time-phased project plan which illustrates the historical and projected tasks and government actions which are necessary for the project to be completed by 1983.

The two basic economic choices for the State are: (1) to buy geothermal water from the proposed Boise City geothermal system, or (2) to construct its own geothermal system. The Office's analysis indicates that either alternative is preferable to continued use of natural gas. If the Boise Project and the retrofit of the Capitol Mall are to be completed on time (1983), the State must begin its engineering designs by July 1980, and the Boise Geothermal Project must begin production drilling by 1980.

The projected cost of heating the Capitol Mall with natural gas in 1983 is $272,156. The estimated 1979 retrofit cost for the Capitol Mall is $194,000. Assuming the retrofit is completed by 1982, the estimated operational cost for the Capitol Mall geothermal heating system for 1983, with a water purchase price of $.878/100 CF of water, is $213,202. When the amortized retrofit cost of $20,841 is included, the yearly cost savings to the State is estimated to be $38,113.

By retrofitting to geothermal heat, approximately 77,403,600 cubic feet of natural gas per year will be conserved. This gas is currently imported from Canada and is equal to 13,362 barrels of oil per year. By the year 2000, natural gas savings will total 1.47 billion cubic feet of natural gas which is equal to .2534 million barrels of oil.

In addition to detailing the economics of retrofitting the Idaho Capitol Mall to geothermal space heating, the Boise Time-Phase Project Plan outlines the complexity of historical actions which have brought the Boise Geothermal Project to its present state. The Plan also shows what tasks must be completed and the projected timetables for the completion of the project by 1983. A number of institutional and logistical tasks are necessary over the next three years. Three major development activities must occur in parallel sequence between now and 1983: (1) the retrofit of the State Capitol Mall, (2) the rebuilding of the Warm Springs Water District System, and (3) the construction of the Boise City Geothermal System.

Figure 2.4.2 outlines the major task involved in the Boise Geothermal Project. When completed the Boise Geothermal System will displace an estimated 1,750 X 10^9 BTUs of fossil fuels per year.

2.4.2 Time-Phased Project Plans - Continued

Rexburg:

Madison County Idaho and Rogers Foods, Inc. proposed to DOE a joint effort in developing the use of geothermal energy for municipal space heating and industrial food processing under the PON program. The application would be at Rexburg, Idaho in Madison County. Rogers Foods has a large potato processing plant located on the edge of Rexburg. Geological surveys and studies indicate this region has a potential for geothermal water. Two major entities have committed to use the energy from the system once it is developed: the City of Rexburg, population 10,000 and Ricks College, with an additional 6,000 full-time students.

The geothermal energy from the production wells to be drilled in this project would be for two main purposes: community space heating and industrial food processing. The needs of the food processing plants (Rogers Foods) can totally be met by 350° F geothermal water, but 250° F water would meet approximately 40% of the needs. Rogers Foods produces dehydrated potatoes in various forms at its Rexburg plant, a large important link in the agriculture economy of this area. The community space heating needs can be met satisfactorily by 150° F to 190° F water, with water as cool as 130° F being useful. To fit these requirements, a deep geothermal well (approximately 6,000 ft.) needs to be drilled at a suitable location to serve the Rogers Foods Rexburg plant. The hot water would be circulated through heat exchangers in the Rogers plant, emerging at a transfer point for Madison County at approximately 190° F. Madison County could purchase geothermal (190°- 210° F) energy from Rogers Foods to supplement its own production of geothermal water from shallower wells (approximately 3000 ft). Madison county is a relatively cool area (8700 degree day) and space heating is required at least 9 months out of the year. When completed the Madison County geothermal system has the potential of saving 4.7 $X10^{11}$ BTU's of fossil fuel per year. Preliminary engineering studies were conducted and geothermal gradient holes were drilled in 1979. The evaluation of the data obtained from the gradient holes will be evaluated to determine if continued exploration is warranted. Site selection for a deep hole will occur in 1980. The project is expected to be completed by 1983.

2.5 State Aggregation of Prospective Geothermal Utilization

Projected Geothermal Energy on Line
BTU's x 10^9

Location	1980	1985	2000
Boise	90	1750	--
Fairfield	--	30	625
Hailey	--	114	357
Ketchum	50	250	500
Rexburg	--	130	--
Stanley	--	18	66
Weiser	--	210	--

2.6 Institutional Analysis

An institutional assessment was conducted during the contract period regarding the role of local, state, and federal governments in geothermal development in Idaho. Local government activities were inventoried regarding local land use, planning, zoning, and building ordinances. The role of State government was analyzed regarding State leasing activities, Public Utilities Commission jurisdiction, tax structures, water laws, and geothermal permits. The role of the Federal government was analyzed regarding the current status of leasing activities and time factors involved in acquiring a lease.

2.6 Institutional Analysis - continued

The institutional document which was produced has a detailed list of local government regulations for all counties and cities with geothermal potential; state and federal leases by lessee and by township and range; and a registry of all exploration wells drilled for oil, gas, and geothermal. An indepth analysis of the potential for conflict between geothermal developers and water resource development concluded that under Idaho law, assurance against third party interference is secured through a valid water license.

The analysis of Federal leasing activity indicates that the average period for obtaining a lease from the BLM in Idaho is 98 weeks.

2.7 Public Outreach Program

The Outreach Program has three major functions: 1) assisting community, business, industrial, and government interest in geothermal development; 2) disseminating information; and 3) coordinating regional programs with other states. A major accomplishment of the Outreach Program was the successful passage of legislation in the 1979 legislature which allows cities to revenue bond geothermal district heating systems.

2.7.1 Outreach Mechanisms

The Office of Energy has developed three basic outreach tools which are used to provide information and assistance to the general public:
1) A brochure on geothermal resources in Idaho. Over 500 brochures were given out at county fairs, public meetings, and other public gatherings during 1979.

2) A handbook which identifies government regulations procedures and fundamental logistical factors involved in geothermal development has been developed by the Office. The handbook is an informational manual to procedures that must be considered in aquiring leases, permits, consultants. and contractors. Two hundred copies of this handbook have been distributed. Fifty copies were distributed to the agricultural extension agents in southern Idaho.

3) A map of geothermal development potential in Idaho has been published by the Office of Energy which displays the current status of geothermal development, resource leasing, and potential resource locations. Six hundred maps were printed. Approximately two hundred maps have been distributed to interested individuals; an additional fifty maps were distributed to key state legislators.

The geothermal Outreach Program also provides technical assistance to prospective resource and project developers.

2.7.2 Summary of Contacts and Results

During the contract period, the Office of Energy provided technical assistance to eight industries, seven agribusiness organizations, three consulting firms, four units of local government, two federal agencies, one foreign government, and twenty-three individuals. Industrial and agribusiness inquiries were concerned with developing geothermal resources for food processing and ethanol production. Considerable interest has been expressed from individuals and agribusiness groups for information regarding ethanol production with geothermal energy. The majority of inquiries from local government and individuals were regarding space heating.

2.7.3 Prospectus of Future Geothermal Activity

Renewed public focus on energy matters has created an increasing interest in Idaho's geothermal resource, since southern Idaho's energy demand depends primarily on imported Canadian natural gas that is intimately tied to world petroleum market prices.

Interest in geothermal energy is increasing at an unprecedented rate. This trend is expected to continue in the forseeable future. The number of inquiries directed to the Idaho Office of Energy, ranging from homeowners and farmers to ministers of foreign governments, has grown at a nearly logarithmic rate in the recent past, and shows no sign of abatement. The focus of national interest on Idaho's geothermal resources has shown the State and the Office of Energy to be in the vanguard of developing direct use applications of geothermal resources. The State, through the Office of Energy, is proceeding in a timely manner in converting state buildings in the Capitol Mall to a geothermal energy source (space heating), and in encouraging similar developments in the public and private sector.

3.0 Summary of Major Findings and Recommendations

During the 1979 contract period, the Idaho Office of Energy has conducted preliminary institutional and economic evaluations on five resource locations within the State of Idaho. A major conclusion of this year's work is that at each location studied, geothermal resources were cost competitive with all other available energy forms. At the cities of Boise, Weiser, Fairfield, Hailey and Stanley, geothermal development is economically feasible today. As fossil fuel prices continue to rise, the economic advantage of geothermal resource development becomes more attractive at more and more locations throughout central and southern Idaho.

Idaho has abundant low and moderate temperature resources which could be developed for spaceheating and industrial applications at numerous sites. A major deterrent to developing these resources is the high risk of exploration drilling and the lack of available financing for drilling. There are numerous locations where developers are willing to use the resources if it is available but cannot assume the risk of drilling.

Institutional delays in leasing of National Forest Lands have retarded exploration for high temperature resources capable of electrical power production. Although fifteen geothermal exploration wells have been drilled in Idaho since 1974, no exploration has occurred on federal lands. This can be attributed to numerous institutional problems associated with the Federal geothermal leasing program.

The average time for processing a federal geothermal resource lease by the BLM in Idaho is 98 weeks. This is an excessive amount of time and indicative of numerous institutional delays.

Assistance programs in the areas of resource assessment and environmental review are needed to "fast track" development on private lands. Better loan mechanisms are needed to aid developers in exploration activities. Current HUD, HEW and EDA programs need to be expanded to provide direct aid to communities and school districts to develop geothermal resources. More funding is needed at the State level to assist local units of government, individuals, and small businesses develop geothermal resources.

Summary List of Topical Reports Developed During 1979 Contract Period:

Geothermal Energy Development In Idaho, Current and Potential, 1979 (Map)

Idaho Geothermal Handbook

Geothermal Energy for Idaho (Brochure)

Report To The Governor's Interagency Task Force on Geothermal Retrofit Of The Capital Mall

Weiser Hot Springs, Idaho, Site Specific Development Analysis

Hailey, Idaho, Site Specific Development Analysis

Fairfield, Idaho, Site Specific Development Analysis

Stanley, Idaho, Site Specific Development Analysis

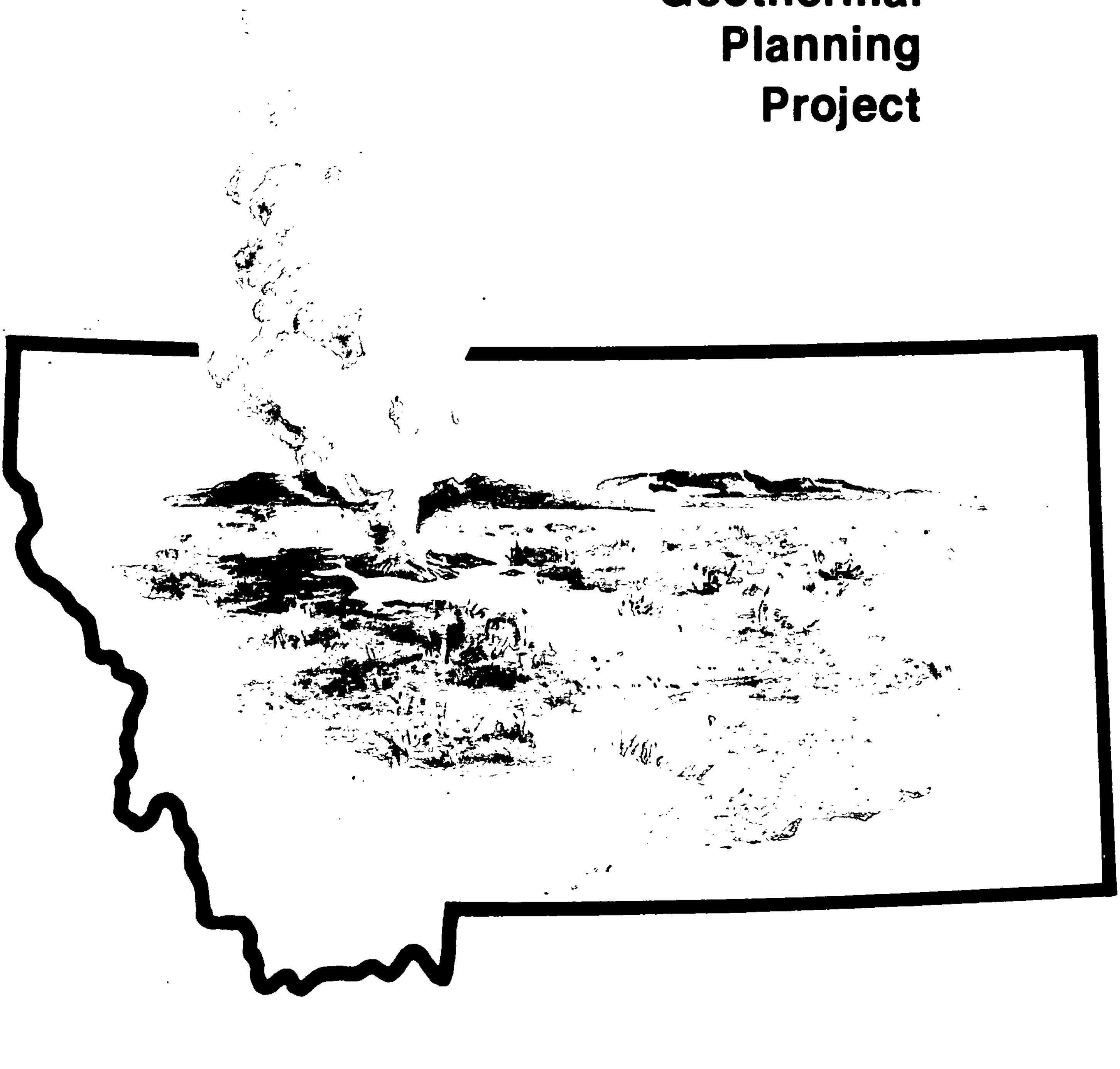
A Review of Institutional Factors Affecting Geothermal Resource Development In Idaho

Idaho Geothermal Industry: A Directory of Architects, Engineers, Geologist, Well Drillers and Consultants

Industrial Application of Geothermal Energy In Southeast Idaho

Chapter 5

Montana Geothermal Planning Project



MONTANA GEOTHERMAL PLANNING PROJECT

SEMI-ANNUAL PROGRESS REPORT

July - December, 1979

Prepared by:

Jeff Birkby
Michael Chapman

Energy Division
Montana Department of Natural Resources and Conservation
32 South Ewing
Helena, Montana 59601

Work performed under Contract No. DE-FC07-79ID12014
U. S. Department of Energy
Idaho Operations Office

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1.0 INTRODUCTION

The following document is the second semiannual report of the Montana geothermal team, comprising work performed mainly during the latter half of calendar year 1979 in accordance with Cooperative Agreement No. DE-FC07-791D12014 between the United States Department of Energy and the Montana Department of Natural Resources and Conservation.

The report contains the following information:

1. Area development plans for Area Four consisting of energy supply and demand figures, population projections, list of geothermal resources, and other considerations affecting geothermal development (see map, page 5, Appendix 2);

2. Site specific development analyses in progress at a number of locations;

3. State aggregation of projected geothermal energy on line; and

4. Results of outreach activities statewide.

This report contains neither an extensive analysis of institutional barriers and incentives to development nor a state geothermal plan. By late 1980, some of the projects now in planning stages may be ready for development. It is hoped that reports on the progress of these projects will provide the basis for a statewide policy encouraging geothermal development where appropriate.

2.0 SPECIFIC TASK DESCRIPTIONS AND PRODUCTS

2.1 GEOTHERMAL PROSPECT IDENTIFICATION

Classifying geothermal resources as inferred, potential, or proven is a qualitative and often ambiguous process.[1] Attempts to clarify definitions have suggested the following guidelines:

1) It may be inferred that a geothermal resource exists at a given site if:
   - there is some surface manifestation of geothermal activity (e.g., a seep or spring);
   - geothermometry provides evidence of elevated subsurface temperatures;
   - the site lies close to a potential or proven site.
2) An inferred source might advance to the potential category if:
   - geophysical studies indicate a high probability that a thermal reservoir exists;
   - test holes or other exploratory techniques confirm a high heat gradient or flow. Sites conforming to these characteristics are designated Pot 1 in Appendix 1;
   - surface manifestations indicate a large resource potential (i.e., relatively high temperature and flow). These sites are designated Pot 2 in Appendix 1;
   - there is a large flow of water at relatively low temperature. These sites are designated Pot 3 in Appendix 1. This condition normally indicates substantial mixing of geothermal with ground

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[1]Meyer & Davidson, 1978

water. While not useful for direct applications, Pot 3 sources may someday provide substantial amounts of energy to community-sized heat pump systems.

3) A potential resource may become <u>proven</u> if:
   - enough is known about the potential of a site to warrant the investment of money and capital to develop it.

Based on the foregoing, two depictions of Montana's geothermal resources were prepared -- the first a tabulation of data alphabetically by spring name, and the second a scatter-gram of the same figures by temperature and flow of surface manifestations (see Appendix 1).

Classification as proven or potential was determined; all springs lacking such designation are presently classed as inferred. A few of the springs are identified by name and number, notably those under study and others of interest for further study.

2.2 AREA DEVELOPMENT PLANS

2.2.1 STATE GEOTHERMAL PLANNING AREAS

Figure 1 shows the geothermal planning areas as set up by the geothermal planning team in 1977. All areas consist of multicounty units representing areas of similar geothermal manifestations. For example, in areas 3, 6, 8, and 10 geothermal resources arise from the Madison Formation, whereas areas 1, 2, 4, 5, 7, and 9 are primarily fault controlled areas. The Montana team has completed area development plans for areas 1, 2, 3, and 4 during the 1978 and 1979 contract years. Areas 5, 6, and 7 will be visited during 1980, and area development plans will be developed for them.

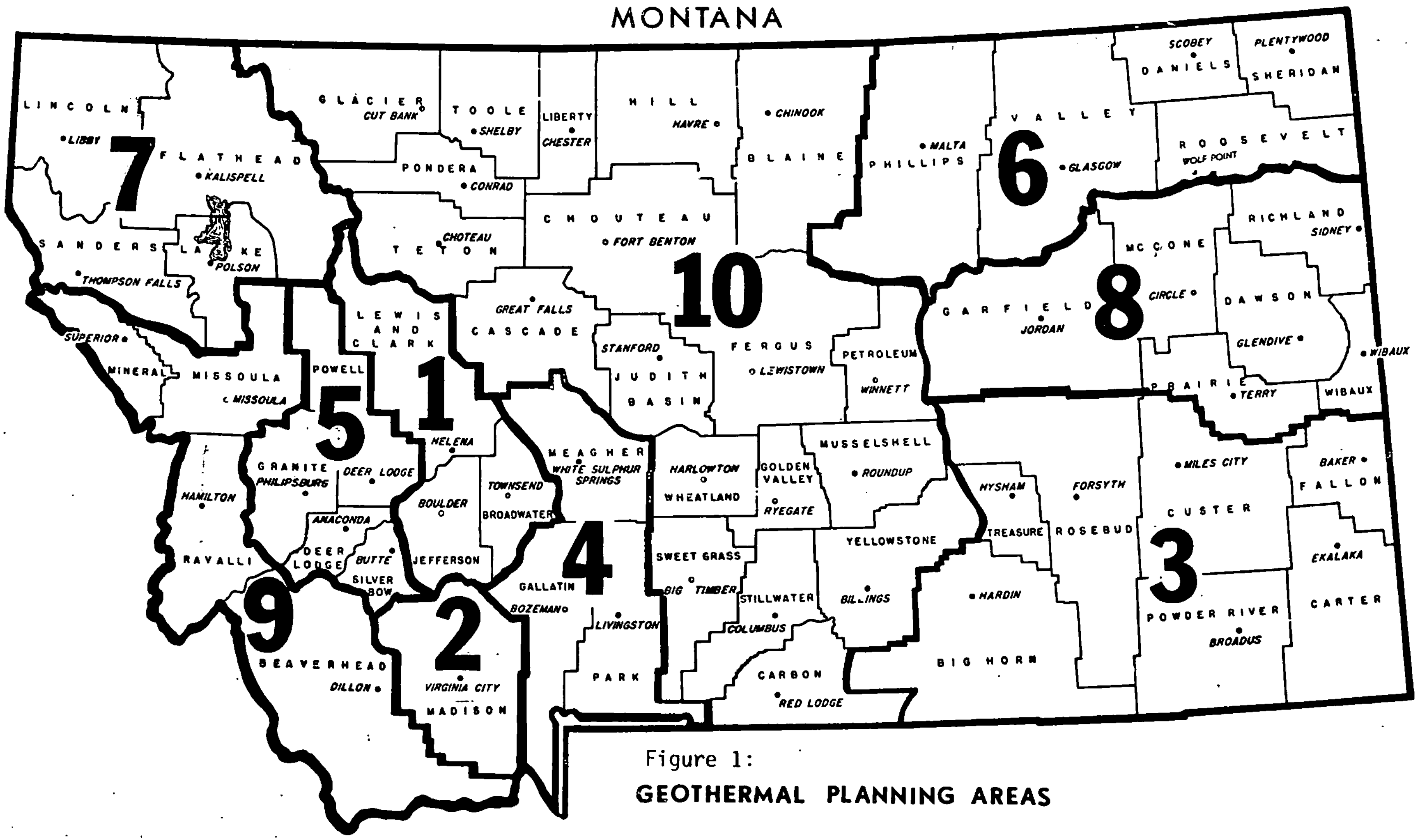


Figure 1:
GEOTHERMAL PLANNING AREAS

2.2.2 SPECIFIC ADPs, COMPLETED OR IN PREPARATION

Area Development Plans for Areas One, Two, and Three have been presented in previous reports. The completed Area Development Plan for area Four can be obtained from the Energy Division, Montana DNRC.

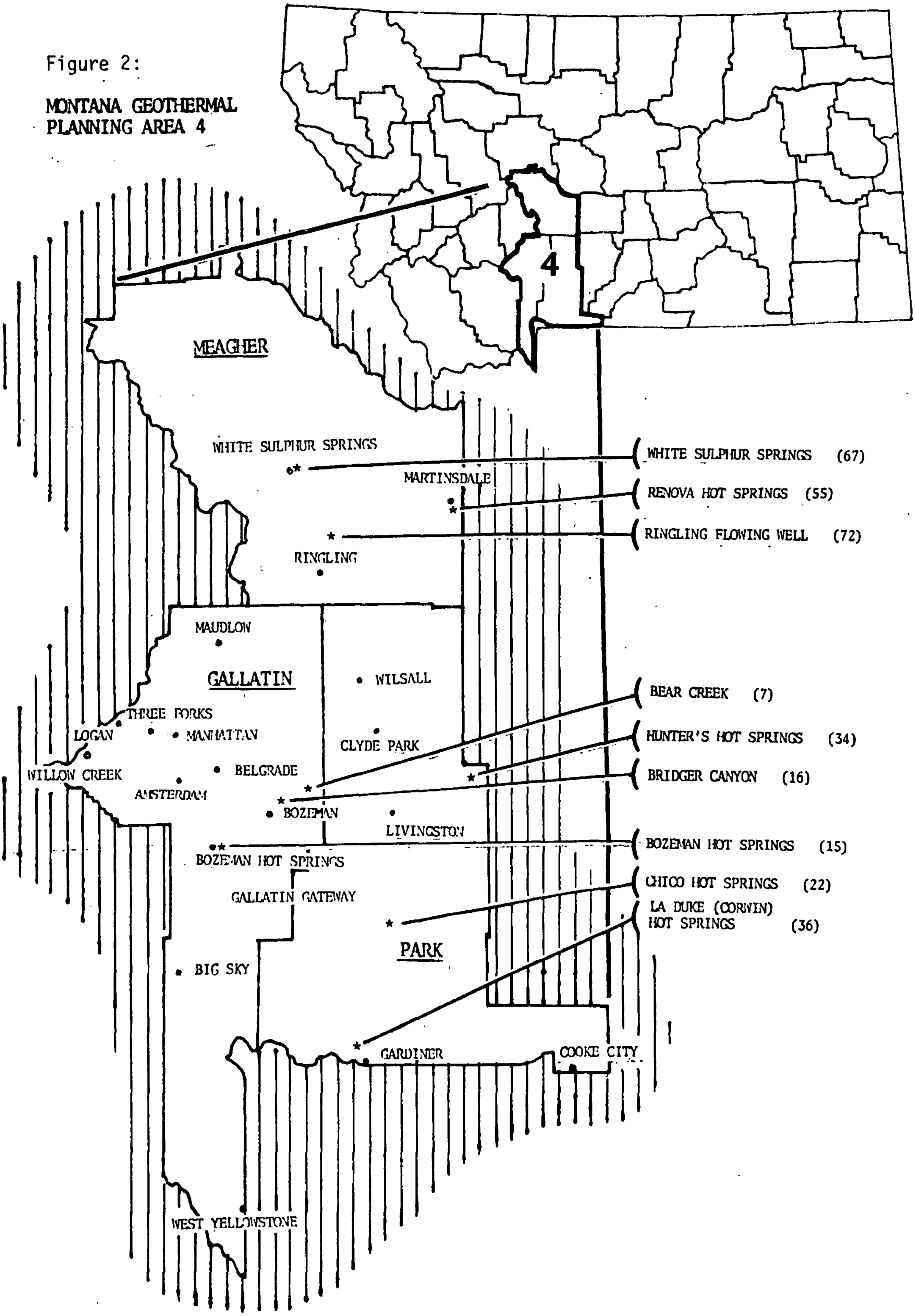
Area Four consists of Gallatin, Park, and Meagher counties in southwestern Montana (see figure 2). This area is primarily agrarian, with wheat, barley, and cattle production accounting for the majority of the area's economic base. Industry is limited, with an estimated 2.72×10^{12} Btu/yr consumed by manufacturers. Residential and commercial space heating in Area Four accounts for 4.15×10^{12} Btu/yr.

Six known hot springs and two hot water wells are found in Area Four. Geological Survey calculations indicate that an estimated 6.6×10^{12} Btu/yr may be recovered from Area Four geothermal resources. New Mexico Energy Institute calculations suggest that 0.34×10^{12} Btu/yr may be on line by 2020, which amounts to less than 10 percent of the present energy consumption in the area.

Primary applications for Area Four geothermal resources in the near future appear to be greenhouses, aquaculture, and other space heating. Interest in geothermal energy development in the White Sulphur Springs area is high, and a geothermal district heating system is a distinct possibility within the next few years.

Figure 2:

MONTANA GEOTHERMAL PLANNING AREA 4



2.3 SITE-SPECIFIC DEVELOPMENT ANALYSES (SSDAs)

2.3.1 CANDIDATE GEOTHERMAL SITES/APPLICATIONS

At present, no site specific development analyses have been completed for Montana. Further refinement of the listing in the Baseline document and the mid-term report indicate the following as most likely candidates for SSDA's in 1980:

1. Boulder Hot Springs

Stuart Lewin, owner, plans to build a greenhouse complex near the resort to grow either produce, tree seedlings, prawns, fish, or a combination of these. To date, a wood-frame, plastic-covered greenhouse has been built by Bob and Peggy Johnson (managers of Boulder Hot Springs). It is heated by water gravity fed from the hotel through 13 recycled radiators. The geothermal team is planning to help Boulder apply for financial aid through the FY1980 Appropriate Technology Small Grants Program. An industrial park has been proposed for the town of Boulder to make use of geothermal waters, should the resource prove sufficient, but it is at best several years away.

2. White Sulphur Springs

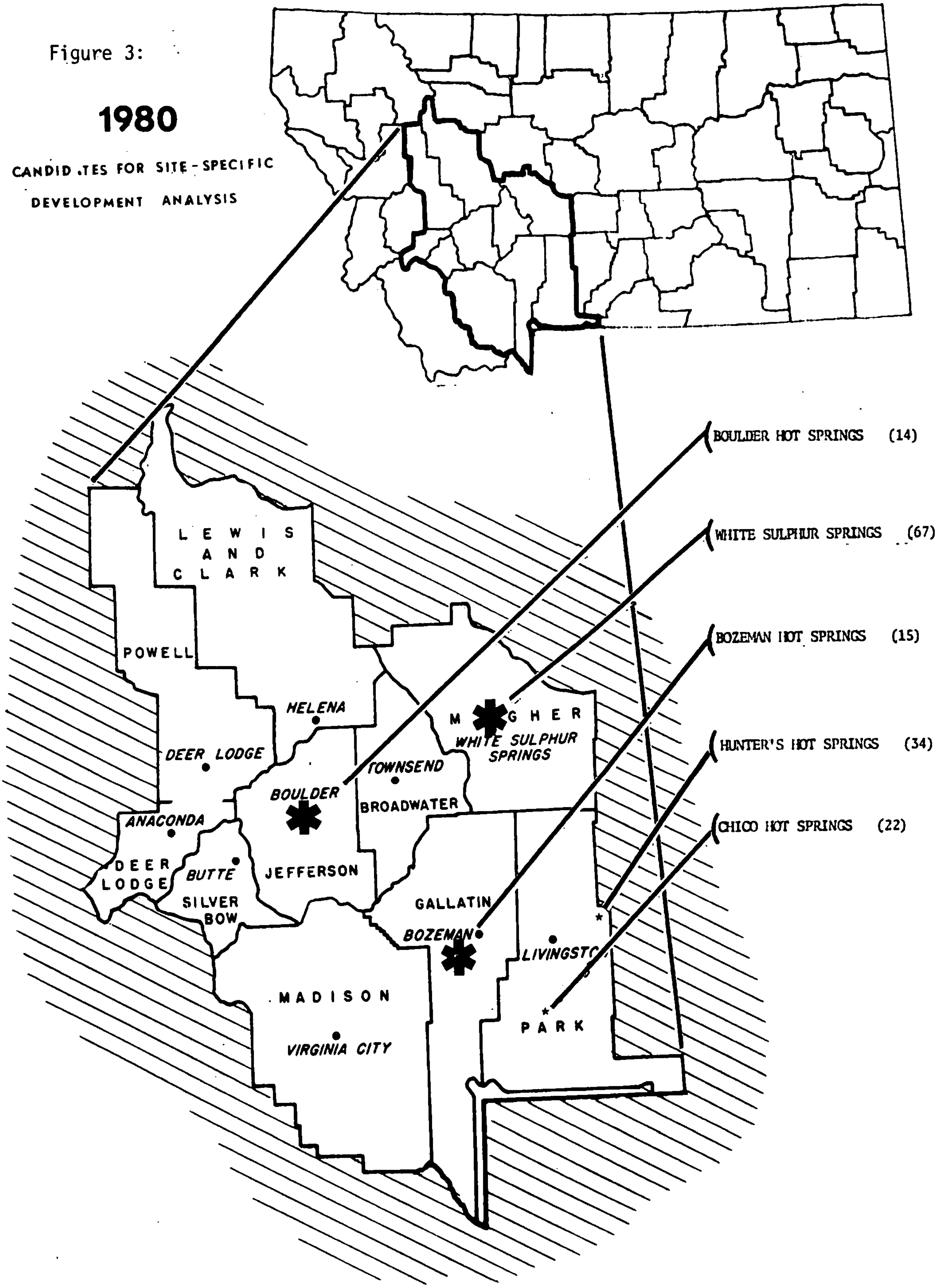
A motel and hot pool utilizing geothermal energy have been in operation here for years. A state renewable energy grant for space heating the First National Bank was authorized in 1977. Since then, a new well has been drilled, piping laid, and the new bank building completed. The whole system is complete except for the finned tube heat exchange coils slated for installation late in January.

Bank President Michael Grove is an enthusiastic advocate of geothermal energy. He has suggested a district heating system for White

Figure 3:

1980

CANDIDATES FOR SITE-SPECIFIC DEVELOPMENT ANALYSIS



Sulphur Springs and recently submitted a proposal for a geothermally based ethanol plant.

3. Bozeman Hot Springs

Charlie Page, owner of the springs/campground complex, used a state grant to drill recently beyond the depth of his original spring well into bedrock. He was hoping to hit a productive fissure of hotter water or at least to measure accurately the bedrock temperature. This would indicate whether deeper drilling might be justified. To date the project has been stalled by caving or debris that has filled in the bottom of the hole.

Whether or not the bottom hole temperature indicates a high probability of drilling into a large reservoir, other shallower production layers are available that should allow Page to expand his operation. He has been hit by the decline in tourism resulting from fuel price hikes, and is looking toward greenhouses or aquaculture as a chance to diversify.

4. Other Areas

There are three other Montana sites in addition to the above that seem to have high potential for site-specific analysis, and which might come to prominence within the next year or two. Each is attractive for a different reason.

a) Hunter's Hot Springs. Although presently undeveloped, there is increasing interest in the private development of a large greenhouse complex and cascaded aquaculture system. This is perhaps the most promising of Montana's resources in terms of temperature and flow.

b) Chico Hot Springs. A grant has recently been approved (12/79) for a pioneering demonstration project - heating a hotel with a geothermal heat pump driven by locally generated hydropower.

c) Madison Formation. This major geothermal aquifer underlies vast areas of eastern Montana and is the location of numerous oil explorations. If a simple and economic procedure for converting oil wells to geothermal production can be developed, and the technical problems of using waters often heavily laden with minerals can be overcome, then the Madison Formation shows good potential of becoming a major energy system in a geothermally undeveloped region.

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2.3.2 SSDAs - COMPLETED OR IN PREPARATION

Strategy for completing SSDAs for the above sites is threefold. Specifically:

1) Assessing broad potential for economic feasibility using the New Mexico Energy Institute (NMEI) site-specific analysis support. Modifications of base case parameters will be worked out in conjunction with resource developers based upon such factors as intended use, funding sources, and development costs.

2) A program for optimum use of each geothermal site will be established, using data from NMEI and other sources. The program will be based on the quality of the geothermal site and its market potential.

3) Finally, a time-phased schedule will be produced identifying major tasks and milestones based on best estimates of time and material required and incorporating prior experiences of geothermal developers, where applicable.

The site specific analyses described above should be in advanced stages for the next semiannual report and hopefully will be completed by the end of 1980.

2.4 TIME PHASED PROJECT PLANS

2.4.1 ACTIVE DEMONSTRATION/COMMERCIALIZATION PROJECTS

There are only two commercial-level geothermal projects aside from long-established balneological resorts. One of them, the Hillbrook Nursing Home at Alhambra (near Helena) has been in operation since the early '70s and employs a radiant heating system of gravity-fed plastic pipe imbedded in the floor of the complex. Since the system has been operated for some time, it is not a suitable candidate for a time-phased project plan.

The other commercial-level project presently operating is the new Broadwater Health Spa in Helena. It features a thermostatically-controlled water-air heating system, stainless steel plate heat exchanger, and a domestic hot water heating system. Geothermal water for the system measures 150^{o}F (65.5^{o}C) and flows at about 150 gpm (568 lpm). Unfortunately, it is also a poor candidate for a time-phased plan, because the developer, Frank Gruber, has accomplished the project almost singlehandedly and has kept no written records. The project was completed without government assistance at a cost of about a million dollars.

Two other projects are approaching completion and should be in operation by the end of 1980. One of them is the state-funded White Sulphur Springs development suggested for site specific analysis above. The other is a DOE-funded drilling and retrofit space heating program at Warm Springs State Hospital. The latter is being administered by MERDI, the Montana Energy and MHD Research and Development Institute in Butte.

2.5 STATE AGGREGATION OF PROSPECTIVE GEOTHERMAL UTILIZATION

An estimate of possible geothermal energy on-line is presented in table 1. The data, produced by computer simulation modeling at NMEI, Las Cruces, postulates the amount of geothermal energy that could conceivably be developed between 1980 and 2020. The computer program contains over 80 variables, including transmission distance, equipment costs, financing costs, degree days and population for each potential site.

However, one should use caution in the interpretation of the data. For example, one basic assumption in the computer model is that geothermal energy resources will be developed as soon as the cost of development is economically competitive to conventional fuels. This assumption may be true. In some instances a geothermal resource may be developed even if it is uneconomical to do so, while in other cases a geothermal resource may remain undeveloped in spite of its economical attractiveness. Also, the model uses postulated reservoir temperatures developed by USGS and other investigations. Since geothermal resources in Montana have, at best, only rough volumetric estimates, the values used in the model are only estimates.

Further, energy costs are assumed to increase in real price at a rate of five percent per year. But the real cost of energy in Montana is running far higher and has done so for some time.[2] This could have the effect of making geothermal cost effective years earlier than projections indicate. Therefore, the value of the computer analysis will increase as old variables are refined and new ones are added.

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[2] Itami, 1979; Montana Public Service Commission, 1979.

Table 1.

GEOTHERMAL ENERGY ON-LINE PREDICTIONS*

Energy On-Line (in Btu/yr)

Area	1980	1985	2000	2020
1	0	1.94×10^{12}	5.40×10^{12}	7.43×10^{12}
2	0	0.38×10^{12}	0.44×10^{12}	0.53×10^{12}
3	0	0	0	0
4	0	0.28×10^{12}	0.31×10^{12}	0.34×10^{12}
5	0	5.15×10^{12}	7.65×10^{12}	8.21×10^{12}
6	0	0	0	0
7	0	0.18×10^{12}	0.20×10^{12}	0.23×10^{12}
8	0	0	0	0
9	0	0.01×10^{12}	0.05×10^{12}	0.06×10^{12}
10	0	0.11×10^{12}	0.13×10^{12}	0.17×10^{12}
AREA TOTALS	0	8.05×10^{12}	14.18×10^{12}	16.97×10^{12}

Source: New Mexico Energy Institute 1979b.

* Predictions are for 20 potential sites developed by city utilities for both residential and industrial use.

2.6 INSTITUTIONAL ANALYSIS

A major change in state law pertaining to geothermal energy went into effect July 1, 1979. Before that time, the state's Major Facilities Siting Act made the same strict requirements for all geothermal production as it did for large power facilities. The new amendment exempts geothermal energy from the permit process if the facility generates less than 25 megawatts.[3] This excludes almost all uses of geothermal energy in the state, although large electrical generating plants would still be subject to the law.

Another institutional barrier to geothermal energy development in the state deals with the conversion of oil wells to geothermal wells in eastern Montana. A streamlined procedure for allowing such a conversion to take place on state lands might increase the geothermal development potential tremendously (barring other difficulties), since the cost of converting an oil well to a geothermal well is significantly less than the cost of drilling a new well. The geothermal planning team is investigating the feasibility of developing a standard state procedure to clear the way for such a conversion.

No change has occurred in the state leasing policy for new geothermal exploration. Presently the state will not allow drilling on state lands without competitive overlapping interest in an area. This effectively excludes a developer from drilling in an area in which he alone has interest. The geothermal team hopes to work with the stage agency responsible for this policy (Department of State Lands) in an effort to change this regulation.

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[3]Title 75, Chapter 133, 1979, MCA.

2.7 OUTREACH

2.7.1 PUBLIC OUTREACH

Outreach activities from midsummer through the end of the year have consisted primarily of telephone conversations and visits to spring owners and letter responses to others with specific requests. There is strong interest in Montant in many geothermal development applications including agribusiness, heating, heat pumps, and industrial processes.

The geothermal team has assembled a packet describing available programs in response to inquiries about grant programs and other financial incentives.

Interest in geothermal greenhouse and aquaculture development seems to be growing in direct proportion to fuel costs. Hot spring owners are beginning to look seriously at the costs of importing fresh vegetables, seafoods, etc., with an eye toward competing for potentially lucrative markets with hydroponic/geothermal produce. The geothermal office is therefore accumulating information on these enterprises both from published articles and from owners of operating systems.

Heat pumps show great promise for heat extraction from geothermal resources of low temperature and/or flow rate by increasing system coefficient of performance. The heat pump opens up a whole new area for the use of resources heretofore not feasible for heating.

A number of new outreach activities are planned for 1980, including a news publication chronicling present geothermal activities to be distributed to developers, hot spring owners, and other interested individuals. Newspaper coverage is planned for dedication ceremonies at White Sulphur and perhaps at Broadwater. The team also plans to produce a photo or slide display for local presentation to interested groups throughout Montana. Quicker response to requests for information will be provided by a cross-referencing index system for the technical materials in the geothermal library. Finally, the publication of a geothermal brochure is planned, similar to numerous other state materials on alternative energy.

2.7.2 SUMMARY OF CONTACTS AND RESULTS

Nearly everyone who has contacted the geothermal office has requested grant information for specific projects in early phases of development. Geothermal team response has usually consisted of providing a prepared packet of grant and loan program information, researching questions remaining and making personal visits to prospective sites for inspection and to offer assistance.

Interest is high in geothermally heated commercial greenhouses. The owners of Boulder, Bozeman, and Hunter's Hot Springs have expressed keen interest in trying to supply their local areas with fresh produce year- round. Bob and Peggy Johnson, who are managing Boulder Hot Springs for owner Stuart Lewin, contacted the geothermal office for heat-loss calculations in order to size a geothermal heating system for a prototype plastic-covered greenhouse now in operation. Charles Page at Bozeman Hot Springs has recently purchased 18 acres adjacent to the springs area with greenhouses in mind and with grant money in pocket to drill more wells. Harold Johnson, owner of Hunter's, and Harvey Bell of Big Timber are contemplating a partnership greenhouse/aquaculture operation that may require little or no funding but could make good use of technical and engineering assistance from EG&G.

Given the scale of geothermal resources available, rapidly rising shipping costs, and the fact that Montana is a heavy net importer of produce, greenhouse operations seem to have great potential, economically and environmentally.

Two areas of incipient but rapidly expanding interest are district heating and the direct use of low temperature geothermal waters (down to about $50^{o}F/10^{o}C$). Both of these increase greatly in their attractiveness when integrated with heat pumps. Literature recently received at the office includes material from the National Water Well Association in Worthington, Ohio, on heat pump systems[4]; studies from Argonne National Laboratories in Argonne, Illinois[5]; publications from EG&G[6]; and information on large-scale heat-pump projects such as the Mormon Church office buildings in Salt Lake City[7]. In the coming year the geothermal team plans to compile a brochure for Montanans on heat pump systems, their availability, performance, and costs.

Heat pumps offer the potential to multiply the "geothermal market" many fold and reduce net energy consumption in the long run. If district heating in Montana is ever to become a reality, the heat pump may well be the key element in making it possible.

A final key outreach effort has been a concentration on resource assessment. Several potential developments, notably at Boulder and Bozeman, will require additional study to aid decision making on major

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[4]NWWA, 1978.

[5]Schaetzle and Everett, 1979.

[6]Keller, 1977; Briggs and Schaffer, 1977.

[7]Ellingson, 1979.

development plans.

2.7.3 OVERALL PROSPECTUS FOR FUTURE GEOTHERMAL ACTIVITY

Interest in direct-use applications of geothermal energy is definitely on the increase, in part due to economic pressures and growing awareness of alternative energies in general. Some credit, too, must go to the outreach efforts of past and present geothermal team members. In the case of Hunter's Hot Springs, for instance, a personal visit rekindled an old interest and the owner contacted a potential developer the following day. Since then there have been several discussions of costs, techniques, and the availability of engineering help. Both men are now interested in developing an extensive greenhouse complex.

Some geothermal resources, notably those with higher temperatures, seem likely to be developed within ten years as fuel costs climb, and those already developed will probably expand if the resource proves to be great enough. Some resources, already developed, may be able to expand and diversify simply by making use of waste water, such as overflow from a pool, perhaps to heat another facility, irrigate, or raise fish.

Marginal systems, with rather low temperatures and/or flow, may be augmented by drilling, pumping, or by integrating the geothermal resource into fossil fuel, heat pump, solar, or other systems.

There seems to be a likelihood of short and long-term success of local, diversified production activities like geothermal greenhouses considering the cost of imported produce and the heating costs of conventional greenhouses which nonetheless are prospering. Studies are being undertaken on the marketability of greenhouse produce in Montana and elsewhere.

One other major "new" development in Montana that might radically alter the use of ground waters is the heat pump. The acceptance of such systems is contingent upon many variables, such as the economic picture and the likelihood of electric power shortages in the future. The combination of heat pump and low-grade geothermal waters seems to be a logical way for geothermal development to expand in the comming years.

3.0 MAJOR FINDINGS AND RECOMMENDATIONS

The move toward greater geothermal use in Montana is gaining momentum, in part due to the efforts of the state geothermal team. The period of preliminary resource compilation and initial contact with owners and managers is drawing to a close and specific projects are beginning to occupy a greater proportion of time.

This transition in emphasis from planning to projects, is altering and rendering rendering more specific the future direction of geothermal team activities. For instance, in the past it has been possible to rule out electrical production from the list of potential geothermal applications. Now it seems possible to go farther and state that the major interests in direct-use categories for major springs are currently centered on space heating for greenhouses and aquaculture, and the potential of heat pumps for "wringing the last Btu" out of low temperature resources, including cold-water wells. The current plans of resource owners and operators in turn raise specific questions susceptible to research by the planning team. What economic environment faces greenhouse/aquaculture development? What factors are likely to affect the growing and marketing of produce (e.g. fuel prices, health regulations, the limiting factor of winter lighting, shipping costs)? Can a geothermal greenhouse feasibly be integrated with, say, solar design to increase total production capacity? These and other questions provide targets for research in the coming year.

Eastern Montana, with an abundance of open land and sunny days, plus the warm waters of the Madison Formation, would also seem to be a natural candidate for extensive greenhouse development. But high well drilling costs in all areas, and high mineral content of geothermal waters in more localized areas call into question the economic feasibility of development. If an equitable and efficient means can be found for converting unsuccessful oil wells (or those about to be abandoned) to geothermal production, significant geothermal development is likely to occur. To find such a means of completing and transferring authority over and responsibility for these wells is a major objective for 1980. At present, those areas further burdened with heavy gypsum scale seem to be economically undevelopable, since water treatment to avoid scaling is expensive. These conclusions, however, are tentative. To confirm them will command considerable effort in the comming year. Study of local market potentials will be coordinated with the NMEI computer program to help setter geothermal developers toward the most proimising alternatives.

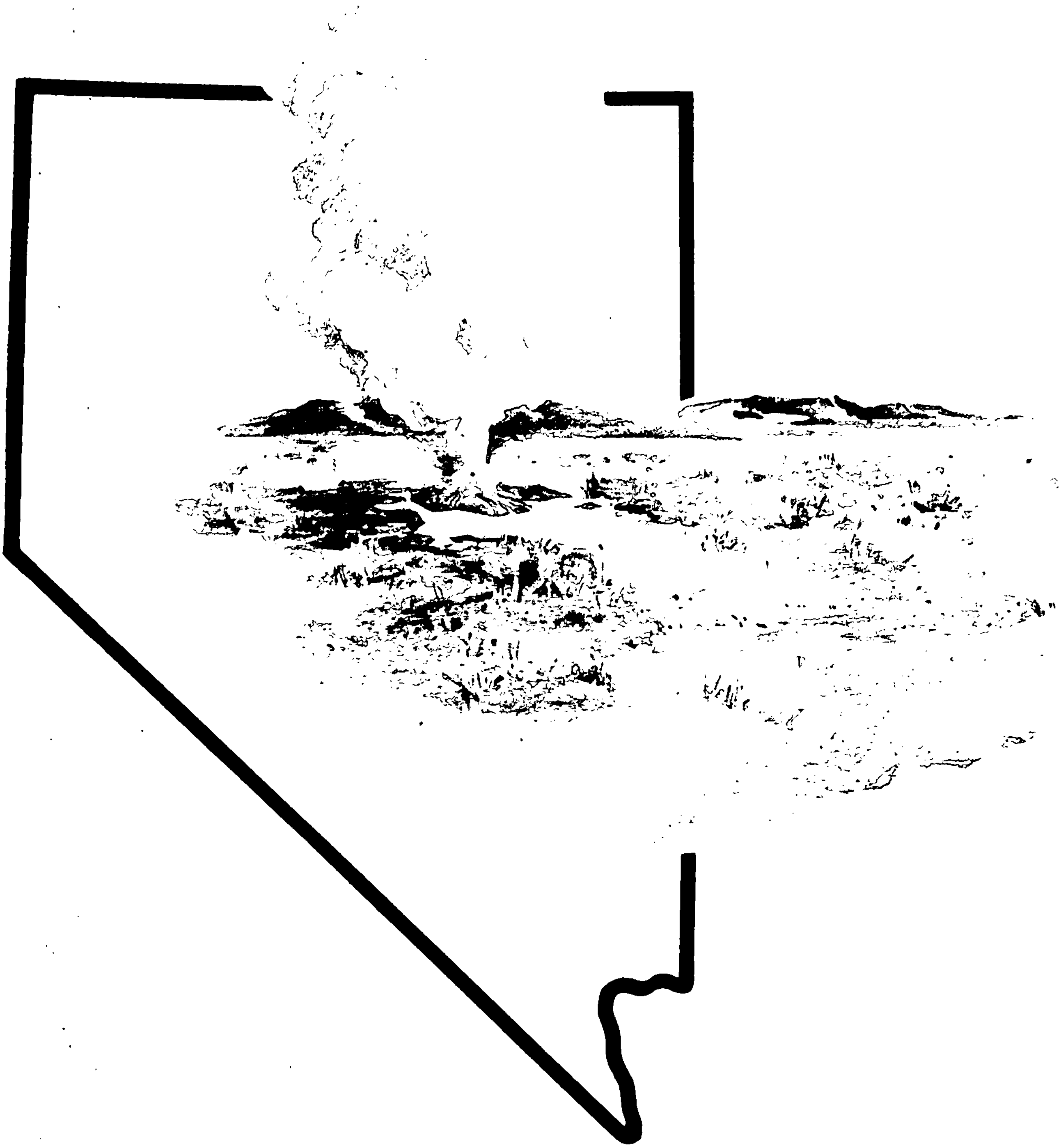
One major task has been to establish a system of organization for previously random information. The aim of this effort is to establish a cross-referenced card file for immediate response to requests.

The geothermal team was actively supportive of a proposal for expanded geothermal resource exploration by the State Resource Assessment Team. That work begins in January, 1980, and will continue for the following year and a half to evaluate the potential of three or four possible resource areas.

The team has also been able to research and deliver information to prospective developers, ranging from heat flow calculations to grant programs, and will expand that role. In at least one case (Hunter's Hot Springs) the act of contacting the spring owner clearly amplified his interest and reactivated a stalled project.

Chapter 6

Nevada Geothermal Commercilization Planning



NEVADA GEOTHERMAL COMMERCIALIZATION PLANNING

SEMI-ANNUAL PROGRESS REPORT

July - December, 1979

Prepared under the direction of:

Noel A. Clark
Kelly L. Jackson

By: Maggie Pugsley

Nevada Department of Energy
400 West King Street
Carson City, Nevada 89710

Work performed under Contract No. DE-FC07-79ID12019
U. S. Department of Energy
Idaho Operations Office

1.0 Introduction

1.1 Purpose of Project

The purpose of Nevada's participation in the Geothermal Commercialization Planning Project (GCPP) is to undertake those planning, technical assistance, and outreach activities that are necessary to stimulate the development and utilization of the geothermal resources found in the state of Nevada.

1.2 Objectives

The objectives of the Nevada Department of Energy (NDOE) in this planning project are:

1. To collect and compile available information regarding the location and quality of Nevada's geothermal resources.
2. To identify potential applications of Nevada's geothermal resources.
3. To evaluate the electric and non-electric energy potential of the geothermal resources that are located in this state
4. To project the likely time frame for the development of Nevada's geothermal resources.
5. To distribute useful geothermal information to public and private organizations that will influence the course of geothermal development and to those persons who are interested in using geothermal energy.
6. To provide direct technical assistance to developers of Nevada's geothermal resources.
7. To serve as a clearinghouse for geothermal information including technical assistance, financial assistance and general information.

8. To identify and remove reasonable institutional barriers to geothermal development.

1.3 Technical Approach and Team Members

The goal of Nevada's GCPP is to meet the objectives outlined above. To meet these objectives the team members are:

1. Collecting and assessing information on Nevada's geothermal resources.
2. Collecting and analyzing information regarding geothermal exploration activities in Nevada.
3. Collecting and developing information regarding industrial, commercial, and residential geothermal applications.
4. Preparing Area Development Plans.
5. Preparing Site Specific Development Plans.
6. Preparing pamphlets and other documents on geothermal energy and its development for distribution to the citizens of Nevada.
7. Providing information and/or technical assistance to the developers of Nevada's geothermal resources.
8. Distributing information through meetings, person to person contacts, or other outreach activities.
9. Reviewing state statutes, regulations, and proceedures to identify and eliminate barriers to geothermal development.
10. Reviewing state and local statutes, regulations, and procedures to identify opportunities to stimulate geothermal development.

Team members for the Nevada GCPP are:

Noel Clark Director Nevada Department of Energy	Kelly Jackson Deputy Director Nevada Department of Energy
Maggie Pugsley Urban Planner Nevada Department of Energy	Rich Sasek Engineer Nevada Department of Energy

In addition to the permanent professional staff, public service interns and various consulting firms have been used as necessary.

1.4 Benefits of the GCPP to the State and the Department of Energy

The benefits associated with the GCPP include:

1. Facilitating the collection of baseline geothermal data that will enable the state and its political subdivisions to:
    a. Identify opportunities to develop geothermal resources as an adjunct to state and regional planning.
    b. Identify potential socio-economic and environmental impacts of geothermal development and to take appropriate measures to mitigate any negative impacts.
2. Providing the NDOE with the opportunity to identify methods by which the state can promote geothermal development by eliminating existing barriers or enacting needed incentives.
3. Providing interested parties with information and technical assistance regarding the development of geothermal resources.

4. Providing the NDOE with the ability to develop an inhouse professional staff with the ability to stimulate geothermal development.
5. Providing the framework to inform the general public about the electrical and non-electrical geothermal in potential in Nevada.
6. Providing the opportunity to develop an informal communication network that enables the NDOE to direct interested parties to organizations capable of providing necessary information and/or technical assistance.
7. Developing the following project products:
   a. Washoe County Area Development Plan (Appendix 2).
   b. Carson City Area Development Plan (Appendix 3).
   c. Geothermal Energy-Resource and Regulation (pamphlet still in printing stage).
   D. Institutional Handbook.

   The primary benefit of the Nevada GCPP to the Department of Energy has been the development of information that will assist in regional and national energy planning.

2.0 Summary of State Project Tasks

Task 1-Area Development Plans

Two geothermal resource areas in Nevada (Washoe County and Carson City) have been studied and the Area Development Plans prepared (Appendix 2 and 3).

Task 2 - Site Specific Development Plans

Three sites in Nevada have been identified as possible locations for the preparation of Site Specific Development Plans: City of Caliente, Crescent Valley, and DaMonte Ranch. Compilation of data for the Site Specific Development Plan for the City of Caliente has begun.

Task 3 - Time Phased Project Plans

To date, the NDOE has not identified any time phased project on which to develop such a plan. Consideration is being given to Brady Hot Springs in Churchill County and Elko Hot Springs in Elko County.

Task 4 - Institutional Analysis

The NDOE suggested several pieces of legislation to the 1979 session of the State Legislature. Two such pieces of legislation were enacted. The department has completed an institutional handbook analyzing various institutional barriers to geothermal development in Nevada. The handbook is designed to assist developers of geothermal resources in Nevada understand the legal requirements governing geothermal development in the state. The NDOE is currently reviewing additional tax, resource, and marketing legislation that will be proposed to the 1981 session of the Nevada Legislature.

Task 5 - Outreach

The following outreach activities have occurred to inform the citizens of Nevada about the state's geothermal energy resources and the potential for their development:

1. NDOE staff has made television and radio appearances.
2. Newspaper articles have been published.
3. A pamphlet describing Nevada's geothermal resources has been prepared.
4. An eight hour presentation was made to the Nevada State Energy Advisory Board on geothermal energy and its development potential in Nevada.
5. Verbal and written information was distributed to interested citizens of the state.

Task 6 - State Market Penetration Analysis

Required information was collected and transmitted to the NMEI for computer modeling. The model has been run and the resultant information returned to the state for analysis.

2.1 Geothermal Prospect Identification

All updated information concerning Nevada's geothermal resources are contained in the U.S.G.S. GEOTHERM file. Changes and additions to this file are made continually as new information is either collected or received by the State Geothermal Resource Assessment Team at the Nevada Bureau of Mines and Geology. Their most recent publication, Thermal Waters of Nevada, by Larry Garside and John Schilling summarizes this data file. New information on Nevada's geothermal resources is continually being added to the GEOTHERM file from such sources as the industry coupled program, other drilling programs, and contacts with geothermal development companies.

2.2 Area Development Plans

2.2.1 State Geothermal Planning Areas

The State of Nevada has been divided into eleven geothermal resource planning areas (Appendix 1). The planning areas were drawn along county lines and were defined on the basis of the geothermal resources available, population, and economic impact factors. Though defining geothermal resource areas on the basis of similar geological features is more scientifically sound, this method was not chosen because of the difficulty in obtaining demographic, socio-economic, and energy consumption data on anything other than a statewide or county basis. The geothermal resource planning areas and the order in which the Area Development Plans are anticipated to be completed are:

	Area	Completion Order
1.	Washoe County	1
2.	Humboldt and Pershing Counties	8
3.	Elko County	6
4.	Carson City	2
5.	Churchill, Lyon, Douglas, and Storey Counties	3
6.	Lander and Eureka Counties	9
7.	White Pine County	5
8.	Mineral and Esmeralda County	7
9.	Nye	11
10.	Lincoln County	4
11.	Clark County	10

2.2.2 Specific Area Development Plans

Two Area Development Plans have been completed by the Nevada Department of Energy: Washoe County and Carson City. The Washoe County Area Development Plan covers a 4,074,240 acre area in northwestern Nevada. There are six major geothermal anomolies in this area: Steamboat Hot Springs, Moana Hot Springs, the Needles Rocks, Gerlach Hot Springs, Ward's Hot Springs, and San Emedio Desert Hot Springs. The Carson City Area Development Plan covers a 94,034 acre area immediately south of Washoe County. This area has three geothermal anomolies: Carson Hot Springs, Prison Hot Springs, and Pinyon Hills. Each of the Area Development Plans contained three major sections: a description of the area; a description of the resource; and a description of the potential uses of the resource. The description of the area included such factors as relief, vegetation, climatic conditions, land use and land ownership, transportation facilities, economic base, energy use, and design information. The description of the resource included such factors as it's location, history of past uses, and physical characteristics. In the Washoe County Area Development Plan an exploration history was also included.

The conclusions reached about the various resources and the potential energy savings resulting from the development of these resources are summarized below:

Washoe County

The six major geothermal sites in Washoe County are all moderate to high temperature sites. Steamboat Hot Springs has an estimated reservoir temperature of 392° F; Moana Hot Springs has an estimated reservoir temperature of 240°F; the Needles Rocks has an estimated temperature of 253°F; the Gerlach Hot Springs an estimated temperature of 352°F; Ward's Hot Springs an estimated temperature of 226°F; and the San Emedio Desert Hot Springs an estimated temperature of 330°F. Based on the information presented in the Area Development Plan the following appeared to be the most promising applications of the geothermal resource at this time:

Steamboat Hot Springs

- Electrical generation
- Recreation
- High, medium, and low process heat
- Individual, district, and industrial space heating

Moana Hot Springs

- Individual and district space heating
- Greenhousing
- Commercial, and domestic hot water
- Recreation

The Needles Rocks

Individual and industrial space heating

Recreation

Low and medium temperature process heats

Gerlach Hot Springs

Electrical generation

District and individual space heating

Domestic, Industrial, and commercial hot water

Ward's Hot Springs

Individual space heating

Industrial space heating

Low to medium process heats

Domestic, industrial, and commercial hot water

San Emedio Desert Hot Springs

Electrical generation

Individual space heating

Calculations were made as to the amount of fossil fuel energy that could be saved by using geothermal energy in place of conventional fuels. Estimates indicate that if only five percent of the total energy demand of Washoe County could be filled with geothermal energy about 4.74×10^{14} BTU's of fossil energy could be saved. In addition, if only one 50 megawatt electrical generations plant could be made operational in 1885, by 2000 2.24×10^{13} BTU's could be generated.

Carson City

All three sites found in Carson City are low to moderate temperature resources. The hottest potential site is Pinyon Hills with an estimated reservoir temperature of about 212°F; Carson Hot Springs is the second hottest with an anticipated reservoir temperature of 167°F; and the coolest is the Prison Hot Springs with an anticipated reservoir temperature of 86°F. The following applications seem to be the most promising to develop at this time:

Carson Hot Springs

Recreation

Residential space heating

Commercial, industrial, and domestic hot water

Greenhouses

Aquaculture

Prison Hot Springs

Aquaculture

Greenhouses

District space heating

Pinyon Hills

Residential space heating

District space heating

Because of the limited nature of the geothermal resource in Carson City the amount of fossil fuel energy that could be saved by the development of geothermal energy is anticipated to be moderately small. If five percent of the total energy demand of Carson City could be filled with geothermal energy, by the year 2000 3.84×10^{13} BTU's of fossil energy could be saved. It was further estimated that if 50 all electric homes, 50 homes using natural gas or oil for heating, and one 10,000 square foot greenhouse were either constructed or converted to use geothermal energy for heating purposes only, 3.8 x 10^{12} BTU's of fossil energy could be saved by the year 2000. Even this limited type of development could dave about 650,000 barrels of crude oil.

2.3 Site Specific Development Plans

2.3.1 Candidate Geothermal Sites

Three site specific locations have been selected for study:

1. City of Caliente - Caliente appears to have much potential for geothermal development. At present it has a 50 space trailer park that has already been converted to geothermal heating with an Appropriate Technology Grant in 1978. Another Appropriate Technology Grant has been awarded to the Grover C. Dils Medical Center to convert the heating system to use geothermal energy. The City of Caliente is interested in the feasibility of installing a district heating system or using the available resources to attract industry to create new jobs. They submitted a proposal to the U.S. Department of Energy for $75,000.00 to do geophysical, economic, and engineering work.

The Nevada Department of Energy and the Oregon Institute of Technology have had several meetings with town officials and have visited the site to make preliminary recommendations. The Oregon Institute of Technology is currently preparing an economic analysis of the project under the 100 hour program. The Nevada Bureau of Mines and Geology has completed an assessment of the reservoir. Before making the final report, however, the results of water samples taken must be received and analyzed. Caliente is a UDAG community. It is hoped that funds to drill two 500 foot wells, and develop a district heating system can be obtained through U.S.DOE and/or UDAG grants.

2. Crescent Valley - The Half Circle Ranch Development Corporation of Salt Lake City, Utah is interested in developing an ethanol production plant on the Half Circle Ranch in Crescent Valley, Nevada. The Half Circle Ranch is located in Eureka County between the towns of Beowawe and Crescent Valley. The western edge of the development borders on Lander County. The combined population of these two counties in the 1970 census was about 3,600 people. Both Beowawe and Crescent Valley have populations of 100 persons or less.

   The project will use geothermal energy in the production of alcohol, processing of feed stock, production of livestock food supplies, and the production of transportable energy. The proposed project will be developed in two phases: Phase I will include geothermal resource confirmation, development of a production well, construction of actual ethanol plant facilities, and the construction of a heated cattle, and hog feed lot. The waste grain mash from the alcohol plant will provide approximately 60 percent of the animal feed. Waste from the feed lot will be used in the farm field development and upkeep. Phase II of the project encompasses the development of an industrial park. Phase I of the project is anticipated to employ about 60 persons in fuel and food distribution, design, construction, equipment maintenance, and secondary reprocessing.

3. Damonte Ranch - The Nevada Central Holding Company is planning to develop the Damonte Ranch in the southeast Truckee Meadows area. The Ranch consists of 2,200 acres that are located in the known geothermally active area of Steamboat Springs. The proposed development will consist of about 6,000 dwelling units and support, commercial, and public facilities. It is planned community development with what is believed to be good potential for the development of a geothermal district heating system.

2.4 Time Phased Project Plans

2.4.1 Active Demonstration/Commercialization Projects

There are two active demonstration projects in Nevada: Multiple Use of the Geothermal Energy at Moana KGRA and Field Experiments for Direct Use of Geothermal Energy at the Elko KGRA.

Moana KGRA Project:

The purpose of this demonstration project is to use the hot water from Moana Hot Springs for heating of the Sundance West Apartment complex. It is anticipated that hot water from two production wells will be piped underground to newly installed shell and tube heat exchangers in the existing boiler rooms of the apartment complex. As of this time, the project is in the initial stage of obtaining necessary environment clearances and permits. Contractual negotiations with the Sundance West Apartment complex are ongoing. Drilling is anticipated to be started in the next few months.

Elko KGRA Project:

The direct application project in Elko, Nevada was selected to demonstrate the technical and economic feasibility of the direct use of geothermal brines from the Elko KGRA for the purpose of providing space, water, and process heat. The project is anticipated to require the drilling of one 700 to 2000 foot deep production well and one similar depth injection well.

Hot water from the production well will be passed over a well head heat exchanger in a closed loop system. The heat will be distributed to a commercial laundry, a 400 unit motor hotel and an office building. Chilton Engineering, the prinicipal investigator of the project, has completed the preliminary resource assessment of the project. This assessment included geological and geophysical mapping of the various fault and geothermal systems in the Elko basin. They are currently developing a drilling program which is anticipated to begin by March 1, 1980. In addition to these two active demonstration projects, there are five developers in Nevada actively investigating the use of geothermal energy in the production of ethanol.
These potential developments are: Brady Hot Springs, Mineral Hot Springs, Crescent Valley, Wabuska Hot Springs, and Winnemucca. In addition to these direct applications, there are five areas in which the development of electrical generation facilities are being investigated: Dixie Valley, Steamboat Hot Springs, Beowawe Hot Springs, Desert Peak, and Humboldt House.

2.4.2 Time Phased Project Plans

The Nevada Department of Energy is reviewing the feasibility of preparing time phased project plans at Brady Hot Springs in Churchill County and Elko Hot Springs in Elko County.

2.5 State Aggregration of Prospective Geothermal Utilization

Direct Uses

The New Mexico Energy Institute has made projections through the CASH model about the anticipated amount of geothermal energy on line for direct uses through the year 2020. Following is a summary of these projections:

Anticipated Direct Use - Energy On Line

(All units expressed in 10^9 BTU)

Geothermal Resource Area	Year	Combined Industrial and Residential Private Developers	Combined Industrial and Residential City Developer
Washoe County	1985	2,330.0	2,330.0
#1	2000	11,900.0	11,900.0
	2020	29,700.0	29,700.0
Humboldt County	1985	784.0	831.0
Pershing County	2000	1,440.0	1,460.0
#2	2020	1,960.0	1,970.0
Elko County	1985	788.0	867.0
#3	2000	2,510.0	2,510.0
	2020	3,580.0	3,590.0
Carson City	1985	403.0	403.0
#4	2000	3,800.0	3,800.0
	2020	7,500.0	7,500.0
Douglas County	1985	1,560.0	1,710.0
Lyon County	2000	4,650.0	5,230.0
Storey County	2020	15,800.0	18,200.0
Churchill			
#5			
Lander County	1985	33.4	98.0
Eureka County	2000	150.0	154.0
#6	2020	180.0	184.0
White Pine County	1985	581.0	581.0
#7	2000	905.0	905.0
	2020	931.0	931.0
Mineral County	1985	257.0	299.0
Esmeralda County	2000	389.0	392.0
#8	2020	450.0	450.0
Nye County	1985	260.0	260.0
	2000	389.0	392.0
#9	2020	450.0	450.0
Lincoln County	1985	76.2	76.2
	2000	91.1	91.1
#10	2020	114.0	114.0
Clark County	1985	Ø	191.0
	2000	692.0	734.0
#11	2020	854.0	899.0
TOTAL	1985	7,320.0	7,890.0
STATE	2000	27,100.0	27,800.0
AGGREGRATION	2020	61,800.0	64,200.0

Electrical Generation

Several different projections have been made on the amount of electrical energy generated from geothermal sources by the year 2020. These projections range from a low of 800mW in U.S.G.S. Circular 790 to a high of 12,590mW in Appendix 8 of the Regional Operations Research Program for Development of Geothermal Energy in the Southwestern United States. Today, private industry is actively investigating the development of several small pilot electrical plants with generating capacities between 20mW and 50 mW. The areas of the state in which interest has been shown for electrical generation are: Beowawe Geysers, Dixie Valley, Humboldt House, Steamboat Hot Springs, and Brady Hot Springs. These ongoing exploration and development programs may bring some electricity on line in the next few years, however it is very difficult to estimate the exact amount. The following projections about potential electrical energy on line are rough estimates based on insufficient information to accurately project any distance into the future.

Anticipated Electrical Generation - Energy on Line

(All units in megawatts)

1982	50	2005	1000 - 1250
1985	100 - 250	2010	1250 - 1500
1990	250 - 500	2015	1500 - 1750
1995	500 - 750	2020	1750 - 2000
2000	750 - 1000		

3.6 Institutional Analysis

3.6.1 Due to the fact that Nevada's legislature meets biannually and was in session during the first two quarters of 1979, the NDOE placed considerable emphasis on stimulating legislative action during that period of time. A presentation was made to the Senate Commerce and Labor Committee in which the NDOE suggested that the legislature consider the following legislative proposals:

1. Authorize general improvement districts to provide district space heating services.
2. Exempt non-producing leasehold interests from property taxation.
3. Require utility companies to justify the non-use of geothermal energy as an electrical generation source when filling applications to construct new electrical generation facilities.
4. Authorize utilities to include "construction work in process" in rate base on an incremental basis during the construction of geothermal electrical generation facilities.
5. Refine the definition of geothermal resources and require the State Water Engineer and the State Environmental Commission to initiate rulemaking proceedings to identify clearly procedures regarding the appropriation and use of geothermal resources.

6. Create a geothermal resource development and demonstration fund for direct thermal applications.
7. Provide funding to activate a Division of Research and Development within NDOE to stimulate use of Nevada's energy resources.
8. Memorialize Congress to pass a geothermal omnibus bill and to appropriate adequate funding for geothermal demonstration and resource assessment projects.
9. Expand existing property tax allowance to include commercial as well as residential geothermal space and water heating applications.
10. Amend the Nevada Constitution to allow tax incentives to promote renewable resource applications.

As a result of the aforesaid presentation the following bills were introduced which would have:

SB 506 - Authorized general improvement districts to provide space heating; and providing other matters properly relating thereto.

SB 505 - Added requirement of consideration of geothermal resources to Utility Environment Protection Act.

SB 525 - Increased types of buildings for which allowance against property tax is granted for systems of heating or cooling using renewable sources of energy.

SJR 19 - Proposed to amend Section 1 of Article 10 of the Nevada constitution by permitting an exemption from property tax for the conservation of energy by using nonfossil resources.

SJR 23 - Memorialized Congress to legislate on geothermal resources and to appropriate money for research and demonstration.

SCR 35 - Directed study of inclusion of cost of developing geothermal energy in rate base of utility.

AB 144 - Provided for the exemption from property tax of leases for geothermal development; and providing other matters properly relating thereto.

Based upon the NDOE's recommendations and subsequent testimony and hearings the Legislature enacted the following bills:

1. Authorized General Improvement Districts to provide district space heating services. See Appendix. 5
2. Exempted non-producing geothermal leasehold interests from property taxation. See Appendix 6
3. Memorialized Congress to implement a geothermal omnibus bill and to increase the level of geothermal funding. See Appendix 7
4. Authorized NDOE's participation in the GCPP and provide funding to activitate the NDOE's Division of Research and Development.

Subsequent to the close of the 1979 session, the Interim Finance Committee authorized the creation of a special study group that will work in conjunction with the National

Conference of State Legislatures and the NDOE to provide policy and legislative suggestions to the legislature when it meets in 1981. Based on the finding of the NDOE's institutional analyses the following legislative recommendations have been made to the Interim Legislative Committee:

1. Enact legislation that limits needed water appropriation to consumptive uses only.
2. Enact legislation that defines the geothermal resources and clearly delineates burden of proof vis a vis ground water system.
3. Consider enactment of legislation that will provide a safeguard to those who are engaged in non-consumptive geothermal uses (i.e., closed loop space heating systems).
4. Enact legislation that expands existing property tax allowance to commercial and industrial applications.
5. Enact legislation which exempts the cost of renewable resource systems from sales taxes.
6. Enact legislation which provides for a property tax credit for renewable resource systems (dependent upon approval of proposed constitutional amendment).
7. Enact legislation which requires Public Service Commission to allow utilities to include construction work in progress in rate base on an incremental basis for geothermal electric generation facilities.

8. Enact legislation which allows public utilities to expense reasonable geothermal exploration and development costs.
9. Enact legislation authorizing amortization of the cost of constructing and developing geothermal facilities whose useful life is shortened because of reservoir or technical problems. (Of course, such legislation must include requirements that utilities take adequate safeguards including reservoir insurance, adequate pre-construction exploration activities, etc)
10. Enact legislation requiring utilities to justify non-use of geothermal for new electric generation projects.
11. Enact legislation exempting or restricting Public Service Commission regulation of steam or hot water sales. One option is to exempt sales to five or less customers from any regulation.
12. Enact legislation requiring state and local governmental entities to review feasibility of utilizing geothermal and other renewable resources in new projects.

The NDOE was also involved in encouraging the Western Governors Conference to take an active role in promoting the development of geothermal energy resources. Specifically, the NDOE prepared two resolutions regarding geothermal energy and geothermal related development that Governor List introduced at the WGC. Both resolutions were adopted by the WGC and forwarded to the U.S.DOE.

Based on the institutional analysis that was completed, the NDOE concluded that existing laws and regulations are not a specific impediment to geothermal development. However, there is a need for legislation directed at stimulating geothermal resource development. In addition, there is a need for the NDOE to initiate workshops and other programs to develop the ability of state and local agencies to effectively regulate geothermal development. A copy of Nevada's institutional handbook is included as Appendix 4. Included in this document is a more detailed analysis of the institutional framework which impacts geothermal development in Nevada.

2.7 Public Outreach Programs

2.7.1 At the present time a person to person approach to much of the public outreach program is being used. In addition to personal contact, the Nevada Department of Energy has participated on various radio and television programs discussing geothermal energy development in Nevada. During these programs, it was indicated that additional information regarding geothermal energy development could be obtained from the Nevada Department of Energy and the Nevada Bureau of Mines and Geology. Articles concerning geothermal development and geothermal potential have been published in the newspapers around the state and the NDOE Newsletter. Local government has been contacted through the Nevada State Energy

Resources Advisory Board and through the Nevada League of Cities to outline the Nevada Department of Energy's interest in helping to promote geothermal development in their communities.

A pamphlet entitled Geothermal Energy-Resource and Regulation is in the final stages of preparation. This pamphlet will be distributed to interested persons around the state. A slide-tape show is in the process of being produced for the Nevada Department of Energy through a contract with EG&G in Idaho. When completed, this show can be made into a traveling exhibit which can assist in making the residents of Nevada aware of geothermal energy. In addition the NDOE has obtained geothermal material from a variety of other sources for dissemination to interested parties.

The Nevada Department of Energy conducted a one day seminar workshop for the Nevada State Energy Resources Advisory Board. During this workshop, those persons charged with the responsibility of formulating energy policy in the state of Nevada were introduced to geothermal energy. The workshop included information on:

1. What geothermal energy is.
2. Where geothermal energy is found in Nevada.
3. Historic uses of geothermal energy in Nevada and around the world.
4. Different types of geothermal development - both electric and direct applications.

5. The potential for geothermal energy development in Nevada.
6. Geothermal related policy and regulatory options.

In the future, the Nevada Department of Energy plans to conduct further orientation seminars and workshops. The agency will continue to provide one to one technical assistance, provide literature, and other information services to any requesting party and to broker activities between potential developers of Nevada geothermal resource and various governmental and financial institutions.

2.7.2 Summary of Contacts and Results

Following is a summary of some of the contacts representatives of geothermal activity in Nevada:

CONTACT	APPLICATION
<u>Industry</u>	
Private Corporate Entity	Electrical generation at Darrows Hot Springs
Private Corporate Entity	Space and water heating for proposed plastic plant
Private Corporate Entity	Space, water heating, and electrical generation for manufacturing plant
Private Corporate Entity	Space heating and process heat in Elko
Private Corporate Entity	Space heating of apartments in Reno
Private Corporate Entity	Space heating of hotel in Reno
<u>Agribusiness</u>	
Private Corporate Entity	Raising prawns
Private Corporate Entity	Production of alcohol and raising vegetables in greenhouses

CONTACT	APPLICATION
Agribusiness Con't.	
Private Corporate Entity	Heating greenhouses with water cascaded from a vegetable dehydrating plant
Winnemucca Chamber of Commerce	Production of ethanol alcohol
Half Circle Ranch Development Corp.	Production of ethanol alcohol and cattlefeed
Private Corporate Entity	Production of ethanol alcohol at Wabuska Hot Springs
Private Corporate Entity	Production of ethanol alcohol at Mineral Hot Springs
Individuals	
Approximately 40 - 50 individuals	Residential space heating

State Government

The NDOE is working with the State Department of Economic Development in an effort to use Nevada's geothermal resources to attract new industry. The agency has been in close contact with the Nevada Bureau of Mines and Geology for resource assessment work and to supply information on technical resource questions.

Local Governments

City of Caliente	Space heating for community and other commercial applications.
City of Gabbs	Space and water heating for local fire station
Washoe County	Space and water heating for swimming pools and selected governmental buildings
City of Wells	Space heating

2.7.3 Overall Prospect for Future Geothermal Activity

At this time, there are no quantative estimates available. However, with the ever increasing price of fossil fuels the prospectus for geothermal energy development seems great.

3.0 Summary of Major Findings and Recommendations

Resource

Nevada has significant geothermal potential with about 21 known sites with temperatures in excess of 300°F and about 94 sites with temperatures between 190° and 300°F. Ongoing exploration activities by private industry and by the Nevada Bureau of Mines and Geology in areas of known geothermal potential and in areas that have possible geothermal potential should greatly expand the knowledge about the number of sites in Nevada, the physical characteristics of those sites, and the possible type of development that could occur. The largest problem facing both the planning process and the actual development of Nevada's geothermal resources is the lack of knowledge about the resource itself on a site by site basis. Because of this, continued funding by the U.S.DOE to develop site specific resource analyses and development plans is greatly encouraged.

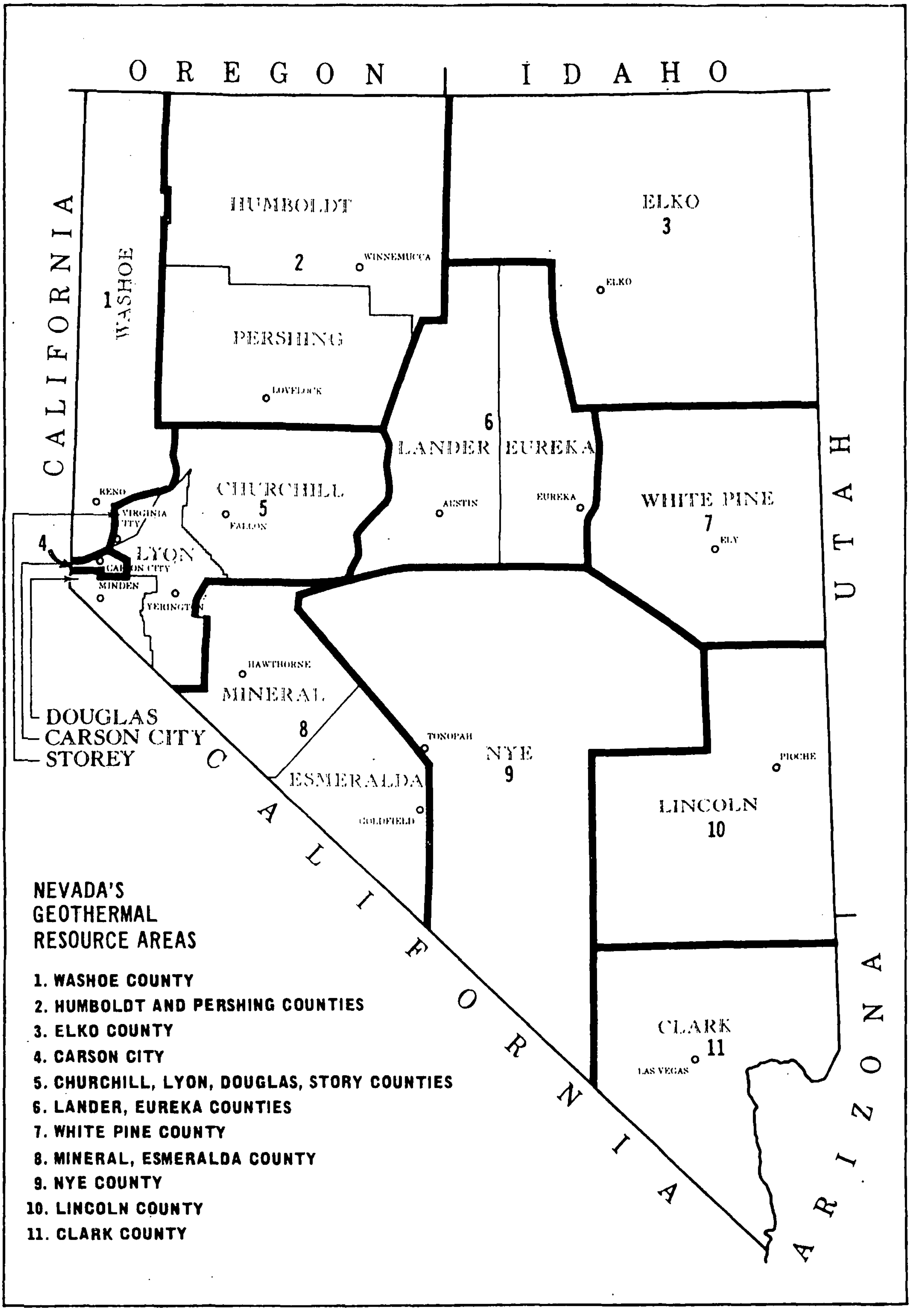
Application

The two areas of most intense interest in geothermal development are electrical generation and alcohol production. Currently there are five electrical sites being investigated and five alcohol sites in the planning stage. Development of either or both of these applications will greatly aid in the net energy status of the state which is currently an importer of energy and which has the potential for a severe liquid fuel crisis. Two other applications of geothermal energy hold much potential for Nevada: space heating and industrial process heat. Several developments in both categories have occurred in the past and more are in the planning state.

Conclusion

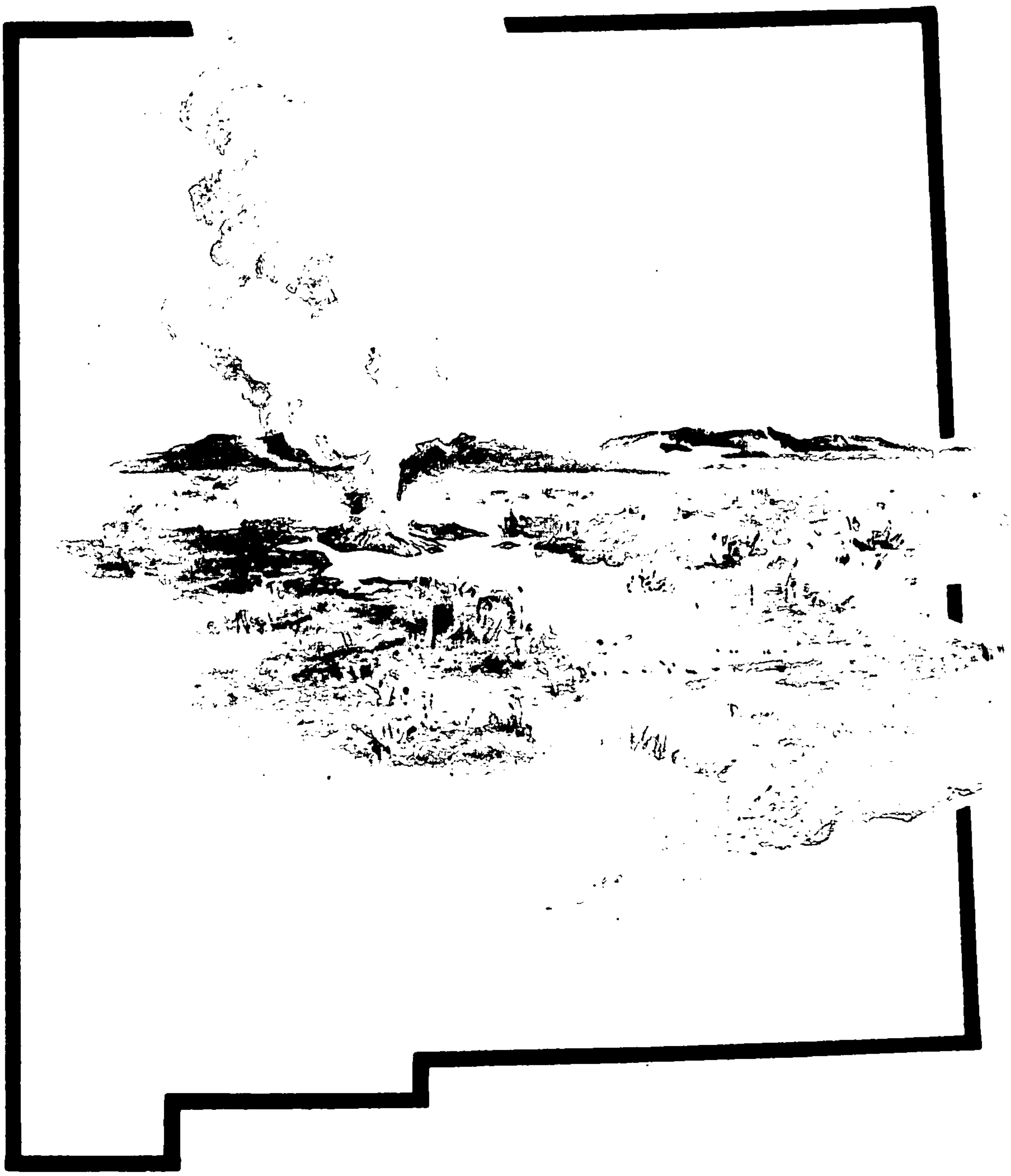
Nevada has a large geothermal resource potential. The development of this resource will be dependent on many social and economic factors, some of which are beyond the control of either the state or federal government. Because of this situation, it is important to consider the potential of geothermal energy's contribution to the economic health of both the state and the country through the economic and energy planning process. Senator Allan Bible has called geothermal energy the "sleeping giant". This giant has begun to awaken because of the great interest shown by various governmental and private organizations. Legislation has been adopted to remove some of the needless obsticles to geothermal energy development. It is time to finally awaken the now slumbering giant by providing economic incentives to developers of the geothermal resource whether it be for a small residential heating system or for a large electrical generation plant.

Appendix 1----Nevada's Geothermal Resource Areas



Chapter 7

New Mexico Geothermal Commercialization Planning



NEW MEXICO GEOTHERMAL COMMERCIALIZATION PLANNING

SEMI-ANNUAL PROGRESS REPORT

July - December, 1979

Prepared by:

Dennis Fedor

New Mexico Energy and Minerals Department
Santa Fe, New Mexico 87501

Work performed under Contract No. DE-FC07-79ID12017
U. S. Department of Energy
Idaho Operations Office

TABLE OF CONTENTS

1.0 Introduction

1.1 Purpose of Project

This project was developed as a mission-oriented program aimed at accelerating the commercial utilization of geothermal resources. It provides the Four Corners Regional Commission, Department of Energy, and the State of New Mexico with a technical and economic guide for commercialization direction and actual implementation of development proposals. This was accomplished through the investigation and promotion of the use of geothermal energy as a viable alternate energy source particularly through direct-heat applications.

1.2 Objectives

In this planning effort of the state geothermal energy commercialization, critical evaluation is made of the potential geothermal energy use and of the promotion of its use.

To evaluate the possibilities for geothermal commercialization, the New Mexico state team, in conjunction with NMEI, is investigating the sub-state regions, and specific sites in the state. This provides the basis for the development of area development plans, site-specific development and commercialization plans, institutional and economic assessments and outreach programs.

1.3 Technical Approach & Team Members

To accomplish the objectives, the state team researchers are evaluating the potential for commercial utilization through the assessment of available resources, industry, activity, and the need for technological or institutional initiatives at all levels. These efforts provide both a plan of attack and a realistic estimate of the achievable levels of utilization.

State Geothermal Team for Commercialization Planning:

Pat Rodriguez, Team Leader
Director of Energy Resource and Development Division
New Mexico Energy and Minerals Department

Dennis Fedor, Energy Consultant, NMEMD and George Scudella, Energy Consultant, NMEMD
Coordinators for data collection, planning development and special studies; industrial, community, and governmental liaison; research and development, institutional analyst and geothermal demonstration program coordinator, public outreach coordinator.

1.4 Benefit of Project to State, Four Corners Regional Commission, and DOE

This program has helped to demonstrate the significant geothermal potential in New Mexico. It identified the action alternatives available to the public sector to stimulate the rapid development of geothermal resources, while at the same time protecting all legitimate interests of the public.

This has provided a greater understanding of the economic, institutional and legal factors in geothermal energy development.

A precise and timely planning of geothermal development could mean future employment-level increases, industrial growth, energy independence, balance-of-payment advantages, additional tax revenues, capital investments, and an improved environment. Thus, through the informational input of this project, the federal, state, and local governments will derive fiscal benefits when the hydrothermal resources are effectively developed.

2.0 Specific Task Descriptions and Products

2.1 Geothermal Prospect Identification

Most of the geothermal resource areas including the eight known Geothermal Resource Areas (KGRA's) are located along the Rio Grande Valley and the southwestern part of the state where Quaternary faulting along deep sedimentary basins allow hot water to travel to the surface and Quaternary volcanism has occurred. Very few of these sites are hot enough for electrical generation while most others are quite adequate for spaceheating, industrial processing, and even food drying. Since the majority of the state's population is located in the Rio Grande Valley, the coincidental pockets of underground heat there are of greatest economic interest.

Information on New Mexico's geothermal areas is growing each year with continued research, exploration, and drilling. An evaluation of the hydrologic characteristics of New Mexico's low temperature geothermal sites were initiated in August 1978 under the auspices of the U.S. DOE-sponsored Western States Cooperative Direct Heat Geothermal Program.

Under this DOE-sponsored program, the researchers are compiling this statewide geothermal evaluation work in a composite geothermal map which is to be published by the New Mexico Energy Institute at New Mexico State University (NMSU). Two sets of maps, one for the lay public and the other with detailed technical information, are expected to be available for distribution in the near future. This work is being coordinated by C. Swanberg, NMSU.

Some of the Federal and State-funded geothermal evaluation projects now taking place include the following:

G. Jiracek, University of New Mexico, and co-workers have selected a geothermal target area in the Albuquerque vicinity on West Mesa. The area covers approximately 225 sq km and includes the site of Albuquerque's proposed new airport. Eight shallow gradient holes were drilled during the summer of 1979 based on electrical resistivity reconnaissance and gravity/magnetic anomalies. One of these holes yielded an 120°C per km geothermal gradient. The researchers plan to drill additional evaluation holes and to continue the detailed resistivity studies of this promising geothermal area near New Mexico's largest city. Also, Jiracek will continue reconnaissance studies in target areas near Albuquerque. These areas include the vicinity of the Jemez Reservoir and the Santa Ana Mesa, the Puerco fault zone, and the Cat Hills volcanoes.

Researchers are also conducting studies at Truth or Consequences, Las Alturas, Socorro, and San Diego Mountain. M. Reiter, NMBMMR (New Mexico Bureau of Mines and Mineral Resources), is continuing his statewide heat-flow studies.

To aid in the evaluation of the energy content of these resource areas, an estimate was made of the areal extent and thickness of each. This resulted in the estimation of the energy content of each reservoir. Tables 2.1 and A.2 list the thermal areas, their areal extent and the amount of energy estimated to be contained in each system. The map, Figure 1, shows the location of the areas. As shown, the amount of geothermal energy contained in all these systems was estimated to total 21.3 quads (1 quad = 10^{15} BTU).

Leasing Activity

As of December 30, 1979, the U.S. Bureau of Land Management (BLM) has issued 123 geothermal leases that are currently active. These leases cover 225,710 acres of national resource land in New Mexico. Seventy-two of these

2.0 Specific Task Descriptions and Products

2.1 Geothermal Prospect Identification

Most of the geothermal resource areas including the eight known Geothermal Resource Areas (KGRA's) are located along the Rio Grande Valley and the southwestern part of the state where Quaternary faulting along deep sedimentary basins allow hot water to travel to the surface and Quaternary volcanism has occurred. Very few of these sites are hot enough for electrical generation while most others are quite adequate for spaceheating, industrial processing, and even food drying. Since the majority of the state's population is located in the Rio Grande Valley, the coincidental pockets of underground heat there are of greatest economic interest.

Information on New Mexico's geothermal areas is growing each year with continued research, exploration, and drilling. An evaluation of the hydrologic characteristics of New Mexico's low temperature geothermal sites were initiated in August 1978 under the auspices of the U.S. DOE-sponsored Western States Cooperative Direct Heat Geothermal Program.

Under this DOE-sponsored program, the researchers are compiling this statewide geothermal evaluation work in a composite geothermal map which is to be published by the New Mexico Energy Institute at New Mexico State University (NMSU). Two sets of maps, one for the lay public and the other with detailed technical information, are expected to be available for distribution in the near future. This work is being coordinated by C. Swanberg, NMSU.

Some of the Federal and State-funded geothermal evaluation projects now taking place include the following:

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Leasing Activity

As of December 30, 1979, the U.S. Bureau of Land Management (BLM) has issued 123 geothermal leases that are currently active. These leases cover 225,710 acres of national resource land in New Mexico. Seventy-two of these leases, comprising 138,170 ac, were issued after non-competitive bidding; 51 leases, comprising 87,540 ac, were issued after competitive bidding.

A lease sale by BLM was held September 18, 1979. Twelve parcels of land comprising 17,401 ac in the Radium Springs and Socorro Peak KGRA's were offered. Bids were received and granted for four of these parcels covering 7,063 ac. High bids totaled $240,632. The total of all bids received was $368,274. The highest bid per acre, $111, was made by Norma K. Hunt for Leasing Unit No. 22 in the Radium Springs KGRA. Acreage in this parcel totals 636 ac. The highest total bonus bid, $75,358, was paid by Thermal Power Company for Leasing Unit No. 27, a 2,426-ac parcel in the Socorro Peak KGRA. No bids were received on Leasing Units No. 23 through 26 in the Radium Springs KGRA, or on Leasing Units No. 30 through 33 in the Socorro Peak KGRA.

Tables 2.1 and A-3 list areas and sites of geothermal prospects in the state of New Mexico as these have been identified by various criteria, for both electric and direct thermal uses.

The prospective sites and areas are broken down in the these lists to those which are (1) proven, (2) potential, and (3) inferred.

The definitions used are those recommended by Meyer (December 1978):

> Proven sites are those: (1) which are in an advanced stage of development or commercialization by a private company or by government for specific applications, or demonstrations, or those (2) on which is available favorable quantitative data on the measured subsurface temperatures, volume, and water flows.
>
> Potential sites are those on which (1) there is exploration/development activity, or (2) some favorable quantitative subsurface data have been estimated or measured.

Inferred sites or areas are those identified by (1) surface manifestations such as wells or springs, (2) chemical thermometry, or (3) proximity to potential or proven sites.

Appendix tables A-1 and A-2 provides further information on proven and potential sites, both for electric and direct thermal applications in New Mexico.

TABLE 2.1

NEW MEXICO IDENTIFIED GEOTHERMAL PROSPECTS

ELECTRIC (150°C)

PROVEN	POTENTIAL	INFERRED
Baca Location	Animas	Closson
	Kilbourne Hole	Columbus Area
	Radium Springs	Guadalupe Area
	S.D.	Jemez Reservoir
		Lordsburg
		Lower Frisco H.S.
		Prewitt Area
		Socorro
		Southern Tularosa Basin
		White Sands (Town)

DIRECT THERMAL (20°C T 150°C)

PROVEN	POTENTIAL	INFERRED
Animas	Albuquerque	Closson
Faywood	Black Mtn. - West Mesa	Crown Point
Gila H.S.	Cliff Area	E. San Augustin Plain
Jemez Springs	Derry H.S.	Fort Wingate
Los Alturas	Mesquite-Berino	Garton Well
Ponce de Leon	Mimbres H.S.	Jicarilla Apache Res.
Truth or Consequences	Ojo Caliente	Little Blue Mesa
	Radium Springs	Mamby's H.S.
	San Diego Mtn.	Mancisco Mesa
	San Ysidro	Montezuma H.S.
	Socorro	Southern Tularosa Basin
	Turkey Creek H.S.	Tohatchi
	Upper Frisco H.S.	

FIGURE 1

NEW MEXICO COUNTIES AND GEOTHERMAL SPRINGS AND RESOURCE AREAS

Number	County
1	San Juan
2	Rio Arriba
3	Taos
4	Colfax
5	Union
6	McKinley
7	Sandoval
8	Santa Fe
9	Mora
10	Harding
11	San Miguel
12	Valencia
13	Bernalillo
14	Torrance
15	Guadalupe
16	Quay
17	Catron
18	Socorro
19	Lincoln
20	De Baca
21	Curry
22	Roosevelt
23	Grant
24	Sierra
25	Otero
26	Chaves
27	Eddy
28	Lea
29	Hidalgo
30	Luna
31	Dona Ana
32	Los Alamos

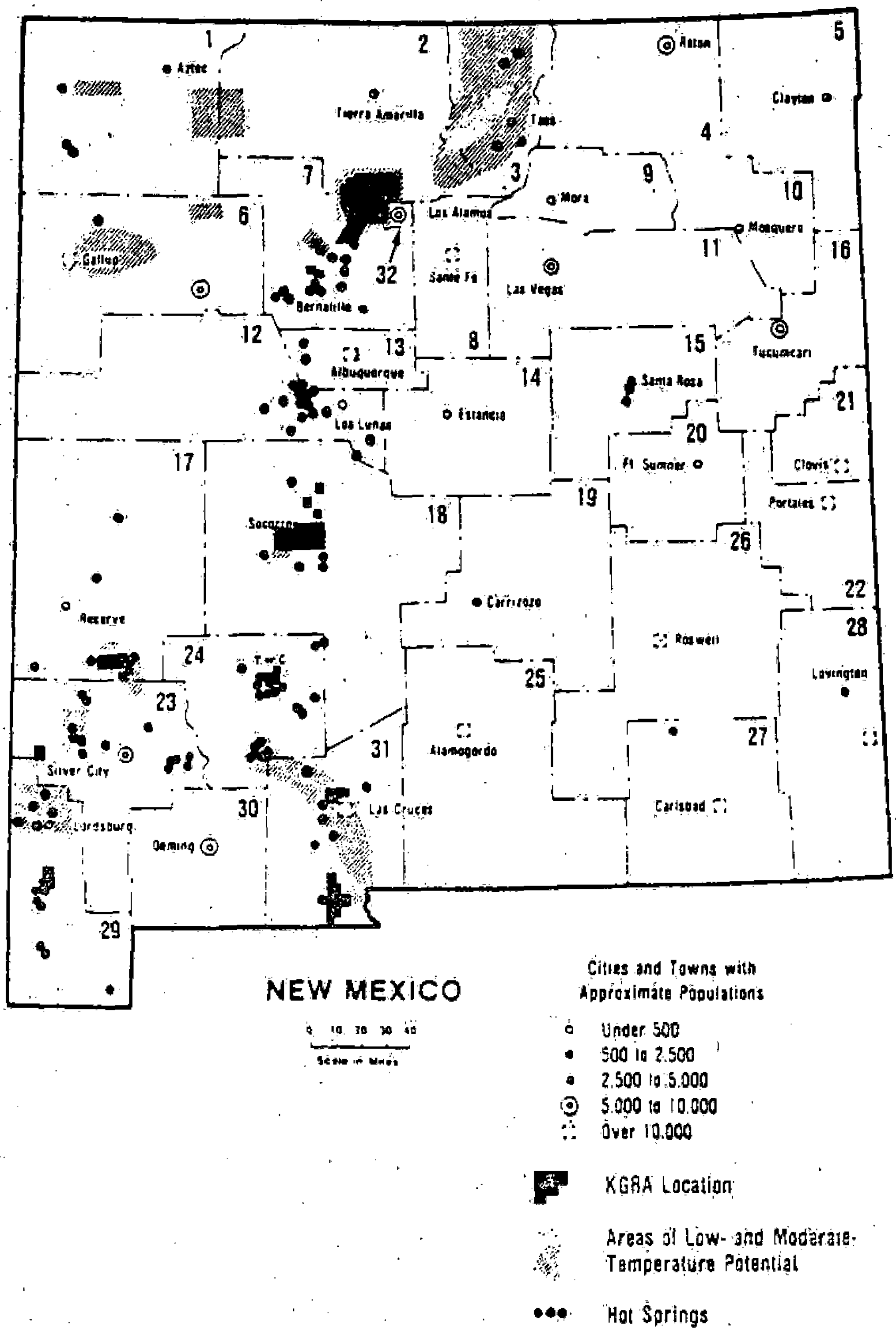
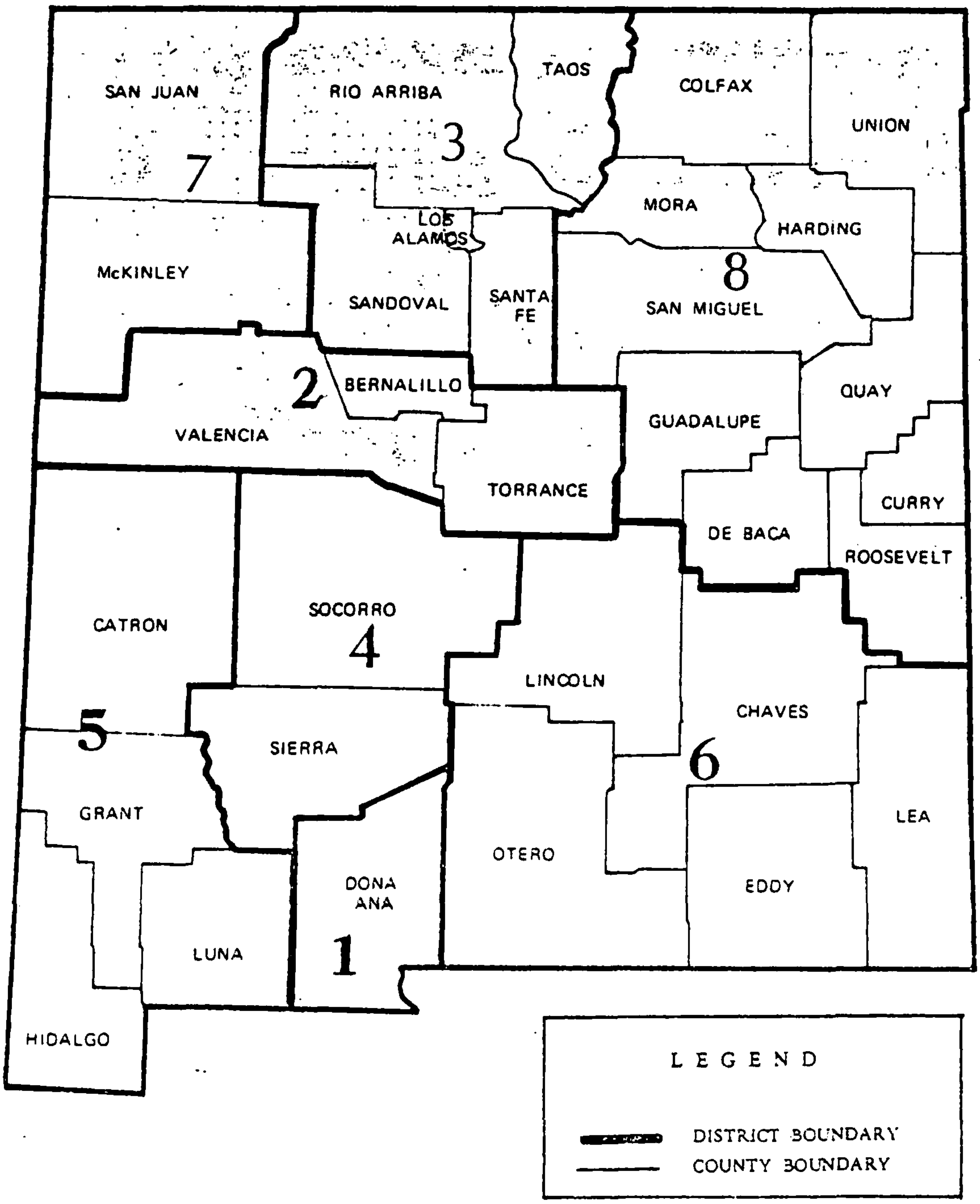
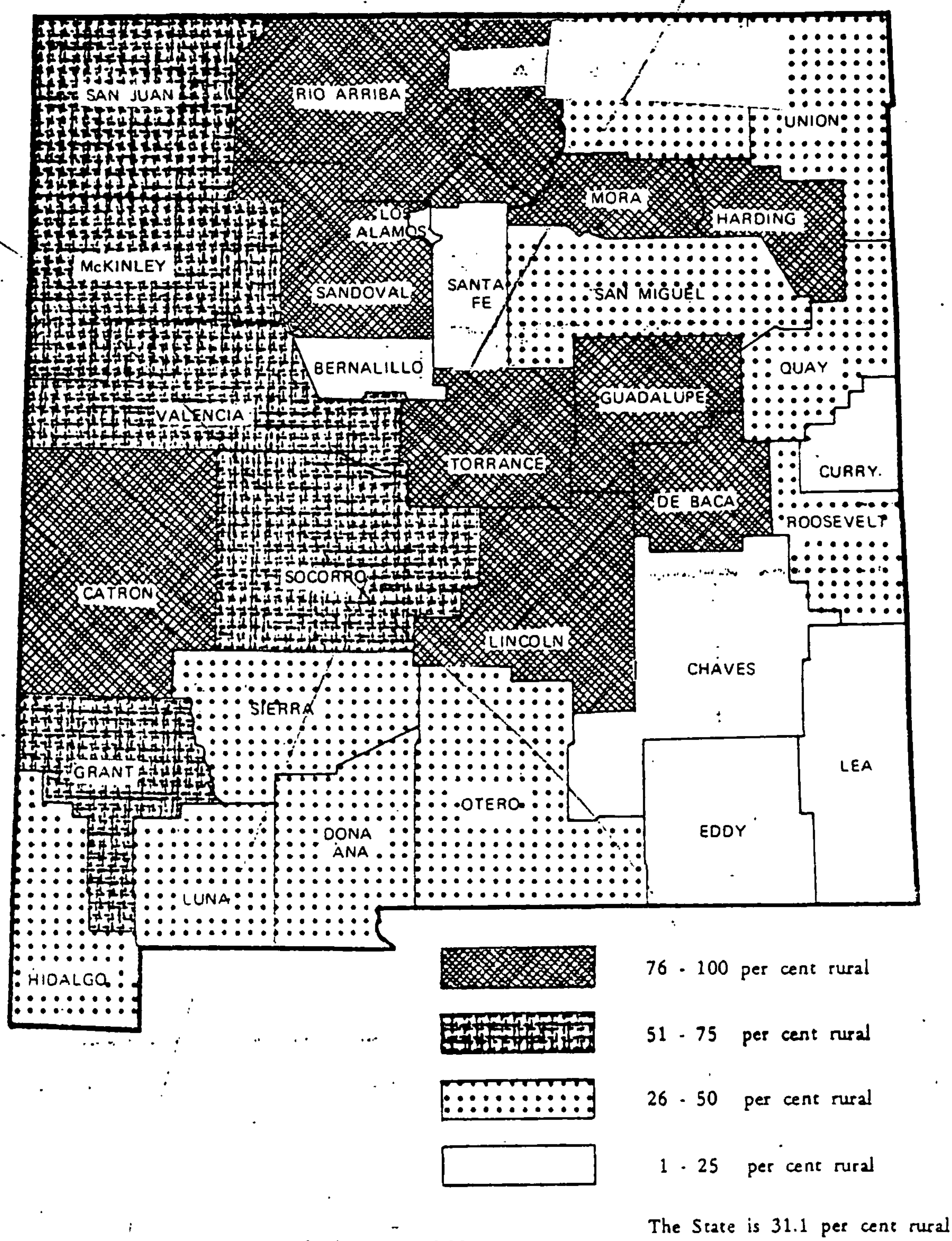


FIGURE 2

STATE PLANNING AREA DEVELOPMENT DISTRICTS



PERCENTAGE OF POPULATION CLASSIFIED RURAL BY COUNTY 1970



Source: New Mexico Statistical Abstract, 1977

2.2 Area Development Plans

2.2.1 State Geothermal Planning Areas

The New Mexico State Team is defining 3 substate geographical areas for which the development and utilization of geothermal energy prospects are likely between now and the year 2020.

The areas considered for commercialization planning are primarily multi-county substate areas based on the state planning district format. These substate regions also coincide with geological provinces and with distributions of geothermal resource sites that are unique to those respective areas.

The 1st-priority target areas for area development planning are centered on the Rio Grande River Valley throughout its entire length within the state.

2.2.2 Specific Area Development Plan: Dona Ana County

This county is emerging as the first area of intense study and planning activity by private and government entities. The strong interest and community leadership shown for geothermal energy for economic considerations plus the adjacent overflowing economic growth pattern of El Paso, Texas provides the basis of selection for the area development plan. A number of research investigations of the geothermal potential here have been conducted. There are 2 KGRA's in the county: Radium Springs and Kilbourne Hole. The Kilbourne Hole KGRA, located next to the U.S. - Mexico border, has potential electrical generation capacity.

The Dona Ana Area Development Plan involves first, the investigation of the area attributes such as geography, population, economy and attitudes of the residents. Second, the energy demands of the area were considered for both current and projected needs by the Standard Industrial Code and fuel types. Third, the current and future geothermal energy development is described. The estimated usable thermal energy is matched with the estimated demand. A possible schedule of activities has been estimated. It should be kept in mind that actual development is entirely dependent on the actions of the entrepreneurs.

Outside the Baca Location, Dona Ana County has the second largest geothermal heat potential in the state.

The county has numerous hot water wells and hot springs as well as 2 KGRA's: Radium Springs and Kilbourne Hole. The geothermal potential considering all sites is 0.9899 Quad BTU's for 30 years for direct thermal use.

Dona Ana County is one of the fastest growing areas in the state. The total county population is about 80,000 and the Las Cruces SMSA stands at about 51,000. Both the expanding industrial and governmental sectors are contributing to a robust economy in the county.

To some degree, most current food drying processes could be suitable to conversion with the use of heat from geothermal water depending on the resource and the location.

2.3 Site Specific Development Plans

2.3.1 Candidate Geothermal Sites

The specific resource sites and energy applications (residential, commercial, industrial, and agribusiness) which are candidates for the SSDP are identified and briefly described as follows:

ANIMAS/LIGHTNING DOCK

Applications: Current: 2 geothermally heated greenhouses with total 130,000 sq. ft.

Projected: 500,000 sq. ft. area of geothermally heated, geothermal irrigation of crops and orchards with soil-warming systems.

Resource Data: Surface Temp. 102°C
Subsurface Temp. 144°C

Estimated Energy Potential: 0.223 quad
Estimated Reservoir Size: 3.3 km^3

LOS ALTURAS (LAS CRUCES):

Applications: Current: none, only used as domestic water supply for Los Alturas subdivision.

Projected: Industrial process heat - L'eggs Corp., space heating: NMSU University Center, NMSU campus, shopping center, hospital, city district heating, dairy, school, and factory.

Resource Data: Surface Temp. 43°C
Subsurface Temp. 120°C

Estimated Energy Potential: 0.16 quad
Estimated Reservoir Size: 3.0 km^3

TRUTH OR CONSEQUENCES

Applications: Current: several resort spas, baths, and pools, Carrie Tingley Hospital therpaeutic pools, spaceheating of lodge.

Projected: spaceheating of senior citizens center, apartment building complex and commercial buildings, pre-heated boiler water for C.T. Hospital

Resource Data: Surface Temp. 45°C
Subsurface Temp. 100°C

Estimated Energy Potential: 0.04 quad
Estimated Reservoir Size: 1.0 km^3

ALBUQUERQUE

Applications: Current: Heat pump spaceheating of multistory office building.

Projected: large user spaceheating: West Mesa airport, West Mesa High School, U of A campus pre-heat boiler system, district heating of future subdivisions.

Resource Data: Surface Temp. 27°C
Subsurface Temp. N/A

Estimated Energy Potential: 0.0449 quad
Estimated Reservoir Size: 3.0 km^3

JEMEZ SPRINGS

Applications: Current: bathhouse, greenhouse spaceheating

Projected: district heating

Resource Data: Surface Temp. 73°C
Subsurface Temp. 103°C

Estimated Energy Potential: 0.0206 quad
Estimated Reservoir Size: 3.3 km^3

2.4 Time Phased Project Plan

2.4.1 Active Demonstration/Commercialization Projects

There are 9 geothermal developments in the state that are currently active demonstration and commercialization projects. All of these projects are considered to be candidates for the time-phased project plans.

2.4.1.1 There are 6 demonstration projects that have been funded by the New Mexico Energy and Minerals Department:

1. Carrie Tingley Hospital at the City of Truth or Consequences thermal basin. The hospital has the right to use 170,350 liters of the basin water (43°C) which contains a useful heat content of 12,000 BTU/min. Previously this water was being used by the hospital in its therapeutic pools for physical therapy. However the energy content is not being fully utilized. The hospital's present energy consumption for hot water is 9000 BTU/min. The project which starts on March 1, 1980, will design, install, operate, monitor and evaluate a geothermal preheating system for the therapeutic pool and boiler by June 1981.

2. City of T or C Senior Citizens Center, spaceheating. The resource is the thermal basin underlying the city averaging 43°C temperature. The geothermal water will be pumped from

a 154m or less well which is being drilled on city property. This well will be connected to the city's Senior Citizens Center to supply up to 100,000 BTU/hr during peak demand period. The complete design, installation and monitoring of the spaceheating system will be completed by June 1981. The project was commenced on June 28, 1979.

3. Solar-assisted geothermal greenhouse, Taos County. (High-Altitude) The resource is the Ponce de Leon Hot Springs near Ranchos de Taos. The springs discharge 1,305,977 liters per day at 35^{o}C at an elevation of about 2,256m (7,400 ft.). The project will analyze and determine the use of a geothermal heat recovery system to provide thermal energy for greenhouse spaceheating (for 5,574m^2) for growing cash crops and other commercial processes. This project uses technology transfer from power plant waste heat recovery. The project began May 22, 1979 and will finish December 1980.

4. Solar-assisted geothermal greenhouse, Faywood (Upper Sonora Desert). The resource is the Faywood Hot Springs 48.3 km (30 miles) southeast of Bayard, New Mexico which flows at 132.5 l/min. at 57^{o}C. Runoff water has previously been used for irrigation. The objective is to operate and monitor the geothermal greenhouse which will produce native plants for waste tailings reclamation projects by Kennecott Copper Corporation. Initiation of this project was on June 18, 1979 and is to be completed December 1980.

5. Spaceheating of the University Center at New Mexico State University, Las Cruces. The resource is the Los Alturas anomaly adjacent to the university's east boundary. It appears to be fault-controlled. Drillings indicate possible 69^{o}C water at flow rates of at least 200 GPM from well

depths of 899 ft. Monitoring and reporting will be completed by June 1981. The project commenced June 28, 1979.

6. Industrial process geothermal heat for L'eggs Products, Inc. No resource is confirmed. However, geophysical studies have begun June 28, 1979 for placement of a geothermal well. If an appropriate resource is encountered a well will be drilled, equipment installed, operated, monitored and evaluated for industrial use by June 1981.

2.4.1.2 With the exception of some aged hot spring resort spas, most private business enterprises utilizing geothermal energy in the state started in the 1960's. The most significant developments are listed here:

1. Baca Location geothermal power plant demonstration program, Jemez Mountains. The resources of the project area inside the Valles Caldera include both a liquid and vapor-dominated reservoir. The major, liquid-dominated reservoir is overpressured and contains a calculated 1.8×10^{12} kg of fluid in place. The average reservoir fluid temperature is in excess of 260°C. The main production and injection zone is the lower Bandelier Tuff; the upper Bandelier forms the caprock. Since the first geothermal well was acquired in 1963, Union Geothermal of New Mexico has drilled 18 wells and probably 13 to 16 more wells may be needed for the proposed 50 MWe plant. Final approval of the environmental impact statement must be made before constructon can start in Spring of 1980. Barring major snags, its believed the demonstration plant could go on line by Spring 1982.

2. The Animas Valley geothermal greenhouses. Operators: Tom McCants and Dale Burgett. Two hothouse operations are described together because of the same underlying resource,

identical characteristics, energy-use applications and geothermal energy-requirements.

The resource is the Animas "hotspot," a very shallow anomalous aquifer, where abundant water of 102°C is obtained at depths of less than 29 meters. The thermal anomaly has hot surface manifestations and it is very geophysically conspicious in a 1 square mile section. This apparently is a fault-controlled feature adjoining a sediment-filled basin.

The 2 greenhouse operations overlying the thermal anomaly use 3600 BTU/min and 1700 BTU/min with no thermal drawdown. The thermal capacity is used for the production of various high-price floral plants particularly roses.

3. Geothermal heat pump system of Sandia Savings Building, Albuquerque. Two aquifers, at 90' and 270' deep, supply cool and warm waters according to the seasonal demand. Two wells are involved in this operation. The shallow well supplies cool water with a temperature range from 60° to 70°F. The deeper well supplies warm water at 78° to 80°F. The water is withdrawn from either the cool or warm well, depending on the season, and injected into the other well. A heat exchanger and three 100 horsepower compressors are used to boost or lower the water temperatures for winter heating or summer cooling. Heating requires 2,518,000 BTU/h and cooling requires 3,467,182 BTU/h.

2.5 State Aggregation of Prospective Geothermal Utilization

Estimates are made of the total geothermal energy on-line for the area development plans as a function of time.

Projected Geothermal Energy On-Line (Quad)

ADP	1980	1985	2000	2020
1	0.000	0.06	0.34	0.76
2	0.0001	0.001	0.03	0.05
3	0.0009	2.17	8.00	16.01
4	0.00001	0.0003	0.005	0.008
5	0.0002	0.001	0.009	0.018
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0

ADP KEY (COUNTIES)

1. Dona Ana County
2. Albuquerque Area - Bernalillo, Torrance and Valencia
3. Los Alamos, Rio Arriba, Sandoval, Santa Fe and Taos
4. Sierra and Socorro
5. Catron, Grant, Hidalgo, and Luna
6. Chaves, Eddy, Lea, Lincoln and Otero
7. McKinley and San Juan
8. All northeastern counties

2.6 Institutional Analysis

An identification and analysis of the local, state, and federal legislative and regulatory procedures and practices . the development and commercialization of geothermal energy was performed by the New Mexico State Team. The analysis encompasses all stages of a geothermal activity, including leasing, exploration surveys, drillings, field development, facility construction, district heating, and application. The roles and responsibilities of local, state, and federal agencies were identified and described. Institutional constraints to the timely and successful development of geothermal energy were identified, and solutions recommended in terms of procedures, manpower, times, etc.

This study resulted in a state handbook, which describes the institutional procedures and time factors for evolving a geothermal resource from the leasing stage through the utilization stage for both electric and direct thermal applications.

This handbook is intended to be an information manual and a procedural guide for the full array of parties who may be participants in geothermal development and commercialization, including, but not limited to, investors, financial institutions, developers, utilities, energy users, industry, commerce, business, and local governments. The handbook charts and describes the agencies, regulatory procedures, action or decision times, and procedural costs in a clear and easily readable form.

2.7 Public Outreach Program

The greatest effort in this project has been in the state outreach program activities.

A outreach program was organized and conducted for the purpose of promoting the utilization of geothermal energy by industry, utilities, commerce, agriculture, business, and government units. The state team implemented various educational and promotional approaches for the public and private sectors.

2.7.1 Outreach Mechanisms

Essentially, the outreach program was conducted by (1) interacting with community, business, industrial, and governmental leaders concerning geothermal development opportunities and programs; (2) disseminating information; (3) coordinating regional support for limited user assistance to potential geothermal developers and users.

In particular, the state team conveyed information on geothermal prospects, applications, economics, energy supply/demand projections, institutional procedures, and environmental advantages. The New Mexico State Team kept a record of its outreach contacts and activities, and these are summarized in the following paragraphs.

This project has provided direction and stimulus for EMD's authorization of geothermal space-heating demonstrations programs as as result of the $200,000 legislative allocation that required matching funds. There are two in Las Cruces, two in T or C, one at Faywood, and one in Taos.

Promotion was provided for the small-scale appropriate energy technology grants program and assisted 9 applications. This effort was successful in DOE's Region 6 awarding (one) 1 grant in the geothermal category to N.M. This award went to Mr. Tom McCants of Animas for $20,000 in September, 1979 for space-heating demonstration greenhouse.

The Columbus area is being evaluated as a prime site for a twin U.S./Mexican industrial park. The evaluation of the geothermal energy option for Columbus was encouraged to the point of having an international meeting of U.S. and Mexican officials including the Mexican national electric company. This has led to further plans for support development surrounding the industrial park concept.

Because of the economic and energy interest shown for the Columbus area, the initial study for the geothermal survey and evaluation was recommended and funded by the New Mexico Energy and Minerals Department. Meanwhile, the State Planning Office and the Commerce and Industry Department have been working closely with the local leaders for the development plans.

2.7.2 Summary of Contacts and Results

CONTACT	PROSPECTIVE APPLICATION	COMMENTS
Arthur Mansure BDM Corporation	Preheat Boiler Water	Contract negotiations on Carrie Tingley Hospital in T or C with DOE
Roger Bowers Hunt Energy Corp	Electrical Generation	Exploration in Radium Springs and Kilbourne Hole KGRA
David Chavez Solar America, Inc.	Commercial Greenhouse	Construction to start spring
L.D. Clark Energetics Corp.	Process Heat	Evaluation continuing on plant energy use at L'eggs
B. Gray-Pendleton Southwestern Services to Handicapped Children and Adults, Inc.	Native Plant Greenhouse	Geared to operation by handicapped
Union Oil Co.	Baca Electrical	Discussed environmental concerns

CONTACT	PROSPECTIVE APPLICATION	COMMENTS
S.M. Roberts Mirador Corp.	Geothermal Services	Seeking funds
Dave Sibila Energy Materials, Inc.	Geothermal Piping Material	
Dave Breuer Pacific Energy Research	Health Center	Seeking suitable hot spring location
Gerald W. Huttrer Intercontinental Energy Corporation	Direct Heat	Seeking investment opportunities
Clive Ashton Sandyland		

INDIVIDUALS

Art Wilbur, DOE	Baca Location Demo	Discussed communication over DOE's project
Marilyn Marquez, DOE	Baca Location Demo	Discussed future objectives
Clayton Nichóls, DOE	Industrial - Coupled Program	Seeking DOE funds
Jack Salisbury, DOE	Industrial - Coupled Program	Seeking DOE funds
Debbie Struhsacker, UURI	Technical Assistance at Gila Hot Springs	Only paper studies
Ivar Engen, E G & G	Technical Assistance at Gila Hot Springs	Only eng & economic studies
Bill Laughlin, LASL	Low Temp. Program	
Mortan Smith, LASL	Low Temp. Prospects for northern N.M.	Investigate structural feature
Arelene Starkey, NMEI	Commercialization for Dona Ana County	
Dr. Harold Daw, NMEI	(Geothermal Demo)	Acting Dir for NMEI
Roy Cunniff, PSL	(Geothermal Demo)	

INDIVIDUALS (cont'd)

Tom Gebhard, Consultant	Spaceheating	T or C Senior Citizens Center
Bob Grant, Consultant	Direct Heat	Furnishes major leads for commercialization
Tom McCants	Greenhouse Operation	Seeking DOE funds for gasohol plant
Dale Burgett	Greenhouse Operation	Seeking DOE funds
Doc Campbell	Resort Spaceheating	Seeking Technical Assistance

2.7.3 Overall Prospectus for Future Geothermal Activity

The New Mexico Geothermal Demonstration Program has successfully raised the profile of the viability of geothermal as an alternative energy resource. New Mexico now finds itself in a position of not only having six active demonstrations but also having an acute interest in geothermal shown by a broad spectrum of our community.

Greatest interest in geothermal development is being shown in Dona Ana County in the southern part of the state. The county is the home of New Mexico State University which has been actively drilling for geothermal energy on campus. The university has successfully completed several wells and and obtained DOE financial assistance for campus space-heating.

Columbus, which is located on the Mexican border, is presently being evaluated for a twin industrial park. Local leaders and the New Mexico Department of Commerce and Industry have shown great interest in evaluating the geothermal potential of the area. Discussions have led to the call for proposals to conduct geophysical testing in the area.

EMD personnel have been working with community leader in Dona Ana County to identify potential users. Initial information has furnished prospects in the areas of spaceheating for a shopping center, process heat for a pet food processor and geothermal application for a dairy.

Finally, the West Mesa area of Albuquerque has become the focal point of geothermal exploration. The West Mesa area is the center of new growth in Albuquerque and geothermal applications may have a viable future. Plans for further exploration in this area is being developed.

All in all, New Mexico's geothermal future is bright and its activity is increasing. The EMD is taking a very active role in geothermal R&D, demonstration, outreach and commercialization and this effort should expedite development.

3.0 Summary of Major Findings and Recommendations

During the 2nd six months, this project has attempted to estimate the market potential for geothermal energy development in New Mexico. It has also attempted to identify those conditions that may impede market penetration. As a third objective, it has identified and initiated those actions that seem necessary to advance the development of geothermal resources.

The results show the market potential of geothermal resources will be most significant in the north central part of the Rio Grande Valley including the Albuquerque Basin. The southern third of the valley from Truth or Consequences to the Texas stateline and isolated areas throughout the southwest corner of the state appear to be strong potential areas of direct application.

The following are the State Team's findings and recommendations:

1. Outreach effort has increased substantially and has raised the geothermal profile.

2. New Mexico's Research and Development fund has had a substantial impact on geothermal development and outreach.

3. New Mexico's Geothermal Demonstration Program has provided the biggest boost to geothermal development and the $200,000 appropriation has been developed into over $500,000 of projects.

4. The determination and delineation of potentially commercial resources should be improved and refined.

5. DOE needs to undertand each state program to a greater degree and should work with the states to enhance the state's objectives. For example, here in New Mexico we have an aggressive R&D Program and Geothermal Demonstration Program yet our present contract requires that more effort go into resource planning (under DOE procedures and guidelines) than go into R&D.

6. Specially trained and experienced geothermal personnel should be made available to the states for 30-90 days to assist the states in organizing and fine tuning their operations. Examples: resource planning, well drilling, contracting, electrical generation, spaceheating engineering.

7. State and Federal agencies have to realize that loan guarantees address a symptom not the illness. Major technical efforts must be made to reduce geothermal risks by improving the technology, especially technologies associated with exploration, well drilling and reservoir identification.

TABLE A-1

STATE OF NEW MEXICO

PROVEN AND POTENTIAL ELECTRIC APPLICATIONS

SITE	LATITUDE / LONGITUDE	TEMPERATURE (°C) SURFACE	TEMPERATURE (°C) SUBSURFACE	ESTIMATED VOLUME (km^3)	ESTIMATED ENERGY (MWe) PROVEN	ESTIMATED ENERGY (MWe) POTENTIAL	ESTIMATED ENERGY (MWe) TOTAL
Animas (lightning Dock)	32° 85' / 108° 50'	102	170	3.3		5	20
Baca Location	35° 54' / 106° 32'		260-315	125.00	50	350	1942
Kilbourne Hole	31° 57' / 106° 58'	45-83	155	3.50		5	25
Radium Springs	32° 30' / 107° 58'	30-85	93-130	3.3		5	30
San Diego Mtn			125	1.00	—	5	20
					50	370	2037

Source: R.T. Meyer and R. Davidson, Summary Report - Southwest Regional Geothermal Operations Research Program, First Project Year, June 1977 - August 1978, U.S. Department of Energy Idaho Operations Office, Report No. IDO-10080 December 1978; revisions by New Mexico Energy and Minerals Department.

TABLE A-2

STATE OF NEW MEXICO

PROVEN AND POTENTIAL DIRECT THERMAL APPLICATIONS

SITE	LATITUDE / LONGITUDE	TEMPERATURE (°C) SURFACE	TEMPERATURE (°C) SUBSURFACE	ESTIMATED VOLUME (km^3)	ESTIMATED ENERGY (MWe) PROVEN	ESTIMATED ENERGY (MWe) POTENTIAL	ESTIMATED ENERGY (MWe) TOTAL
Albuquerque	35° 05' 106° 45'	27	30°	3.0			0.0449
Faywood H.S.	32° 33' 108° 00'	54		1.0			
Gila H.S.	33° 12' 108° 12'	68	125				
Jemez Springs	35° 47' 106° 4'	73	103	3.0		0.0206	0.6150
Los Alturas	32° 16' 106° 42'	55	120	3.0			0.5635
Ojo Caliente	36° 18' 106° 3'	45	122-161	3.3			
Radium Springs	32° 30' 107° 58'	30-85	130-198	3.3			0.0368
San Diego	35° 37' 106° 58'		52°				
San Ysidro	35° 30' 106° 40'	50	80	1.0			0.0206
Socorro	34° 2' 106° 56'	33	35	3.0			0.0135
Truth or Consequences	33° 9' 107° 15'	36-46	100	1.0		0.0269	0.4563
Animas	32° 85' 108° 50'	102	144	3.3	____	0.0359	0.4102
					0	0.0834	2.1508

Source: Same as Table A-1.

TABLE A-3

STATE GEOTHERMAL RESOURCE CHARACTERISTICS

NAME	COUNTY	RES. VOL. (KM)^3	SUB-SURFACE T (°C)	SURFACE T (°C)
Baca Location	Sandoval	125.00	273*	87
Lightning Dock	Hidalgo	3.30	170	102
Lwr San Francisco HS	Catron	3.30	109	49
Kilbourne Hole	Dona Ana	3.50	155*	45
Jemez Springs	Sandoval	3.30	103*	73
Radium Springs	Dona Ana	3.30	98*	53
Ojo Caliente	Rio Arriba	3.30	130	56
Gila HS Below Bridge	Grants	1.00	77	66
Gila HS Middle Fork	Catron	1.00	77	65
Montezuma HS	San Miguel	1.00	130	59
Gila HS Doc Campbell	Catron	1.00	77	66
Mambys HS	Taos	1.00	125	41
Turkey Creek	Grants	1.00	0	74
White Sands MSL RGE	Dona Ana	3.00	150	54
Las Alturas	Dona Ana	5.00	120	55
Berino - Mesquite	Dona Ana	3.00	120	31
Mimbres HS	Grants	1.00	0	58
Ponce de Leon	Taos	1.00	105	34
Upper San Francisco HS	Catron	1.00	0	27
Faywood HS	Grants	1.00	0	54
T or C	Sierra	1.00	100*	0
Gila HS UPR MDL FRK	Catron	1.00	77	36
Black Mtn W. Mesa	Dona Ana	1.00	95	0
Closson	Valencia	3.00	150	61
Playas Valley	Hidalgo	3.00	144	28
Cliff Area	Grants	1.00	0	31
Derry Warm Spring	Sierra	3.00	100	33
Tohatchi Area	McKinley	1.00	0	39
Crown Point	McKinley	3.00	150	37
Prewitt North East	McKinley	3.00	150	46
Guadalupe SP	Sandoval	1.00	120	0
Hot Well	Sandoval	1.00	100	0
San Ysidro	Sandoval	1.00	100	52
Crocker	Sierra	3.00	0	30
Freiborn Canyon	Catron	1.00	0	30
Las Palomas	Sierra	3.00	0	30
Rincon East	Dona Ana	3.00	0	50
Aleman	Sierra	1.00	110	0
Garton Well	Otero	1.00	0	34
Carne	Luna	3.00	40*	0

TABLE A-3 (cont'd)

STATE GEOTHERMAL RESOURCE CHARACTERISTICS

NAME	COUNTY	RES. VOL. $(KM)^3$	SUB-SURFACE T (°C)	SURFACE T (°C)
Guadalupe Area	Sandoval	1.00	170	35
Columbus	Luna	3.00	155	31
San Diego Mountain	Dona Ana	1.00	125	0
Tularosa Basin South	Otero	3.00	150	71
Socorro	Socorro	3.00	35	33
Jemez Reservoir	Sandoval	3.00	150	0
Lordsburg	Grants	3.00	150	33
Fort Wingate	McKinley	1.00	0	61
San Augustine Plain	Catron	3.00	0	35
Isleta	Bernalillo	3.00	33*	0
Albuquerque	Bernalillo	3.00	0	27
Laguna	Bernalillo	3.00	50*	0
Mancisco Mesa	San Juan	3.00	72*	27
Jicarilla Apache Ind.	Rio Arriba	3.00	98*	41
Blue Mesa	McKinley	3.00	98	32

* Measured, all other estimated

TABLE A-4

TOTAL ACREAGES OF GEOTHERMAL LEASES - NEW MEXICO

Federal Leases	
Total Acreages of Competitive Lease in KGRA's: (51 Leases)	87,540
Total Acreages of Non-Competitive Leases: (72 Leases)	138,170
State Leases	
Total Acreages of State Leases: (111 Leases)	45,663
TOTAL OF ALL ACREAGES LEASED	271,373

TABLE A-5

FEDERAL ACTIVE COMPETITIVE GEOTHERMAL LEASES - NEW MEXICO

(as of 1-25-80)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	KGRA/LOCATION	DATE ISSUED & (COST/ACRE)
DONA ANA			
Aminoil USA, Inc.	1,235.45 (1)	Radium Springs, KGRA, T21S, R1W	2/1/78 ($8.29)
Anadarko Production	18,476.45 (9)	Kilbourne Hole, KGRA, T27 & 28S, R1W	7/1/75 ($10.06-31.26)
Chevron USA	2,198.48 (3)	Radium Springs, KGRA, T21S, R1W	12/1/77 & 12/1/78 ($30.50 & $10.63)
N.K. Hunt	360.00 (2)	Radium Springs, KGRA, T21S, R1W	12/1/78 ($56.00)
HIDALGO			
Amax Exploration	6,580.43 (3)	Lightning Dock, KGRA, T25S, R19 & 20W	Various ($3.13, 8.11 & 13.07)
Aminoil USA, Inc.	1,271.64 (1)	Lightning Dock, KGRA, T25S, R19W	1/1/77 ($1.99)
J.E. Blakenship	1,235.72	Lightning Dock, KGRA, T25S, R19W	1/1/77 ($1.99)
Earth Power Corp.	5,060.12 (3)	Lightning Dock, KGRA T24 & 25S, R19 & 20W	10/1/76 & 12/1/78
Phillips Petroleum Co.	2,898.37 (2)	Lightning Dock, KGRA T25S, R19W	10/1/76 ($3.38 & 5.23)
RIO ARRIBA			
Amax Exploration	6,183.45 (4)	Baca Location No. 1 KGRA, T21N, R3 & 4E	8/1 & 12/1/77 ($5.67 & 5.31)
SANDOVAL			
Amax Exploration	3,870.84 (2)	Baca Location No. 1 KGRA, T18N, R3 & 4E	8/1/77 ($5.67)

TABLE A-6

FEDERAL ACTIVE NON-COMPETITIVE GEOTHERMAL LEASES - NEW MEXICO

(as of 7/6/79)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	LOCATION	DATE ISSUED
DONA ANA			
Mary Antweil	1,365.44 (1)	T19S, R2W	3-19-79
Chevron USA Inc.	2,522.17 (2)	T20 & 21S, R1E & 1W	6-29-79
J.F. Grimm	9,568.61 (5)	T25 & 26S, R1E	6-11-75
C.L. Hunt	13,730.68 (6)	T27S, R1 & 2W & T20 & 21S, R1W	5-30-75 & 4-27 & 6-26-79
Lamar Hunt	17,904.2 (8)	T28 & 29S, R2W & T20S & 21S, R1W	5-29-75 & 6-26-79 & 1-25-80
Nancy B. Hunt	1,280.00 (1)	T28S, R2W	5-29-79
Nelson B. Hunt	15,536.00 (7)	T26S, R1 & 2W	5-29-79
N.K. Hunt	8,306.94 (4)	T29S, R1 & 2W	5-29-79
M.W. Sands	2,440.00 (1)	T20S R1W	4-27-79
Ramona Sands	4,307.79 (3)	T20 & 21S, R1W	4-27-79
H.W. Schoellkopf, Jr.	9,636.92 (3)	T17 & 28S, R2W	5-29-75
Southland Royalty Co.	14,263.29 (7)	T19, 20 & 21S, R1E, 1W & 2W	6-15-79
HIDALGO			
Chevron USA, Inc.	5,814.13 (4)	T26S, R20W	9-11-79 & 11-1-79
Earth Power Corp.	533.68 (1)	T26S, R19W	12-28-76

TABLE A-6 (cont'd)

FEDERAL ACTIVE NON-COMPETITIVE GEOTHERMAL LEASES - NEW MEXICO

(as of 7/6/79)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	LOCATION	DATE ISSUED
HIDALGO (cont'd)			
Sun Oil Company	1,280.00 (1)	T25S, R20W	10-24-79
Thermal Resources, Inc.	1,320.00 (2)	T25S, R19W	1-7-77
U.S. Geothermal Corp.	2,954.57 (2)	T25 & 26S, R19 & 20W	5-29-75 1-7-77
SANDOVAL			
Occidental Geothermal, Inc.	2,817.95 (4)	T15N, R1 & 2E	1-7-77 & 6-21-79
Sunoco Energy Dev. Co.	1,542.32 (2)	T15N, R3 & 4W	7-28 & 8-19-77
SIERRA			
Fluid Energy Corp.	12,182.93 (5)		

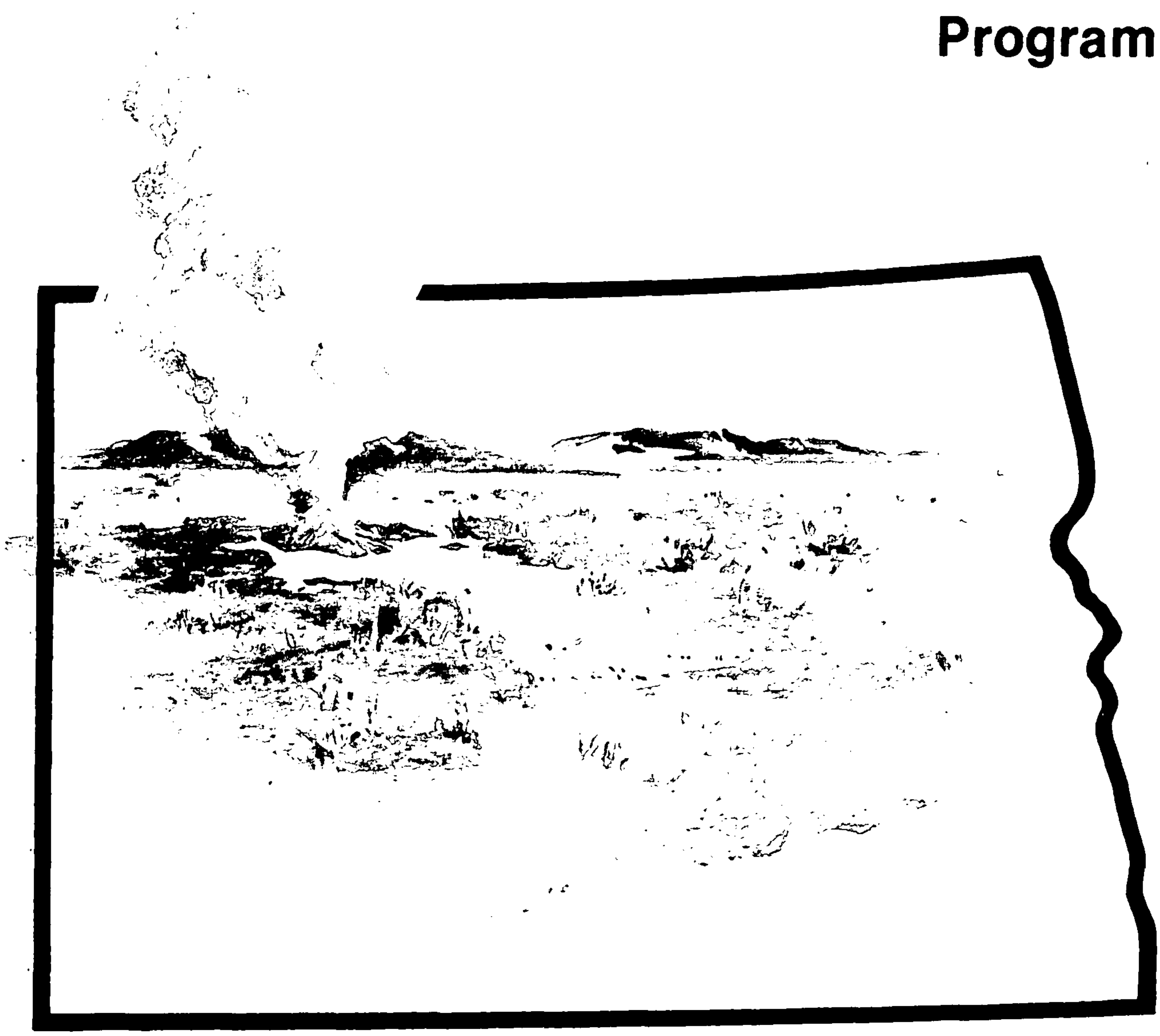
TABLE A-7

STATE LEASES - NEW MEXICO
(as of 8-1-79)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	DATE ISSUED
DONA ANA		
Chevron	639.36 (1)	8-14-79
Monument Solar Corp.	640.00 (1)	7-19-79
GRANT		
Aminoil USA	4,695.63 (18)	8-3-79 & 3-12-75
Supron Energy Corp.	3,868.9 (18)	3-12-75
HIDALGO		
Amax Exploration	8,176. (19)	7-10-79 & 7-19-79
Aminoil USA	11,078.55 (25)	8-3-79 & 3-12-75
SANDOVAL		
Cherokee & Pittsburg Mining	4,433.19 (7)	3-12-75
E.E. Fogelson	1,280. (2)	3-12-75
SOCORRO		
Arco	5,437. (10)	7-19-79
J.W. Covello	640.00 (1)	3-12-75
J.M. Kelly	2,624.27 (5)	3-12-75
Gulf Oil Corp.	2,150.56 (4)	3-12-75

Chapter 8

North Dakota Geothermal Commercialization Program



NORTH DAKOTA GEOTHERMAL COMMERCIALIZATION PROGRAM

SEMI-ANNUAL PROGRESS REPORT

July - December, 1979

Prepared by:

Bruce A. Gaugler
Program Coordinator

State of North Dakota
Bismarck, North Dakota

Work performed under Contract No. DE-FC07-79ID12011
U. S. Department of Energy
Idaho Operations Office

TABLE OF CONTENTS

1.0 INTRODUCTION

North Dakota has a significant but largely undeveloped geothermal energy potential. Most of the known geothermal water is of low to moderately high temperature. Water in this temperature range could be used extensively for industrial process heat and space heating.

There are several obstacles to developing the geothermal resource:

- A lack of information regarding quantities and qualities of geothermal reservoirs
- A lack of geothermal legislation and incentives
- Uncertainties regarding cost
- General public unfamiliarity with geothermal resources
- Limited amount of public and private funding

The North Dakota Geothermal Commercialization Planning Program is seeking to remove these roadblocks. Through all the facets of our program--area development plans, site-specific plans, time-phase project plans, institutional assessments, and outreach programs--we seek to assess and remove these obstacles. Our state planning staff has begun to analyze and encourage the development of geothermal resources. This report summarizes partial findings and tentative answers found in the first four months of the program. Further study, exploration, and experimentation will determine the degree to which geothermal resources can or will be developed in North Dakota.

1.1 Purpose of Project

The State Geothermal Commercialization Planning Project (GCPP) is funded by the U. S. Department of Energy (DOE) and the State of North Dakota.

The purpose of the project is to provide DOE and North Dakota with planning data and to initiate a program for fostering geothermal commercialization in the state. Initiatives by the federal government and the state will encourage geothermal commercialization. Increasing public awareness of the advantages of geothermal use will also stimulate commercialization.

1.2 Objectives

The objectives of the State Geothermal Commercialization Planning Project are as follows:

- Identify prospective geothermal users/developers within North Dakota
- Evaluate the potential uses of geothermal resources
- Project the probable time frame for developing geothermal resources
- Identify institutional considerations pertaining to geothermal development in North Dakota
- Provide assistance to those entities that are interested in developing geothermal resources

1.3 Technical Approach and Team Members

To evaluate the possibilities for geothermal commercialization, the state planning team is investigating substate regions and specific sites in the state. By so doing, the state planning team builds the foundation for the following:

- Area development plans
- Site-specific development analyses

- Commercialization plans
- Institutional assessments
- Economic assessments
- Outreach programs

The Geothermal Energy Office is conducting the North Dakota Geothermal Commercialization Planning Project. The state planning team members are as follows:

- Bruce A. Gaugler, Program Coordinator
- Jolene Wetch, Graphics and Statistics Analyst and Secretary
- Jill Johnson Sholts, Technical Writer

In addition the state team may call upon other state agencies to perform selected Geothermal Commercialization Planning Project activities on an ad hoc basis.

Using standardized methods and assumptions, the state team is gathering necessary data from the most direct sources available and incorporating this data into their reports. The outreach program disseminates the information and provides other services to the public.

1.4 Benefits of Project to State and DOE

The Geothermal Commercialization Planning Project has stimulated North Dakota to take several steps:

- Develop a professional geothermal staff
- Collect and disseminate geothermal information
- Institute programs that will promote commercialization of North Dakota's geothermal resources

North Dakota's program assists DOE by providing information concerning North Dakota's resources and the contribution that those resources can make to the national energy balance.

2.0 SUMMARY OF STATE PROJECT TASKS AND WORK ACCOMPLISHED

2.1 Area Development Plans

The state planning team has identified eight substate regions for area development analysis. These eight geographic regions coincide with the boundaries of North Dakota State Planning Regions. Three of these substate regions are presently being analyzed. They are:

- Roosevelt-Custer Region, consisting of eight southwestern counties including Dunn, Billings, Golden Valley, Stark, Slope, Hettinger, Bowman, and Adams
- Lewis and Clark 1805 Region, consisting of ten southcentral counties including McLean, Sheridan, Mercer, Oliver, Burleigh, Kidder, Morton, Grant, Emmons, and Sioux
- Williston Basin Region, consisting of three northwest counties including Divide, Williams, and McKenzie

Research for the Roosevelt-Custer Area Development Plan is nearly completed. The New Mexico Energy Institute (NMEI) surveyed the major industries in all eight planning regions to determine actual energy consumption, types of energy presently consumed, and process temperatures required. The North Dakota Geologic Survey inventoried the geothermal resource prospects in North Dakota. The state planning team is compiling the two other area development plans as more data becomes available. Institutional profiles are being compiled by the Geothermal Energy Office for all regions. Currently, the institutional profile in the Roosevelt-Custer Area Development Plan is undergoing revision by several state agencies.

2.2 Site-Specific Development Plans

For selected major geothermal prospects that may experience development or commercialization between now and Calendar Year (CY) 2000, the state planning team will prepare site-specific development plans.

Each site-specific development will be based largely upon the information gathered from the substate area development plans. Site-specific plans will examine the quantitative aspects of the technical, economic, environmental, and institutional considerations influencing geothermal development and use. Each site-specific development plan will define the potential amount of useable geothermal energy as a function of time to the year 2020. Also, each plan will describe the considerations or actions that will influence, control, or accelerate the prescribed rate of development.

The state planning team has identified one of the site-specific plans that it will construct. This site-specific plan will analyze the criteria for installing geothermal energy space heating in a business area of downtown Bismarck. Our team will analyze resource, institutional, and market considerations to determine the project's feasibility.

The state planning team will provide the results of the site-specific development plans to planners and developers within the state as well as to the Department of Energy and the New Mexico Energy Institute (NMEI).

2.3 Time Phase Project Plan

A time phase project plan is a detailed time line scenario, which outlines those critical tasks which must be completed to bring a geothermal development to successful completion. Time phase project plans are constructed for sites with specific development activities currently in progress or pending.

In North Dakota there are ten identified sites making use of geothermal space heating. These sites, however, are not incorporated into a time phase project. The University of North Dakota Engineering Experiment Station proposes to conduct a monitoring program using these ten sites.

2.4 Institutional Analysis

Local and state legislative and regulatory procedures and practices that might be associated with the development and commercialization of geothermal energy are being studied by the state planning team. Institutional considerations will affect all phases of geothermal development from leasing to construction, and the state team is examining interactions and overlapping jurisdiction among state and local agencies.

The draft of the Roosevelt-Custer Region Area Development Plan contains our tentative institutional analysis. Currently, the state team is consulting with various state agencies that we have identified as possibly instrumental in all stages of geothermal activity to discuss our analysis.

This information will be used to develop the substate area development plans, the site-specific development plans, the state handbook, and the selected time phase commercialization project plans.

2.5 State Handbook of Institutional Analyses

The state team is preparing to draft an information manual. This state handbook will identify the governmental regulations, procedures, and practices that may affect geothermal development in North Dakota.

As it is a procedural guide, a full array of parties, who may be participants in geothermal activity, will use the handbook. Among the parties may be investors, financial institutions, developers, utilities, energy users, industry, commerce, business, and local governments. The handbook will chart and describe the agencies, regulatory, procedures , action or decision times, and procedural costs in a clear and easily readable form. DOE/EG & G has prescribed a specific format for the manual.

2.6 State Outreach Program

To promote the use of geothermal energy, the state team is organizing and conducting a state outreach program. The state team is drawing upon the resources of NMEI, EG & G, and DOE to carry out an effective outreach program. In particular, the state team is conveying to interested developers geothermal information. This data includes geothermal prospects, applications, economic and environmental advantages, and energy supply demand projections. The project monthly progress reports will record these outreach contacts and activities.

Essentially, the state team conducts the outreach program by the following methods:

- Interacting with community business, industrial, and governmental leaders concerning geothermal development opportunities and programs
- Disseminating information via television, newspaper, personal contact, and hand-outs
- Coordinating regional support for limited user assistance to potential geothermal developers and users

3.0 SPECIFIC TASK DESCRIPTIONS

3.1 Area Development Plans

3.1.1 State Geothermal Planning Areas:

Area development plans will cover multi-county areas. Criteria for choosing the planning areas included the types of resources in the counties, the types of industry, the population, and the potential economic impact of geothermal development. The order in which the state team will complete the area development plans are as follows:

- Roosevelt-Custer Region
- Lewis and Clark 1805 Region
- Williston Basin Region

The first area development plan, the Roosevelt-Custer Region, is well under way. Geothermal site resource information has been gathered and is being reviewed and revised. Geothermal data are being updated for subsurface temperatures and site-specific depth, volume, and energy content.

The area development plan for the Roosevelt-Custer Region relied primarily upon data obtained from the area itself, both in the form of published documents and conversations with local officials. In cooperation with Rod Landblom of the Roosevelt-Custer Regional Council, the state team is revising the area development plan draft. Because of this "grass roots" approach, the plan will reflect closely the actual conditions in the region that will determine the ultimate extent of development.

Having secured energy consumption data from the utilities that serve the Roosevelt-

Custer Region, the state team reduced it to a meaningful format, which can be used to project future energy needs that may be satisfied by geothermal energy.

To obtain a computer simulation modelling of the state and each region, the state planning team director met with NMEI in December, 1979. This modelling data will be used in the preparation of each area development plan.

3.2 Site-Specific Development Plans

3.2.1 Candidate Geothermal Sites/Application

Carlson Homes, Inc., a volume builder in Dickinson and Bismarck, has submitted a proposal to the Old West Regional Commission for funds to conduct a geothermal demonstration project. Under the direction of the University of North Dakota's Engineering Experiment Station, Carlson Homes, Inc. proposes to install water-to-air heat pump systems in two of four model homes to prove that heat pump systems can save energy and money.

With University of North Dakota Engineering Experiment Station's supervision, Carlson Homes, Inc. will monitor the heat pump systems for twelve months. They will then compare operating cost of these systems against that of the natural gas systems in two "control" homes.

Carlson Homes, Inc. is currently awaiting the Old West Regional Commission's decision on project funding.

3.2.2 Site Specific Development Plans in Preparation

A site-specific Development is currently being prepared for one site, a commercial heat district, in Bismarck, North Dakota. The state planning team chose this site because an initial development activity beginning with preliminary planning investigations and attempts to obtain funds and/or technical assistance has begun. Data is now being collected for this site. The site-specific development plan will include an analysis of the current and forecast conditions at the site that limit or encourage development, as well as an analysis of the requirements for development at the site.

3.3 Time Phase Project Plans

The Geothermal Commercialization Planning Project staff is compiling a list of all known geothermal users in North Dakota--currently ten projects, which use geothermal fluids through the application of a ground water heat pump, have been identified:

KNOWN GEOTHERMAL USAGE

Geothermal Users	Application	Location
Gillman Beck	Ground water heat pump space heating	Northwood, Grand Forks County
Lee Christopherson, M.D.	Ground water heat pump space heating	Fargo, Cass County
Art Johnson	Ground water heat pump space heating	Larimore, Grand Forks County
Wesley D. Meland	Ground water heat pump space heating	Northwood Grand Forks County

Geothermal Users	Application	Location
Oakes Electric	Ground water heat pump space heating	Oakes, Dickey County
Mike Peterson	Ground water heat pump space heating	Berlin, Lamoure County
Alvin Pocrice	Ground water heat pump space heating	Sykeston, Wells County
Fred Rosenau	Ground water heat pump space heating	Ellendale, Dickey County
Traut Wells	Ground water heat pump space heating	Jamestown, Stutsman County
Adam and Agnes Vetter	Ground water heat pump space heating and direct space heating	Emmons, Logan, and McIntosh Counties (Junction)

Source: Geothermal Energy Office, Natural Resources Council, Bismarck, ND; December, 1979

The University of North Dakota Experiment Station has applied to the Old West Regional Commission for money to monitor the ten residential installations that the state planning team has identified. The proposed monitoring program will obtain the following information:

- Actual energy savings experienced during the course of a year
- Operational problems or maintenance items characteristic of the system
- *The net energy extracted from the ground water supply during the course of a year*

- Variations in system performance based on design differences and local ground water temperatures

This data can then be used to predict potential effects of large scale application of this heating/cooling system on ground water aquifers and demand loads of electric utilities. In addition, projections of energy savings by fuel oil displacement with ground water heat pump systems can be made. The study will also serve as a reference document for future installations on the methods of water handling and disposal currently employed.

3.4 Institutional Analysis

3.4.1 Overview of State Laws and Regulations

Little geothermal development has occurred in North Dakota. Therefore, no state legislation has been aimed at defining geothermal resources and establishing a government policy for the development of geothermal resources. Currently, there are no procedures for geothermal leasing in the state. Any leasing would probably follow procedures set forth for coal, oil, and gas leasing. Additionally, geothermal has not been identified as a mineral, water, or unique resource. Due to this situation, several state agencies may have jurisdiction over the geothermal resource, depending on location, use, and developer. The state planning team is presently working with these state agencies to delineate leasing and permitting policies.

3.4.2 Detailed State Institutional Procedures

No data at this time.

3.5 Public Outreach

3.5.1 Outreach Mechanisms

A. Existing:

- Regular contact with state and federal lawmakers regarding possible geothermal legislation
- Limited assistance for interested geothermal developers and researchers
- Provision of NMEI data to any interested developers
- Television interview, November, 1979
- Radio broadcasts of geothermal application, November, 1979
- Handouts of geothermal literature to all interested parties

B. Proposed:

- Broader use of television and radio
- Acceptance of invitations to speak at civic clubs and schools (time and funding permitting)
- Placement of information brochures in public libraries and local government offices
- Distribution of movies on geothermal activity to schools and interested civic groups

3.5.2 Summary Listing of Contacts

Contact	Interest	Affiliation
Robert Kaiser	Energy Activities	Federal Government
Charles Mumma Soil Conservation Service	ADP Information	Federal Government

Contact	Interest	Affiliation
Rod Landblom Roosevelt-Custer Regional Coordinator	ADP Progress	Local Government
Milton Lindvig State Water Commission	Regulations	State Government
Former Gov. William Guy	General	Basin Electric
Ken Harris North Dakota Geological Survey	Resources Assessment	State Government
Dean Montieff State Planning Commission	Fed. & State Land Land Surface Ownership; ADP Data	State Government
Gerard D. Sholts; Fenton Warner	Geothermal Development	Architects
Loren Kopseng, Vice-President Carlson Homes, Inc.	Geothermal Demonstration Project	Home Builder
Don Mathson University of North Dakota Engineering Experiment Station	Geothermal Research	State University
John O'Leary Lewis & Clark 1805 Regional Coordinator	ADP Progress	Local Government
Joe Cullen	Geothermal Loan Guarantee Program	Federal Government
Norm Peterson State Health Department	ADP Information	State Government
125 Well Drillers	Geothermal Users Identification	Industry

Contact	Interest	Affiliation
270 Plumbers	Geothermal Users Identification	Industry
Harvey Schneider Toman Engineering	Geothermal Development	Business

3.5.3 Overall Prospectus for Geothermal Activity

The North Dakota Geothermal Commercialization Program is successfully raising the viability of geothermal as an alternative energy resource. During the four months that our program has been in existence, a broad spectrum of our community has shown a strong interest in geothermal development.

The University of North Dakota Engineering Experiment Station is currently one of geothermal's strongest advocates. It has developed a detailed proposal for monitoring existing ground water heat pump systems and is actively seeking financial assistance. With the data obtained from this type of research, the Engineering Experiment Station will be able to project geothermal's contribution to solving the energy crisis.

Carlson Homes, Inc., a volume builder, has also submitted a proposal to install ground water heat pump systems in two of four model homes as a demonstration project. This kind of program will prove to the public geothermal's importance as an alternative energy source. In addition, if the demonstration project is a success, Carlson Homes, Inc. intends to install geothermal space heating in future homes.

An elderly housing renovation project in Bismarck is also very interested in utilizing geothermal space heating. If geothermal heating is installed, the present owners will be able to lower the heating cost and slow the rising rent costs. The owners are seeking a geothermal loan guarantee so they will be able to obtain additional financing.

Furthermore, private individuals have contacted the state planning team to discuss the use of ground water heat pump systems in private homes as well as in farming and ranching operations.

It is difficult to estimate future commercialization commitments for several reasons; these include cost, reservoir information, and institutional barriers.

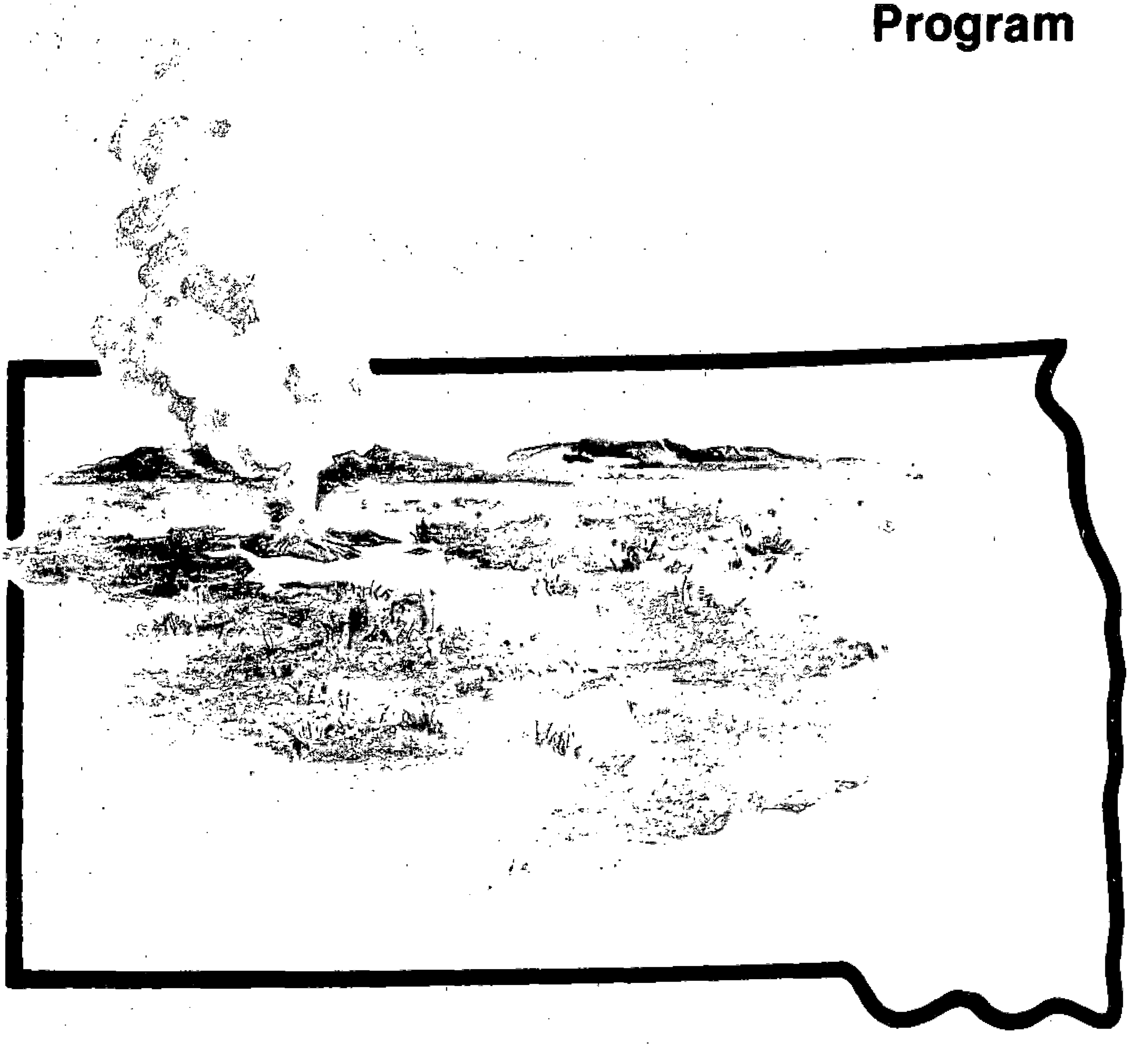
Utility bills are soaring and interest in geothermal and other energy sources has increased. Some areas of the state face severe energy shortages. It is probable that those areas will become very active in alternative energy planning.

North Dakota's geothermal future is bright and activity is increasing. The state planning team is taking an active role in research, demonstration, publicizing, and commercialization of geothermal resources.

This effort will expedite geothermal development and lessen our dependence on fossil fuels.

Chapter 9

South Dakota Commercialization Program



SOUTH DAKOTA COMMERCIALIZATION PROGRAM

SEMI-ANNUAL PROGRESS REPORT

July - December, 1979

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Work performed under Contract No. DE-FC07-79ID12012
U. S. Department of Energy
Idaho Operations Office

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INTRODUCTION

Western South Dakota is blessed with a prime low temperature low temperature geothermal resource. The Madison Formation consisting of Mississippian age carbonate rocks has been producing geothermal energy for over 60 years. Virtually every well completed in the Madison Formation encounters above average temperatures and water flows which are artesian at surface elevations of 700 meters or less.

It is thought that the major recharge for the Madison Formation comes from the winter snow melt and summer rains in the Black Hills area. This meteoric water flows through the fractured Madison system to depths of more than a thousand meters. The water is heated from the normal geothermal gradient except for an area of hotter water in south central South Dakota that may have a separate heat source. Temperatures range from 42°C at Pierre to 70°C at Philip to 83°C at Lemmon.

The Madison Formation in South Dakota is shaped like a trough, outcropping in the Black Hills to the west, pinching out at a shallow depth against the Precambrian granite east of the Missouri River and increasing in depth in northwestern South Dakota. Depths to the Madison Formation vary from 640 meters at Pierre to 1768 meters at Lemmon. Water quality is generally good in central South Dakota except for an area that contains radium 226; it deteriorates in northwestern South Dakota where the dolomitic limestones contain evaporite beds in the upper part of the Madison Aquifer.

The other formation that may become increasingly important in geothermal energy production is the Dakota Sandstone of Cretaceous Age. The Dakota underlies South Dakota from depths of 244-549 meters. Artesian flows are present in the Dakota Formation with temperatures of 20-25°C east of the Missouri River and up to 50^{o}C in Tripp County west of the Missouri River. A resource assessment program including a drilling program is needed in Tripp County to determine the source of heat at shallow depths. The 20-25^{o}C water east of the Missouri River could be coupled with groundwater heat pumps to give eastern South Dakota a viable alternative energy resource.

Present Geothermal Activities

Four PONs were funded by DOE in 1977; of these, two are complete, one is nearing completion and one was suspended. Projects not federally funded include space heating and stock water heating by numerous ranchers in western South Dakota. Source of the water is both the Madison and the Dakota Formations. In one instance a local resident is using Dakota low temperature water in conjunction with a groundwater heat pump system. The Midland School District is space heating two buildings with 66^{o}C water from the Madison Formation. Lemmon, with the full backing of the local businessmen and residents, has developed a multi-purpose geothermal energy program. They have hired a consultant to prepare an unsolicited proposal for submittal to DOE.

Number	County
1	Harding
2	Butte
3	Lawrence
4	Perkins
5	Meade
6	Pennington
7	Custer
8	Fall River
9	Shannon
10	Bennett
11	Washabaugh
12	Jackson
13	Haakon
14	Ziebach
15	Corson
16	Dewey
17	Stanley
18	Jones
19	Mellette
20	Todd
21	Tripp
22	Lyman
23	Hughes
24	Sully
25	Potter
26	Walworth
27	Campbell
28	McPherson
29	Edmunds
30	Faulk
31	Hyde
32	Hand
33	Buffalo
34	Jerauld
35	Brule
36	Aurora
37	Gregory
38	Charles Mix
39	Douglas
40	Bon Homme
41	Hutchinson
42	Davison
43	Hanson
44	Sanborn
45	Beadle
46	Spink
47	Brown
48	Marshall
49	Roberts
50	Day
51	Grant
52	Clark
53	Codington
54	Deuel
55	Hamlin
56	Kingsbury
57	Brookings
58	Miner
59	Lake
60	Moody
61	McCook
62	Minnehaha
63	Turner
64	Lincoln
65	Yankton
66	Clay
67	Union

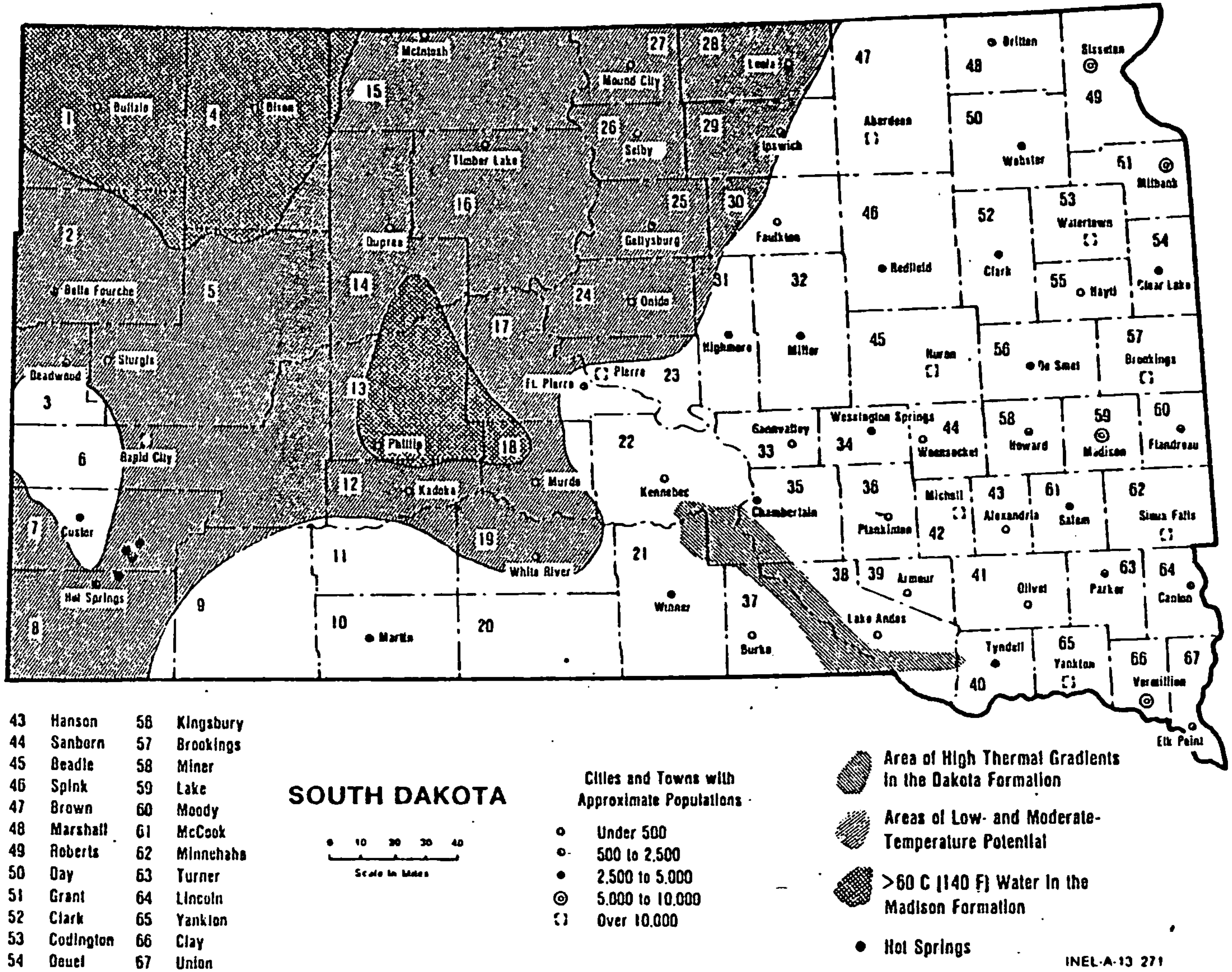


Fig. 1.1 South Dakota counties and geothermal springs and resource areas

THE MADISON FORMATION IN SOUTH DAKOTA

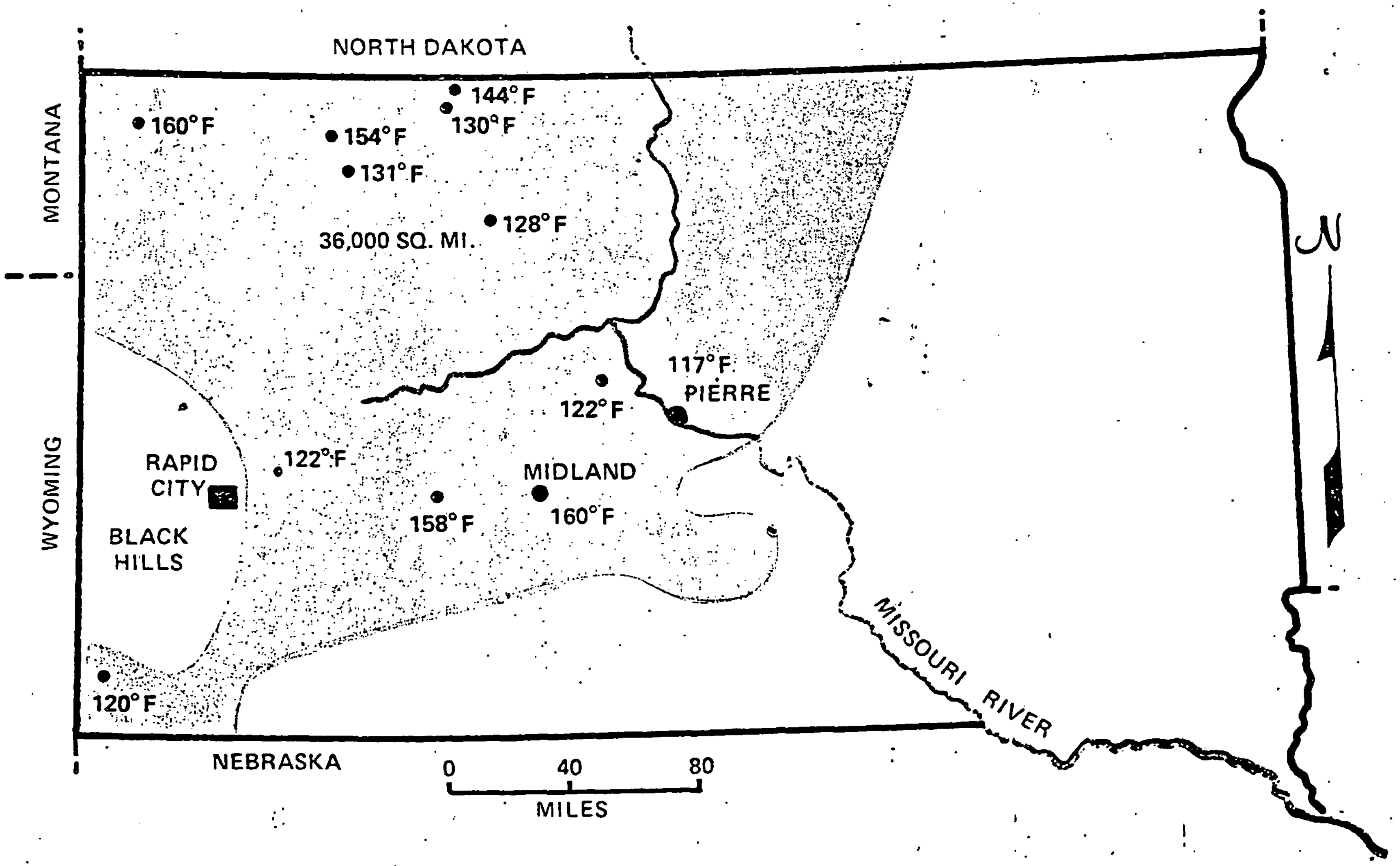


Figure 1.2

2.0 SPECIFIC TASK DESCRIPTIONS AND PRODUCTS

Resource assessment data have been obtained from R.A. Schoon and D.J. McGregor, Geothermal Potentials in South Dakota, Report of Investigation 110, South Dakota Geological Survey 1974; J.P. Gries, Geothermal Applications on the Madison (Pahasapa) Aquifer System in South Dakota, Final Report IDO/1625-2, South Dakota School of Mines and Technology, September 1977 and the South Dakota Hydrothermal Commercialization Baseline by J.A. Hanny and B.C. Lunis, EG&G Idaho, Inc., Idaho Falls, Idaho, August 1979. This information has been refined through personal communications with South Dakota Geological Survey personnel and categorized into proven, potential and inferred areas. Site-city matchups have been identified on a NMEI worksheet.

South Dakota has been divided into 11 Area Development Plans (ADPs) by the State Commercialization Team and prioritized, Area I being the highest priority. Most of the commercialization efforts the past six months have been centered on Areas I, II, and III which are underlain by the Madison Aquifer. Area IV is the area of unusually high geothermal gradients from the Cretaceous Dakota sandstones that needs more field study as discussed earlier. There are four Indian Reservations within the area covered by the three ADPs under study. They are:
1) Pine Ridge in Shannon and Washabaugh counties. (Washabaugh is unorganized and is now the southern half of Jackson County),
2) Rosebud in Todd County, 3) Standing Rock in Corson County and
4) Cheyenne River in Dewey and Ziebach Counties. The reservations are separate political entities and will be treated accordingly.

2.1 GEOTHERMAL PROSPECT IDENTIFICATION

South Dakota is the only Rocky Mountain Basin and Range State that does not have an ongoing resource assessment program. Efforts are now being made to rectify that situation. However, funding is a problem.

The lack of such data has hampered the State Geothermal Commercialization Planning Team in their identification efforts. Confirmed and potential sites for Area Development Plans I through IV have been obtained from the South Dakota Geological Survey, Vermillion; the United States Geological Survey, Huron; Program Opportunity Notices at Philip, Haakon County, and Pierre and the Lemmon test well. Thirty-five towns have been selected as confirmed and potential geothermal sites in the 4 areas.

The depths and temperatures of the potential sites were extrapolated from data of existing geothermal wells in the area and from knowledge of the local geology. The resource information, population projections and present conventional fuel prices have been given to NMEI. These data consequently have been utilized in NMEI's city-site matchups, CASHRUN and BTHERM programs.

2.2 AREA DEVELOPMENT PLANS

The division of South Dakota into 11 geothermal districts by the State Geothermal Commercialization Team was made on the basis of industry use, population, and geothermal resource. The Madison Formation does not underly eastern South Dakota. Artesian flows are obtained from the lower Cretaceous Dakota Formation with temperatures of 20-25^{o}C in eastern South Dakota. For this reason the 4 Area Development Plans west of the Missouri River have been given top priority. County by county population projections have been made through the year 2020. Historical employment and income data have been obtained on a county wide basis. The geothermal resource

AREA DEVELOPMENT PLAN

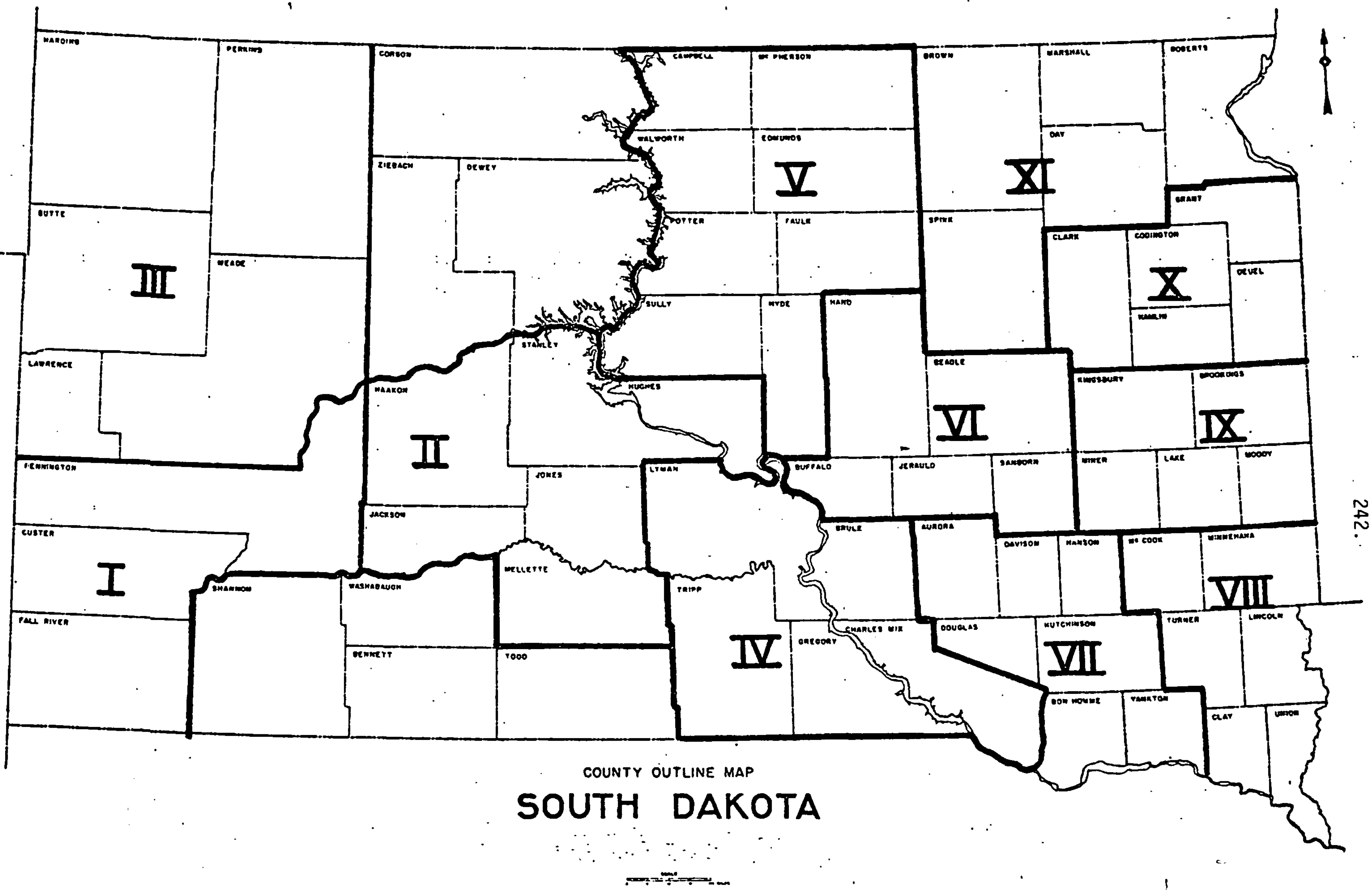


Figure 2.2

is presently being matched with potential application in Areas I, II, and III. These data along with data from tasks 1 and 2 have been provided NMEI and energy use is being developed for the three Areas for the next 40 years.

A survey of present and projected energy use by the economic sector is being conducted. Data for the industrial sector were obtained from NMEI, DOE and the 1979 South Dakota Manufacturers and Processors Directory published by the Industrial Division of the South Dakota Department of Economic and Tourism Development. Since confirmed geothermal resource underlying western South Dakota (the Madison Formation) has temperatures less than $90^{o}C$, however, only energy use data from industries that could utilize direct thermal applications were compiled.

Historical energy use information in the commercial, residential, agricultural and governmental sectors is being collected. Lists of fuel oil costs compiled for October, December and January indicate a dramatic and persistant rise in conventional fuel prices. Present fuel costs per million BTU's are as follows: fuel oil - $7.00, LPG - $6.00, and natural gas - $3.00. LPG and fuel oil costs have increased 14% since October 1979.

2.3 SITE SPECIFIC DEVELOPMENT PLANS

Thirty-five towns in western South Dakota are co-located with confirmed or potential geothermal resource sites. All of these sites are candidates for site specific development plans. The sites selected for analysis during the calendar year 1980 are:

1. Lemmon, Perkins County
2. Philip, Haakon County
3. Edgemont, Fall River County
4. Midland, Haakon County

1. Lemmon has indicated a great deal of interest in utilizing geothermal energy to avoid the high cost of LPG (50¢/gal.) and fuel oil (95¢/gal.). A local survey shows 100% of the businessmen and 80% of the private citizens are in favor of obtaining geothermal energy. A test well completed in 1979 indicates 82°C water at a depth of 1860 meters rising to within 152 meters of the ground surface. South Dakota water permits have been obtained for three 2000 GPM wells. (A fourth well is planned for north Lemmon in North Dakota).

   Easements have been obtained and an industrial park site has been selected. Current plans for geothermal energy use include space heating, grain drying, gasohol plant, and agriculture. The New Mexico Energy Institute (NMEI) in their report #30-6 "Geothermal Prospects for Lemmon, South Dakota" published October 15, 1979, discussed nine possible geothermal development scenarios. The NMEI report states that geothermal energy offers the potential for Lemmon to save as much as 1800 billion BTUs per year of fossil fuel in the next 30 years.

   Dunham and Associates, a Rapid City consultant, has been retained by the Lemmon people to prepare an unsolicited proposal for the Department of Energy.

2. The Philip School System received a PON in 1977 to develop geothermal energy for heating 3 buildings. A well drilled to a depth of 1300 meters provides 67°C water with a flow of 300 GPM. Hengel, Berg, and Associates, a Rapid City consultant, were selected to design and construct the system. Local businessmen provided the funds for a feasibility study of the use of the residual water. This study indicates nine businesses have the potential for space heating their buildings. This project was delayed because of the presence of radium 226 in the water that will necessitate the building of a barium chloride treatment plant.
3. A PRDA project under the direction of John Iszler, Edgemont Superintendent of Schools, was completed in 1979. The results of the study indicate that the city's 4 wells could space heat the school system and an additional 285 private homes. The wells have water with a combined flow of 875 GPM and a temperature of approximately 52°C. Mr. Iszler and John Kruger, Edgemont City Planner, are presently trying to generate local interest in geothermal space heating.
4. Midland, a small Haakon County community with a population of 320, has a 1220 meter deep well with a 200 GPM flow at a temperature of 70°C that heats their school system. The Stroppel Hotel has hot mineral baths from Dakota Formation water that is approximately 48°C.

CLASSIFICATION OF GEOTHERMAL RESOURCES THAT ARE SUITABLE FOR DIRECT THERMAL USE (<150°C)

Class	Location of Site	Measured Subsurface Temperature	Estimated Subsurface Temperature	Depth	Flow
	AREA DEVELOPMENT PLAN I				
P	Ardmore 912S 4E		50	3000	
C	Box Elder 30 2N 9E	34		2160	
P	Cascade Springs 26 5S 6E		67	2000	
C	Edgemont 1 9S 2E	52		2983	175
P	Hot Springs 20 7S 5E		67	2000	
P	New Underwood 31 2N 11E		60	4000	
C	Wall 31 1N 16E	38		2845	
P	Wasta 4 1N 14E		50	4000	
	AREA DEVELOPMENT PLAN II				
C	Belvidere 32 2S24E	44		2410	
C	Draper 14 1N 29E	52		2690	
P	Ft. Pierre 36 5N 31E		43	2200	
C	Kadoka 32 2S 22E	54		2956	
C	Midland 6 1N 25E	47		1880	
C	Diamond Ring Ranch 16 5N 23E	67		4000	125
C	Murdo 21 2S 27E	58		3728	
C	Philip 24 1N 20E	69		3730	300
C	Pierre 4 110N 32W	41		2170	500
	ADP III				
P	Belle Fourche 10 8N 2E		50	4000	
P	Buffalo 29 19N 5E		60	7000	
P	Camp Crook 3 18N 3E		60	7000	
P	Dupree 31 13N 21E		67	6300	
C	Eagle Butte 17 12N 24E	53		4322	106 GPM
P	Faith 10 12N 17E		65	3000	
P	Isabel 32 17N 22E		50	4000	
C	Lemmon 5 23N 16E	88		6100	500 below surface 0
P	McLaughlin 5 21N 27E		66	6000	
C	McIntosh 20 23N 22E	72		7470	
P	Morristown 25 23N 19E		88	6100	
C	Nisland 6 8N 5E	32		2250	
C	N. Eagle Butte 17 12N 24E	53		4322	106
P	Timber Lake 17 17N 25E		50	4000	
C	Newell 19 9N 6E	38		2741	

Class	Location of Site	Measured Subsurface Temperature	Estimated Subsurface Temperature	Depth	Flow
P	Kennebec 20 105N 75W		58	2200	
P	Winner 23 100N 77W		49	2400	
P	Presho 10 105N 77W		58	3700	

C = Confirmed resource

P = Potential resource

2.4 TIME PHASED PROJECT PLANS

There are no time phase project plans presently under presently under preparation by the State Commercialization Team. Three candidate projects are as follows: 1) The Diamond Ring Ranch, a PON project in Haakon County that should be completed in the immediate future. The resource is an existing well 1220 meters in depth producing 174 GPM water at 67°C. All the piping has been completed and the heat exchangers installed for space heating 2 homes, 3 mobile homes, a hospital barn, a shop area and two livestock shelters. In addition the water will be used for drying sorghum and corn and for stock water warming. The water will be discharged into two holding ponds which provides habitat for fish and fowl and used for irrigating corn and sorghum. 2) The Pierre St. Mary's Hospital PON project. A 663 meter deep well is producing 42°C water flowing at 400 GPM. The well will provide space heat, ventilation air and hot water for the new hospital addition plus providing space heat for the present structure. The well has a total heating capacity of 5.5 million BTU's per hour. Two million BTU's/hrs. of heat is needed for the new addition, leaving 3.5 million BTU's/hr. for the present facilities. The well house is now being constructed after the heat exchanger will be installed. The project should be functional by Spring. 3) The Philip School Project has been described in section 2.3.

2.5 STATE AGGREGATION OF PROSPECTIVE GEOTHERMAL UTILIZATION

No energy supply/demand projections have been made for the Areas.

2.6 INSTITUTIONAL ANALYSIS

This section is summarized in the appendix in the Handbook of State Government Institutional Procedures for Geothermal Resources submitted to the Office of Energy Policy by Resource Management Services, Inc.

2.7 PUBLIC OUTREACH PROGRAM

2.7.1 OUTREACH MECHANISMS

Various articles pertaining to geothermal energy have been featured in the public information newsletter "Energy Times" published by the South Dakota Office of Energy Policy. This publication, which has a circulation of 2000,is sent to people interested in energy ranging from private individuals to all state agencies to educational institutions. Articles published in the last 8 months include: (1) EG&G's 100 Hour Technical Assistance Program, (2) St. Mary's Hospital Geothermal Well, (3) The State Renewable Energy Tax Credit Pertaining to Geothermal Energy, (4) an article entitled "Geothermal System Provides Heating and Cooling for Ft. Pierre Family, and (5) Geothermal Space Heating of Rest Area on Interstate 90. Other activities include contact with a developer and the Natural Resource specialist for the United Sioux Tribe of South Dakota; also contact is maintained with the city planner of Edgemont and the businessmen of Lemmon, SD. Individual requests for technical assistance and financial aid for geothermal programs have been answered. Personal contact has been established with consulting firms that have expertise in the design and construction of geothermal systems.

Outreach plans in the future include meetings with developers, bankers, universities and consultants to develop a multi-use systematic approach to the development of geothermal resources in the four areas. It is tentatively planned to form local committees to plan the development of geothermal energy. These committees will be composed of a cross-section from all sectors of the economy. These committees will be given technical advice by local engineers and consultants.

3.0 SUMMARY OF MAJOR FINDINGS AND RECOMMENDATIONS

Resource assessment and the matching of site-city pairs by NMEI were the major accomplishments in this time period. Resource assessment was difficult because there is no state Resource Assessment Team in South Dakota. Data were obtained from R.I. 110 and from personal communication with the South Dakota Geological Survey. Numerous wells have been completed in the Madison Formation; the data from these wells were extrapolated to the city locations to obtain site-city pairs. The state was divided into 11 multi-county area development plans, priority being given to the region west of the Missouri River underlain by the Madison Formation.

Site specific development analyses are being prepared for Lemmon, Philip, Edgemont, and Midland. The Philip School, Diamond Ring Ranch and the St. Mary's Hospital at Pierre are candidates for Time Phased Project Plans.

An institutional analysis has been completed by Resource Management Services, Inc. and will be the basis for the South Dakota Handbook.

FUTURE GOALS IN GEOTHERMAL DEVELOPMENT

* Funds for a State Resource Assessment Program are essential for the rapid commercialization of geothermal energy in South Dakota.
* A handbook of institutional guidelines and barriers will be made available to the general public by the State Commercialization Team.
* The State Commercialization Team must help a cross-section of the leaders in all economic sectors become advocates of geothermal development.
* Technical advice will be given to developers; particular attention will be given to the use of groundwater heat pumps to complement geothermal resources.

APPENDIX A

ADP I

COUNTY	CITY	INDUSTRY	SIC	TEMP	NUMBER OF EMPLOYEES	ENERGY USE 10^{10} BTU/YR
Custer	Custer	Custer Lumber Company	2421	93	62	0.05
	Custer	4 Mile Post & Pole Co.	2491	93	13	0.121
	Custer	Linde Sawmill, Inc.	2421	93	13	0.01
	Custer	Nelson Custom Cabs	3713	93	13	0.26
	Custer	O'Connor Lumber	2431	93	13	0.13
	Custer	Scotts Rock Shop	3281	66	13	0.108
Fall River	Edgemont	Kustom Kraft Corp.	2499	93	62	3.224
	Edgemont	Lackey Machine Products	3429	93	13	0.075
	Hot Springs	Ranchland Mfg. Company	3199	93	13	0.13
Pennington	Rapid City	Anderson Millwork Co.	2431	93	13	0.13
	Rapid City	Benson's Optical Co.	3851	77	13	0.061
	Rapid City	Black Hills Jewelry Co.	3911	93	175	1.033
	Rapid City	Black Hills Milk Products	2026	77	62	1.959
	Rapid City	Black Hills Slate Co.	3281	66	13	0.108
	Rapid City	Black Hills Workshop	2448	N/A	62	2.285
	Rapid City	Black Hills Workshop	2542	93	62	2.285
	Rapid City	Black Hills Workshop	2499	93	62	2.285
	Rapid City	Brown Swiss Milk Co.	2026	77	175	5.530
	Rapid City	Buckingham Wood Products	2451	N/A	175	1.750
	Rapid City	Buckingham Wood Products	2431	93	175	1.750
	Rapid City	Buckingham Wood Products	2434	N/A	175	1.750
	Rapid City	Central Mix	3273	66	62	0.004
	Rapid City	Coco-Cola Bottling Co.	2086	77	62	0.397
	Rapid City	Coleman Bedding Co.	2515	93	13	0.164
	Rapid City	Dakota Steel & Supply Co.	3441	93	62	1.004
	Rapid City	Electroplating Company	3471	93	13	0.572
	Rapid City	Haedt Sash & Door Co.	2431	93	13	0.130
	Rapid City	Jaehn's Independent Bindery Co.	2522	93	13	0.268
	Rapid City	Knecht Industries, Inc.	2439	N/A	13	0.130
	Rapid City	Knecht Industries, Inc.	2431	93	13	0.130
	Rapid City	Leather Unlimited	3171	93	13	0.043
	Rapid City	Leather Unlimited	3172	N/A	13	0.043
	Rapid City	Pepsi Cola Bottling Company	2086	77	13	0.083
	Rapid City	Rapid Crystal Ice Company	2097	66	13	0.156
	Rapid City	Rapid Tank & Supply Company	3443	93	13	0.367
	Rapid City	Stampers Black Hills Gold	3911	93	62	0.366
	Rapid City	Warne Chemical & Equipment Co.	3443	93	13	0.367
	Rapid City	Warne Chemical & Equipment Co.	3523	N/A	13	0.367

COUNTY	CITY	INDUSTRY	SIC	TEMP	NUMBER OF EMPLOYEES	ENERGY USE 10^{10} BTU/YR
Pennington	Rapid City	Wave Manufacturing Co.	2511	66	13	0.100
	Rapid City	Wave Manufacturing Co.	2515	93	13	0.100
	Rapid City	Weather Shield	2431	93	13	0.164
						21.279

ADP II

COUNTY	CITY	INDUSTRY	SIC	TEMP	NUMBER OF EMPLOYEES	ENERGY USE 10^{10} BTU/YR
Haakon	Philip	Little Scotchman Industries	3523	N/A	62	N/A
Hughes	Pierre	Coca-Cola Bottling Co.	2086	77	13	0.083
	Pierre	Midwest Culvert Company	3444	93	13	0.520
Stanley	Ft. Pierre	Cedar Breaks Beef Co., Inc.	2011	177?	13	0.374
	Ft. Pierre	Triple U Enterprises	2011	177?	13	0.374
						1.341

ADP III

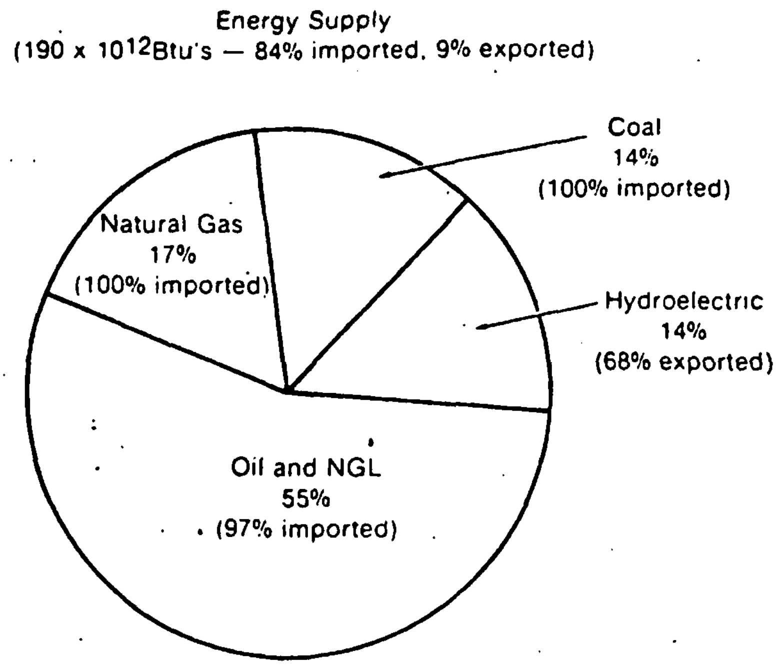
COUNTY	CITY	INDUSTRY	SIC	TEMP	NUMBER OF EMPLOYEES	ENERGY USE 10^{10} BTU/YR
Butte	Belle Fourche	Belle Fourche Sawmill	2421	93	13	0.010
Lawrence	Deadwood	F.L. Thorpe Company	3911	93	62	0.366
Lawrence	Spearfish	Gems by Jim Inc.	3961	93	13	0.085
	Spearfish	Gems by Jim Inc.	3911	93	13	0.085
	Spearfish	Homestake Forest Products Co.	2421	93	175	0.140
	Spearfish	Kellogg Moulding Co.	2431	93	13	0.13
	Spearfish	Langer Sawmill	2421	93	13	0.010
	Spearfish	McLaughlin Sawmill	2471	93	13	0.010
	Spearfish	Northern Hills Forest Products	2421	93	62	0.05
	Spearfish	Square Timber Company	2421	93	13	0.010
	Whitewood	Hales House Logs	2421	93	13	0.010
	Whitewood	J & M Saddlery	3199	93	13	0.13
	Whitewood	St. Regis Paper Co.	2491	93	62	0.577
	Whitewood	Whitewood Post & Pole Company	2491	93	62	0.577
Meade	Sturgis	Dakota Wood Products Inc.	2421	93	13	0.010
	Sturgis	Dickson Forest Products Inc.	2421	93	62	0.050
	Sturgis	Grams H. & Sons	2421	93	13	0.010

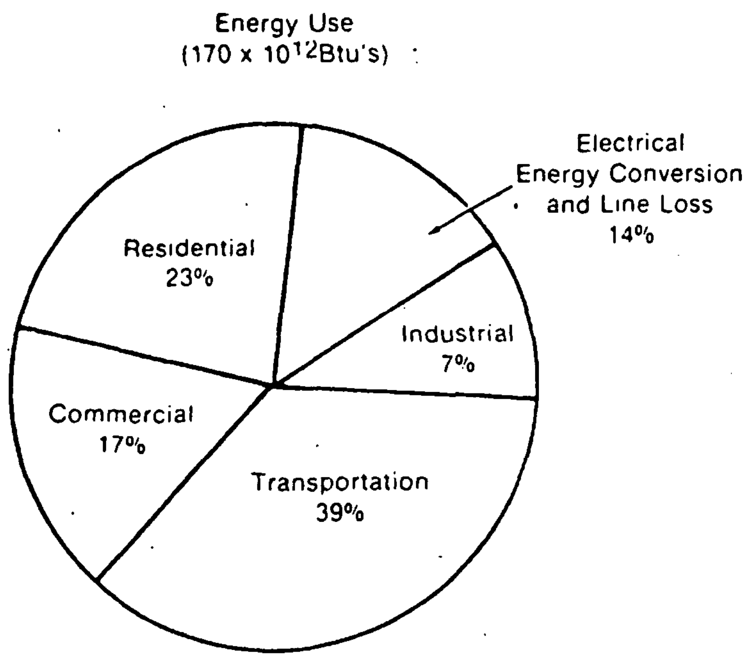
COUNTY	CITY	INDUSTRY	SIC	TEMP	NUMBER OF EMPLOYEES	ENERGY USE 10^{10} BTU/YR
Meade	Sturgis	Marolf Dakota Farms	2022	93	13	1.126
	Sturgis	Neugebauer Jewelers	3911	93	13	0.077
						2.917

ADP IV

COUNTY	CITY	INDUSTRY	SIC	TEMP	NUMBER OF EMPLOYEES	ENERGY USE 10^{10} BTU/YR
Brule	Chamberlain	Pepsicola Bottling Co.	2086	77	13	.083
Gregory	Burke	Jim's Furs	3999	93	13	.155
	Burke	Rosebud Cheese Factory	2022	93	13	1.126
						1.364

South Dakota 1975





South Dakota energy supply and use

SOUTH DAKOTA ENERGY USE BY FUEL TYPE, PRELIMINARY, 1975

	Trillion BTU	Million Gallons	% of Fuel Type
A. Petroleum			
1. Motor Gasoline			
Transportation	65.958	527.663	100.0%
2. Distillate Oil			
Residential & Commercial	13.851	99.871	57.8
Industrial	.817	5.893	3.4
Transportation	9.034	65.138	37.7
Electrical Generation	.270	1.946	1.1
TOTAL	23.972	172.848	100.0
3. LPG			
Residential & Commercial	8.661	94.138	77.5
Industrial	1.142	12.416	10.2
Transportation	.533	5.798	4.8
Electrical Generation	.838	9.112	7.5
TOTAL	11.174	121.464	100.0
4. Residual Oil			
Residential & Commercial	.018	.121	1.1
Industrial	.439	2.934	26.9
Transportation	.0	.0	.0
Electrical Generation	1.173	7.839	72.0
TOTAL	1.630	10.894	100.0
5. Kerosine			
Residential & Commercial	.048	.359	69.3
Industrial	.021	.159	30.7
Transportation	.0	.0	.0
Electrical Generation	.0	.0	.0
TOTAL	.069	.518	100.0

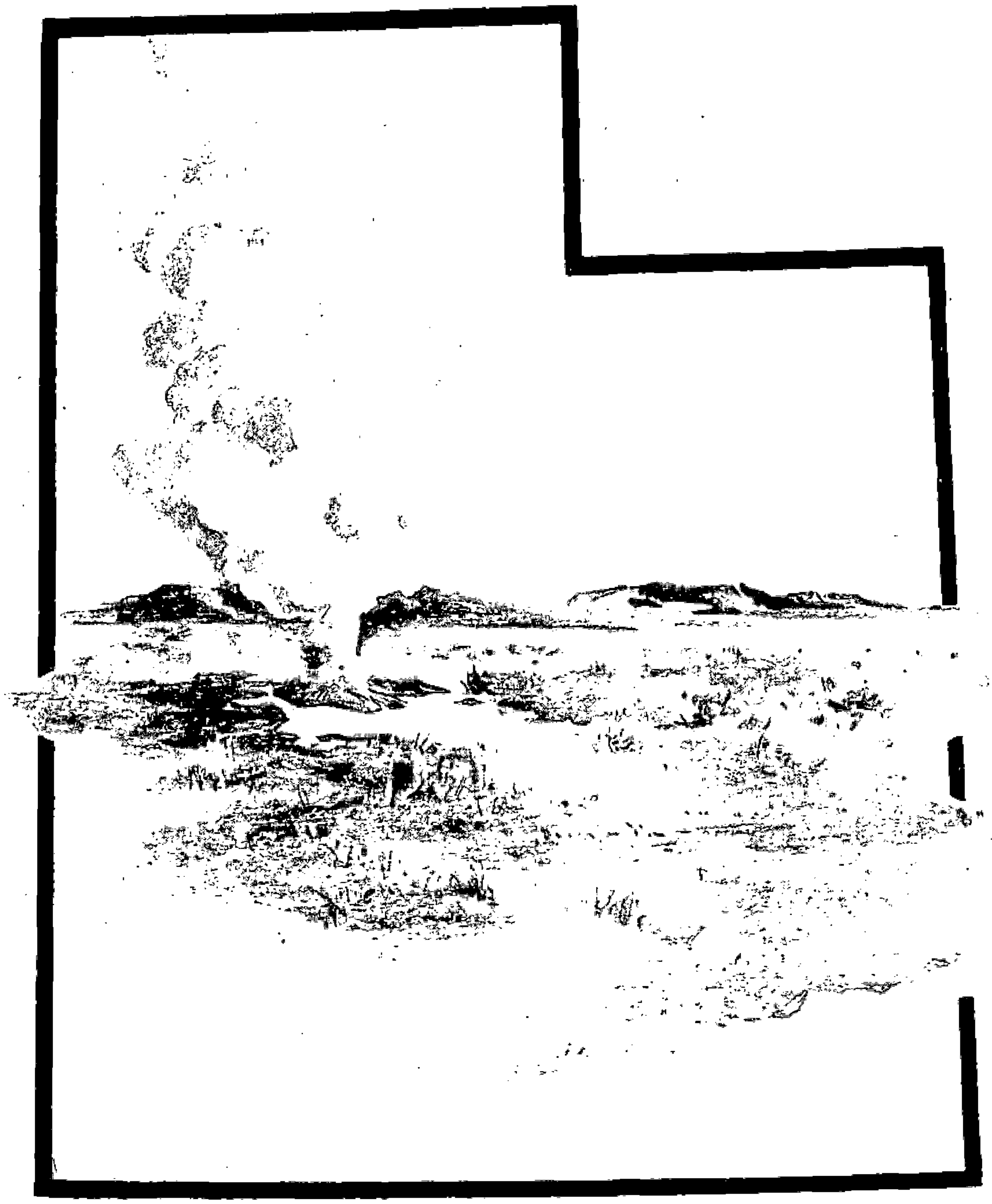
	Trillion BTU	Billion Cubic Feet	% of Natural Gas
B. Natural Gas			
Residential	12.277	11.908	37.7
Commercial	10.159	9.854	31.2
Industrial	6.012	5.832	18.5
Transportation	.0	.0	.0
Electrical Generation	4.094	3.971	12.6
TOTAL	32.542	31.565	100.0

		Trillion BTU	Million Gallons	% of Coal
C.	Coal			
	Residential & Commercial	.345	.016	.7
	Industrial	1.08	.050	2.3
	Transportation	.0	.0	.0
	Electrical Generation	46.094	2.134	97.0
	TOTAL	47.519	2.200	100.0

		Trillion BTU	Billion Kilo-Watt Hours	% of Elec. Purchased
D.	Electricity Purchased			
	Residential & Commercial	10.853	3.181	82.3
	Industrial	2.333	.684	17.7
	Transportation	.0	.0	.0
	TOTAL	13.186	3.865	100.0
	GRAND TOTAL	196.050		

Chapter 10

Utah Geothermal Commercialization Project



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July - December, 1979

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Work performed under Contract No. DE-FC07-79ID12016
U.S. Department of Energy
Idaho Operations Office

Utah Geothermal Commercialization Project

Semi-annual Progress Report
January, 1980

1.0 Introduction

The Utah Geothermal Commercialization Project is part of a United States Department of Energy regional program to commercialize geothermal resources. The DOE has contracted with an agency in each state to conduct planning and outreach activities; in Utah, the contracting agency is the Division of Water Rights. Personnel working on the Utah project are Stanley Green, project supervisor, L. Ward Wagstaff, planning and technical analysis, and Douglas Nielsen, information and outreach.

2.0 Specific Task Descriptions and Products

2.1 Geothermal Prospect Identification

Geothermal exploration of all types continued in Utah through the latter half of 1979, but a shift in emphasis from high temperature resources to moderate temperature resources was evident. Exploration for resources suitable for electrical production continued, but at a lower rate than earlier years; on the other hand, the exploration and commercialization of moderate temperature resources has accelerated. (Electrical development is still much larger in terms of potential project size and energy utilized; however, more visible activity has occurred in connection with direct applications.)

Table 1

Electrical Prospects in Utah

Prospect	Measured Temp. °C	Well Depth	Notes
Roosevelt Hot Springs (Proven)	265	1200-7000 ft.	20 MWe plant planned for 1982, followed by 55 MWe plants about 1985 and 1986. Development by Phillips - ATO
Thermo (Potential)	177-205	7300 ft.	May be suitable for binary system.
Cove Fort (Inferred)	150	5200-7800 ft.	Does not appear suitable for electrical resources-Cove Fort Unit dissolved.

Table 2

Proven Direct Use Geothermal Prospects

(Verified by Drilling)

Prospect	Location	Temp °C	Well Depth, m.	TDS ppm	Notes
Monroe Hot Springs	Sec. 15, T25S, R3E; Sevier Co.	74	457	2800	Production well drilled
Crystal Hot Springs	Sec. 11, T4S, R1W Salt Lake Co.	86(1)	125(2)	1665 (3)	Production well drilled by Utah Roses; Geological investigations planned by the State of Utah
Sandy City	Sec. 1, T3S, R1W Salt Lake Co.		1527(4)	1120	Two production wells drilled
Newcastle	Sec. 20, T36S, R15W Iron Co.	96(5)	153		
Beryl	Sec. 18, T34S, R16W Iron Co.	149(6)	2134		Deep well drilled for electrical exploration program
Cove Fort	Sec. 7, T26S, R6W Sec. 33, T25S, R6W Beaver and Millard Counties	173(7) 130(7)	2358 1691	9405(8) 10,000(8)	Two wells electrical exploration

(1) Temperature in temperature gradient hole, measured by UGMS.
(2) Depth of production well drilled by Utah Roses; being tested.
(3) TDS in spring (surface discharge)
(4) Deep well drilled by Utah Roses to 1527 m (5009 ft.)
(5) Temperature, depth of first well, and TDS from Goode, 1978.
(6) Temperature and depth of Beryl well from Goode, 1978. TDS reportedly low.
(7) Data on Union Wells #42-7 and #31-33 released through UURI.
(8) TDS data for Cove Fort wells shows wide range of variation. Well #42-7: 4775 and 9405 ppm: Well #31-33 1320 and 10,000 ppm.

Table 3

Potential Prospects For Direct Utilization of Geothermal Resources(1)

Prospect	Location	Maximum Measured Temperature, ^oC
Wasatch Hot Springs Springs	Sec. 25, T1N, R1W Salt Lake County	40(2)
Beck's Hot Springs	Sec. 14, T1N, R1W Salt Lake County	55(2)
Midway	T3S, R4E Wasatch County	46(3)
Udy (Belmont) Hot Springs	Sec. 23, T13N, R3W Box Elder County	45(2)
Crystal (Madsen's) Hot Springs	Sec. 29, T11N, R2W Box Elder County	60(2)
Utah Hot Springs	Sec. 14, T7N, R2W Weber County	59(2)
Ogden Hot Springs	Sec. 23, T6N, R1W Weber County	57(2)

1. Sites investigated by UGMS, including temperature gradient surveys.
2. Peter J. Murphy, UGMS
3. Kohler, 1979

Updated data on electrical prospects are presented in Table 1; data on direct use prospects are presented in Tables 2, 3, and 4.

Most of the exploration for electrical-quality resources was associated with major prospects, i.e., Roosevelt Hot Springs, where development is quite advanced, and Cove Fort - Sulphurdale, where considerable exploration has been conducted without the discovery of a suitable resource. At Roosevelt, a working agreement was reached between Phillips Petroleum Company and the A-T-O Consortium (AMAX Exploration Inc., Thermal Power Company, and O'Brien Resources, Inc.). Testing of the reservoir has continued.

Union Oil Company drilled a deep well at Cove Fort during the Spring of 1979, their fourth in the prospect. The well was later plugged and abandoned. Later in the fall, Union relinquished its leases, dissolved the Cove Fort - Sulphurdale Unit, and assigned two wells to Forminco, Inc., a mining company with property in the area. The two wells may be usable for direct applications.

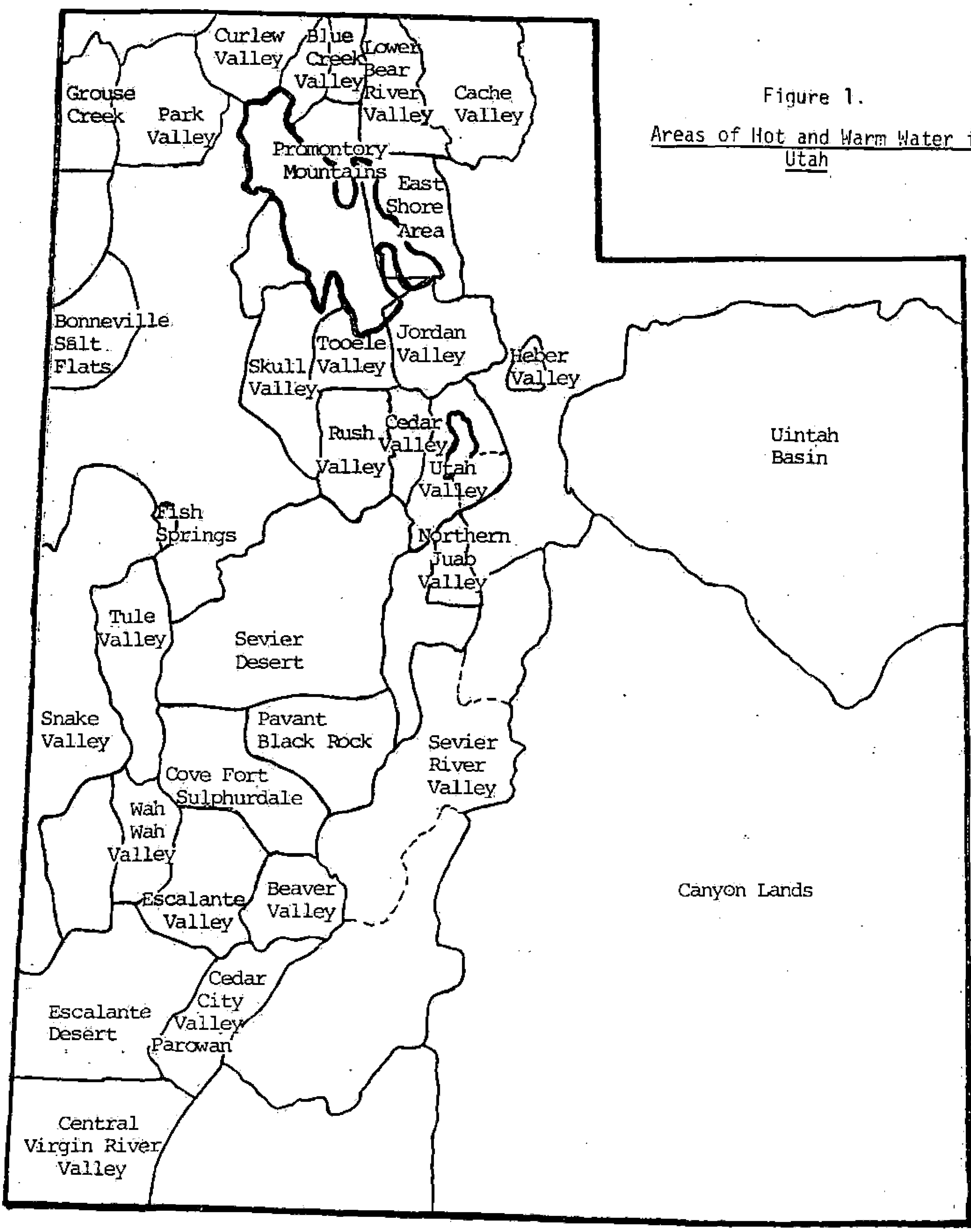

Figure 1.

Areas of Hot and Warm Water in Utah

From Goode, 1978.

Table 4

Areas of Inferred Direct Thermal Resources

Prospect	Maximum Recorded Water Temperature (°C)
Lower Bear River Area	105
Bonneville Salt Flats	88
Cove Fort - Sulphurdale	165
Curlew Valley	43
East Shore Area	62
Escalante Desert	149
Escalante Valley	85
Fish Springs	61
Grouse Creek	42
Heber Valley	44
Jordan Valley	89
Pavant Valley/Black Rock Desert	67
Sevier Desert	82
Sevier Valley	77
Utah Valley	46
Central Virgin River Basin	42
Uintah Basin	55
Beaver Valley	24
Blue Creek Valley	28
Cache Valley	49
Canyonlands	28
Cedar City and Parowan Valley	21
Cedar Valley	27
Northern Juab Valley	20
Park Valley	23
Promontory Mountains Area	25
Rush Valley	27
Skull Valley	24
Snake Valley	27
Tooele Valley	32
Tule Valley	28
Wah Wah Valley	29
Castilla Hot Springs	40
Como Warm Springs	25
Diamond Fork Warm Springs	20

A shallow well at Crystal Hot Springs (Bluffdale) was drilled by Utah Roses, Inc., a floral industry. The well was successful with temperatures near 88^{0} C (190^{0} F). Test data from the well are not yet available. Utah Roses also drilled a 5009 ft. well near Sandy City as part of a DOE cost-share program; the well reportedly has a slight artesian flow, with a maximum downhole temperature of 75^{0} C (157^{0} F). Testing of the well is scheduled for January. Although the temperatures reached are not as high as had been hoped, they will be warm enough to heat the greenhouses as planned.

At Newcastle, a second shallow well was drilled by Christensen Brothers for a greenhouse (hydroponic) operation. This well was reportedly similar to a well drilled in 1975, with good quality water at near-boiling point temperatures at shallow depths.

Two deep temperature-gradient wells were drilled at Hill Air Force Base in an attempt to locate resources suitable for space heating. The temperature gradient (and hence the temperatures) was less than a normal gradient, a condition which was predicted on the basis of cold water infiltration from the Weber River Delta.

Several state geothermal leases were issued in 1979. Table 5 lists the leases which were issued during the reporting period; a complete list of state leases may be obtained from the Utah Division of Water Rights.

Table 5

New State Geothermal Leases

July - December 1979

COUNTY	SIZE, ACRES (No. of Leases)	LOCATION	DATE ISSUED
BEAVER			
Frederick E. Payne	1,280.00 (2)	T30S, R9W	8/9/79
BOX ELDER			
Diane Katz	400.00 (3)	T8H, R7, 8W	9/14/79
PIUTE			
Moly Minerals, Inc.	1,280.00 (2)	T28S, R1W	7/2/79

2.2 Area Development Plans

2.2.1 State Geothermal Planning Areas

Area Development Plans (ADP's) are intended to match projected energy demand for a given area with the geothermal energy potential for that area, in order to estimate the portion of energy demand which might be satisfied through commercialization of the geothermal resource. The data generated by the ADP's should provide the basis for further market analysis, such as market penetration analysis, as well as indicate which site specific sites are the best candidates for site specific studies.

The first step in the ADP process was to divide the state into areas suitable for analysis. For this initial analysis, county lines were used as area boundaries, and counties were grouped according to existing Multi-County Planning Districts. They were then further subdivided according to geographic and social characteristics and according to the size and characteristics of their economic base and geothermal resources. The planning areas for the ADP's are shown in Figure 2 and listed by priority in Table 6. The primary and secondary priority areas are planning targets for the past and coming contract years.

2.2.2 Specific ADP's

Completed work on Area Development Plans is summarized in Tables 7, 8, and 9. Table 7 shows the results of projected residential energy consumption for the primary and secondary planning areas in Utah. As used here, equivalent natural gas is the estimated amount of natural gas which would be consumed if natural gas were used in the home. Space and water heating data are derived from equivalent natural gas projections. Electricity projections are based on existing records for Utah; the assumption is implied that the dwellings are serviced by both electricity and natural gas. More specific and detailed data as well as explanations of the assumptions and methodology used to derive these figures are found in the Appendices of this report.

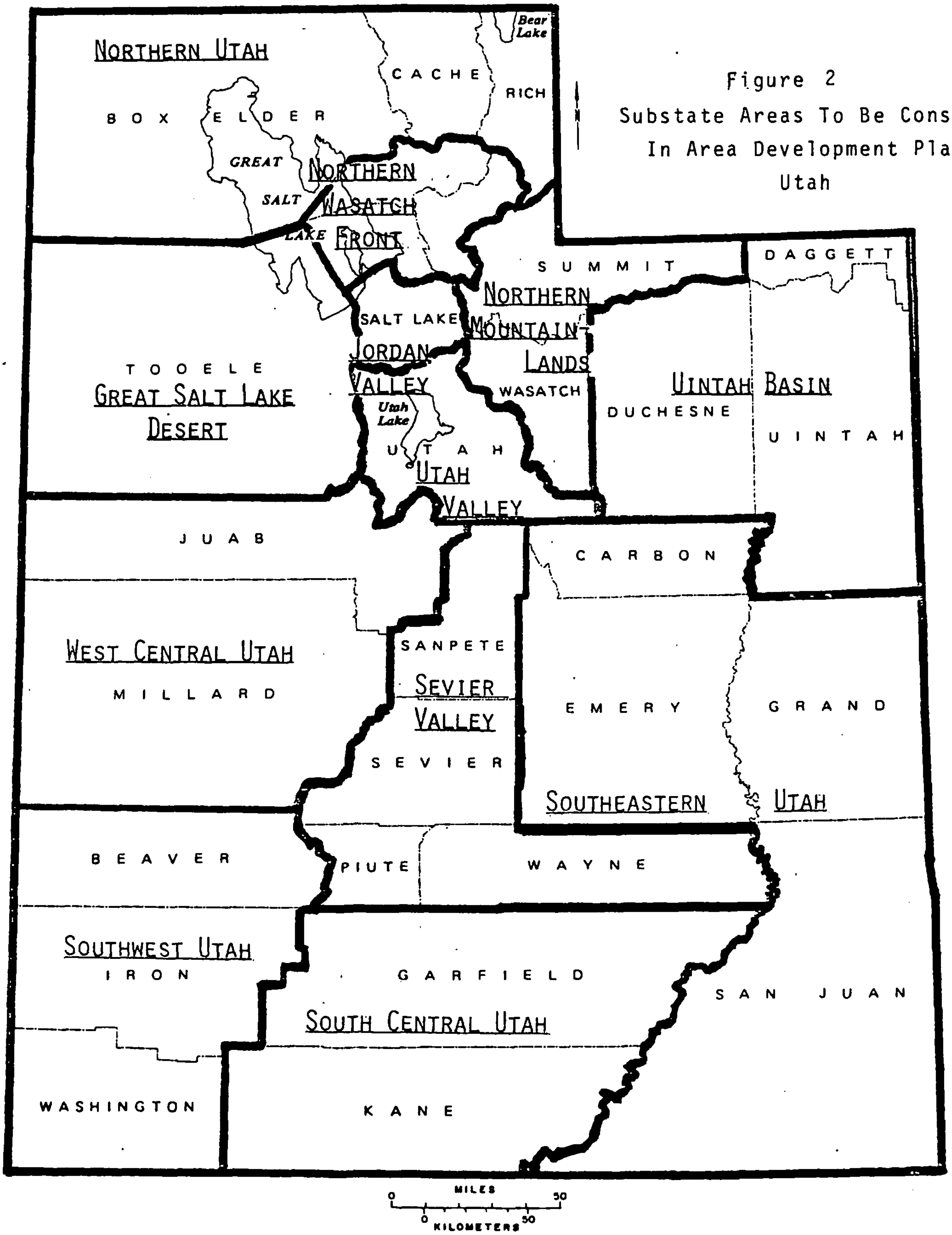

Figure 2
Substate Areas To Be Considered
In Area Development Plans
Utah

Table 6

AREAS TO BE CONSIDERED IN AREA DEVELOPMENT PLANS

PRIMARY		SECONDARY		OTHER	
Areas	Counties	Area	Counties	Area	Counties
JORDAN VALLEY	Salt Lake	NORTHERN WASATCH FRONT	Davis Morgan Weber	UINTAH BASIN	Daggett Duchesne Uintah
SOUTH WEST UTAH	Beaver Iron Washington	UTAH VALLEY	Utah	SOUTH CENTRAL UTAH	Garfield Kane
SEVIER VALLEY	Sanpete Sevier Piute Wayne	WEST CENTRAL UTAH	Juab Millard	SOUTH EASTERN UTAH	Carbon Emery Grand San Juan
		NORTHERN UTAH	Box Elder Cache Rich		
		NORTHERN MOUNTAIN-LANDS	Summit Wasatch		
		GREAT SALT LAKE DESERT	Tooele		

Industrial energy demand projections for the years 1979 and 2020 are found in Table 8. These data were generated by the Physical Sciences Laboratory at New Mexico State University at Las Cruces, based on employment information contained in the 1979-1980 Directory of Utah Manufacturers.

Estimates of geothermal resource capacity have not yet been completed for most of the resource areas in Utah. Table 9 contains estimates of beneficial heat for several hot springs in Utah, as reported in USGS Circular 790, Assessment of Geothermal Resources of the United States - 1978. These estimates do not reflect the updated resource information which is now available for some of the sites, nor do they cover all of the resource sites for which data are now available. In addition, these estimates are based on rather broad and general assumptions, which may have limited application in the case of smaller, fault-controlled hydrothermal systems such as those commonly found in Utah.

Table 7

Projected Residential Use

	Equivalent Natural Gas, (10^3 Mcf)			Space and Water Heating (10^9 Btu's)			Electricity (Mkwh)		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
Jordan Valley	30,700	53,700	78,000	21,100	36,900	53,600	123,000	216,000	313,000
Salt Lake County	30,700	53,700	78,000	21,100	36,900	53,600	123,000	216,000	313,000
Southwest Utah	2,188	3,964	6,626	1,483	2,686	4,492	12,330	24,070	40,790
Beaver	241	436	728	163	295	494	1,280	2,510	4,190
Iron	916	1,659	2,774	621	1,124	1,880	4,900	9,560	16,500
Washington	1,031	1,869	3,124	699	1,267	2,118	6,150	12,000	20,100
Sevier Valley	1,760	2,805	3,873	1,199	1,902	2,625	9,560	16,400	22,620
Sanpete	786	1,252	1,729	532	849	1,172	4,270	7,330	10,110
Sevier	791	1,261	1,741	536	855	1,180	4,300	7,380	10,180
Piute	77	123	169	59	83	115	420	720	990
Wayne	106	169	234	72	115	158	570	970	1,340
Northern Wasatch Front	13,903	24,321	35,345	9,555	16,716	24,293	45,280	80,000	116,270
Davis	6,513	11,395	16,560	4,477	7,832	11,382	22,140	38,990	56,660
Morgan	340	594	863	233	408	593	1,180	2,130	3,100
Weber	7,050	12,332	17,922	4,845	8,476	12,318	21,960	38,880	56,510
Utah Valley	9,145	15,750	24,000	6,199	10,678	16,767	33,060	58,300	88,810
Utah	9,145	15,750	24,000	6,199	10,678	16,267	33,060	58,300	88,810

Table 7 Continued

	Equivalent Natural Gas, (10^3 Mcf)			Space and Water Heating (10^9 Btu's)			Electricity (Mkwh)		
	1980	2000	2020	1980	2000	2020	1980	2000	2020
West Central Utah	806	1,285	1,772	547	870	1,202	4,110	6,980	9,620
Juab	320	510	703	217	345	477	1,510	2,520	3,470
Millard	486	775	1,069	330	525	725	2,600	4,460	6,150
Northern Utah	4,619	7,591	10,364	3,002	4,944	6,737	16,420	27,580	37,890
Box Elder	1,587	2,817	3,561	1,085	1,926	2,436	4,930	8,850	11,190
Cache	2,920	4,597	6,551	1,840	2,897	4,128	11,100	18,100	25,800
Rich	112	177	252	77	121	173	390	630	900
Northern Mountainlands	935	1,605	2,443	643	1,103	1,680	3,220	3,440	5,250
Summit	537	922	1,401	369	633	963	1,780	920	1,400
Wasatch	398	683	1,042	274	470	717	1,440	2,520	3,850
Great Salt Lake Desert	1,059	1,854	2,694	728	1,274	1,851	4,950	8,680	12,620
Tooele	1,059	1,854	2,694	728	1,274	1,851	4,950	8,680	12,620

Table 8

Industrial Energy Demand

10^{10} Btu's/Year

Area Counties	1979	2020
Jordan Valley	1017	1560
Salt Lake	1017	1560
Southwest Utah	10.833	16.617
Beaver	1.170	1.794
Iron	3.211	4.926
Washington	6.452	9.897
Sevier Valley	123.178	188.952
Sanpete	18.272	28.029
Sevier	103.707	159.083
Piute	0.610	0.936
Wayne	0.589	0.904
Northern Wasatch Front	407.830	625.603
Davis	37.866	58.086
Morgan	0.836	1.283
Weber	369.128	566.235
Utah Valley	169.074	259.356
Utah	169.074	259.356
West Central Utah	39.938	61.264
Juab	1.292	1.982
Millard	38.646	59.282
Northern Utah	181.128	283.189
Box Elder	16.530	26.276
Cache	164.108	256.161
Rich	0.490	0.752
Northern Mountainlands	2.360	3.468
Summit	0.743	1.140
Wasatch	1.517	2.328
Great Salt Lake Desert	357.5	548.4
Tooele	357.5	548.4

Data from New Mexico Energy Institute, based on information in the 1979 Directory of Utah Manufacturers.

Table 9

Estimated Thermal Energy

	Mean Estimated Temperature (^{o}C)	Mean Reservoir Thermal Energy (Quads)	Recoverable Beneficial Heat (Quads)
Abraham Hot Springs	97± 7	1.29± 0.46	0.77
Monroe - Red Hill	101± 8	1.03± 0.36	0.062
Joseph Hot Springs	107± 9	0.79± 0.24	0.047
Thermo Hot Springs	142± 4	2.7 ± 1.1	0.162
Newcastle Area	130± 11	1.80± 0.86	0.108

Estimates of temperature, reservoir thermal energy, and beneficial heat by Brook et al, USGS Circular 790. 1 Quad = 10^{15} Btu

The results of the ADP's to date should be considered qualitatively; nevertheless, they do provide some insight into possible energy use patterns for the state. The data indicate, for example, that the demand for space and water heating energy for Salt Lake County will be nearly as much as for all the other areas combined (about 47% of the total analyzed demand in both 1980 and 2020). The populated area along the Wasatch Front would account for up to 83% of the total space and water heating demand for the areas analyzed. The industrial energy projections indicate that the Jordan Valley would also account for about 44% of the total for the areas analyzed. Another interesting aspect is that in most of the counties analyzed, the projected residential energy use is much more than the projected industrial energy use; in some cases, the projected industrial energy use is only a few percent of the projected space and water heating energy use.

The projections presented here do not take into account several possible modes of development for the state (such as the MX Missile Project) which might drastically affect population and industrial distribution patterns. Policy decisions regarding development of resources such as coal, oil shale, and tar sands could also affect these distributions. A case in point is the siting of the I.P.P. Power Plant near Lynndyl, far from the source of the coal which will be used in the plant; the siting decision was based on policy, not economical or technical considerations.

It is much simpler to project the amount of energy which is by nature replaceable by geothermal energy than it is to predict the amount of geothermal utilization which will actually occur. Development of the resources will undoubtedly occur earlier in better known resource areas, and, once the resource at a particular site becomes economical to recover, development will probably be limited by the capacity of the resource. On the other hand, the widespread use of heat pumps could provide a substantial displacement of convential energy sources, but would be very difficult to predict.

New Mexico Energy Institute has completed a preliminary market penetration analysis for Utah, but it was not available for inclusion in this report.

2.3 Site Specific Development Analysis

Site Specific Development Analyses (SSDA's) are intended to portray various aspects of development for a particular application at a specific geothermal resource site. The analysis would consist of a step-by-step outline of development procedures, time frame estimates for expediential development, a preliminary analysis of the technical and economic feasibility of the project, and the identification of specific factors which might hinder or prohibit the successful completion of the project. The SSDA's are more detailed and technical than the Area Development Plans, and so would offer more insight into the real development potential at a given site.

2.3.1 Candidate Geothermal Sites and Applications

Proven or potential resource areas may be candidate sites for SSDA's, i.e., sites where either successful drilling has occurred ("proven" sites) or where some subsurface data are available ("potential" sites). The site specific candidate sites are listed in Table 10. Two categories are listed in the table - - sites where specific projects are already underway, and sites which appear to be good prospects for development but for which no specific plans have been announced.

Table 10

Candidate Sites for

Site Specific Development Analysis

Planned Developments	Other Promising Sites
Crystal Springs - Space Heating	Cove Fort
	Beck's Hot Springs
Crystal Hot Springs - Greenhouses	Wasatch Hot Springs
	Utah Hot Springs
Sandy City - Greenhouses	Ogden Hot Springs
	Hooper Hot Springs
Uddy Hot Springs - District Heating	Newcastle
	Midway
	Beryl
	Abraham Hot Springs
	Thermo

2.3.2 Site Specific Development Analyses: Completed and in Preparation

During the first year of the project, rough site specific analyses were attempted. The data base for these analyses was as good as was available, but the projections which were made were not based on the real potential or likelihood of development. The SSDA's will be based on this earlier work but will go into much more detail; they are envisioned as being an effective tool in commercialization efforts.

Sites where development is already underway are candidates for SSDA's, but sites where a project is only contemplated might benefit more from an SSDA than more advanced projects. By the time a project actually gets underway, much of the planning and analysis has usually been completed, whereas a project in the very early stages might benefit substantially by the SSDA's. For these reasons, the sites for which SSDA's will be completed will be carefully selected.

2.4 Time Phased Project Plans

Time Phased Project Plans (TPPP's) are intended to be a detailed analysis of all the factors involved in a particular development project, emphasizing the specific steps, the sequence in which they occur, and estimates of when they will begin and end. The project is followed through all stages of development, including pre-lease activities, leasing, exploration, developer negotiations, reservoir analysis, marketing negotiations, permitting, power plant construction, and transmission line constructions. The TPPP should delineate in detail the actions required for development to occur, which should assist planning efforts and allow potential barriers and impediments to be detected. The end goal would be to use the TPPP as a basis for recommendations which would facilitate the development.

2.4.1 Active Direct Use Projects

Active direct use projects in Utah are candidates for TPPP's and are listed in Table 11. The only active electrical project in Utah is at Roosevelt Hot Springs. A brief summary of each project follows:

- Utah Roses at Crystal Hot Springs (Bluffdale): In November 1979 a 410 ft. (125 m) well was drilled by Utah Roses to heat greenhouses. Utah Roses would like to eventually expand to as much as 20 acres of greenhouses if the resource is adequate, and hopes to begin construction of the initial greenhouses early in 1980.

- Utah State Prison at Crystal Hot Springs (Bluffdale): The Utah Department of Social Services is proceeding on a project to heat the minimum security building at the State Prison using geothermal fluids. The project is partially funded by a DOE grant through the PON program. Geological and geophysical studies are in process to site a production well.

- Utah Roses at Sandy City: In December, a 5009 ft. (1527 m) well was drilled by Utah Roses at their present greenhouse facility at Sandy City in Salt Lake County. The project is partially funded by a DOE grant through the PON program. The well reportedly had a slight artesian flow with temperatures as high as 157^{o} F. Although high temperatures were hoped for at shallower depths, the resource will be suitable for heating the greenhouses.

- Christensen Brothers at Newcastle: In the fall of 1979, Christensen Brothers converted an existing hot well and drilled a second, both of which will be used to heat greenhouses for the production of tomatoes using hydroponics. The water is hot at shallow depths and of exceptional quality.

- U.S. Air Force at Hill Air Force Base (Ogden): Two deep temperature-gradient holes have been drilled in an effort to locate resources suitable for space heating, probably in warehouses. The temperatures encountered were reportedly lower than would be expected from normal temperature gradients because of infiltration from the Weber River delta, but may still be warm enough for the uses contemplated.

Table 11

Active Direct Use Geothermal Projects

Site (Developer)	Application	Resource Characteristics	Geothermal Energy Requirements	Statis of Project
Crystal Hot Springs (Utah Roses)	Greenhouses	Artesian flow of 200 gpm at 193^{o} F in 125m well.	Development will occur as supported by the resource, up to about 234 x 10^9 Btu's/yr.	Utah Roses has acquired the land and has drilled a hot well and a fresh water well. The hot well has not yet been fully tested.
Crystal Hot Springs (State of Utah)	Space Heating	Probably similar to Utah Roses Well.	Initial phase, Minimum Security Building: 10.9 x 10^9 Btu's/yr. Possible eventual development to 55.7 x 10^9 Btu's/yr.	Geophysical surveys completed - temperature gradient survey and siting of production well planned.
Sandy City (Utah Roses)	Greenhouses	1527 m well slight artesian flow, bottom hole temperature	Greenhouse conversion from natural gas - 70.0 x 10^9 Btu's/yr. 75^{o} C.	Deep production well drilled, testing not yet completed; resource is expected to be adequate for the greenhouse operation.
Newcastle (Christensen Bros.)	Greenhouses	152 m well 95.5^{o} C	Development will probably occur as supported by the resource.	Good quality hot water at shallow depths. 2 wells drilled. Will be used for hydroponic greenhouses.
Hill Air Force Base (U.S. Air Force)	Space Heating	2 deep temperature gradient holes drilled	Development will occur as supported by the resource.	Temperatures apparently abnormally low, due to cold water infiltration in the Weber River Delta. Resource may be adequate for the uses contemplated.

Table 11 cont.

Site (Developer)	Application	Resource Characteristics	Geothermal Energy Requirements	Statis of Project
Monroe Hot Springs (City of Monroe)	District Heating	457 m well drilled slight artesian flow, about 74° C	Initial phase, South Sevier High School: 4.48×10^{9} Btu's/yr.	Production well, two deep temperature gradient holes drilled; project now in design phase.
Crystal (Madsen's)	Resort	Hot Springs- 55.5° C, flow about 100 Lps	Multiple use for the resort and space heating are planned.	The resort is in the first phase of renovation, with work planned to continue for several years.
Midway (Individual Builders)	Space Heating	Max Measured Temp: 46.3° C Generalized hot groundwater system.	Resource now used for resorts, some houses; heating of homes likely to expand.	Several resorts and houses use the warm springs for space heating. Additional individual development is planned.

- City of Monroe at Monroe Hot Springs: Monroe City has drilled a production well near Monroe Hot Springs as part of the first phase of a district heating project, partially funded by the DOE through the PON program. Several observation holes were drilled by the University of Utah (with DOE funding) in connection with studies of the resource. The project is now in the engineering and design phase.
- Crystal Hot Springs Resort at Crystal (Madsen's) Hot Springs (Honeyville): The new owners of the resort are undertaking extensive remodeling of the resort facility and plan to upgrade and expand the use of the geothermal fluids from the hot springs.
- Midway: Several homeowners and resorts already use warm water from hot springs or from the warm water aquifer, and more plan to build geothermally heated homes.

2.4.2 Time Phased Project Plans - Completed or in Preparation

During the first half of 1979, much of the effort of the Utah Geothermal Commercialization Team was directed towards the completion of a Time Phased Project Plan for the electrical development at Roosevelt Hot Springs. The plan was completed in July, and was included as an appendix to the progress report of the Utah Geothermal Commercialization Project for the period of January - June, 1979.

Several important events related to the development at Roosevelt Hot Springs have taken place during the latter half of 1979. A major event was the finalization and approval of an agreement between Phillips Petroleum Company (the unit operator) and the ATO Consortium (AMAX Exploration, Inc., Thermal Power Company, and O'Brien Resources Corp.), and the joining of the unit by ATO. The agreement was the result of long and difficult negotiations between the groups, and will undoubtedly contribute to the reasonable and efficient development of the resource.

Current plans for the project are for a 20 MWe demonstration plant to come on line in 1982 or 1983, followed by 55 MWe plants a few years later, probably about 1985 and 1986. The project is now in a phase of market negotiations, which are also proving slow and difficult. The primary market being considered is Utah Power and Light, because it is the major electrical utility in the state; however, other groups are also under consideration as plant constructors and/or operators and as power customers.

2.5 State Aggregations of Prospective Geothermal Utilization

Adequate data had not been generated by the end of 1979 to permit useful aggregation of projected geothermal utilization for Utah on a statewide basis. Energy demand data were generated as part of the ADP process, but estimates of resource energy capacity are not available. New Mexico Energy Institute made some energy-on-line projections for the state, but these projections were completed late in December and were not available for integration into this report. The NMEI projections were done as a preliminary effort and did not include active input from the state team, a departure from the procedure which NMEI has used for making corresponding projections in other states. It is anticipated that this interactive effort will take place early in 1980.

2.6 Institutional Analysis

Early in 1979, legislation was introduced to the Utah Legislature which was intended to resolve a number of problems related to the commercialization of geothermal resources in Utah. The legislation was not adopted, and will be introduced to the 1980 budget session of the legislature in essentially the same form that was introduced to the 1979 legislature. The legislation would define geothermal resources as hotter than 120^{0} C (248^{0} F), clarify the relationship between water and geothermal resources, specify ownership and rights to geothermal resources, delineate the role and authority of the State Engineer as the regulatory officer, and provide guidelines for unitization. There is some opposition to the legislation, in particular, by Utah Power and Light. The bill may be considered as a budget item, or it may be introduced by a two-thirds vote of acceptance for consideration by the legislature, in which case it must still achieve a majority approval to be enacted.

Because the future of the geothermal legislation is at this time uncertain, the institutional handbook for Utah will not be completed until the legislative issue has been decided, even though most of the information for the handbook has been gathered.

2.7 Public Outreach Program

2.7.1 Outreach Mechanisms

The outreach program is designed not only to inform the public about the advantages of utilizing geothermal energy, but also to provide assistance to prospective users. A complete discussion of existing outreach mechanisms is too lengthy for inclusion in this report. Several of the more important features of the Utah geothermal outreach program are summarized below:

- Information Services: Providing data and information to developers, researchers, governmental agencies, etc.
- User Assistance: Assisting developers, usually with institutional procedures and requirements, but also with research.
- Coordination with contracted User Assistance Programs: Referring users to the assistance programs available through UURI (resource assessment assistance) and EG&G Idaho, Inc. (technical assistance), and coordinating with those programs to follow up with the user.
- Legislation: Assisting the state legislature to draft geothermal legislation for the state. In particular, Stanley Green, the team leader, acted in an advisory capacity to the legislative committee and coordinated much of the work on the bill.
- Interagency Coodination: Serving as one of the primary contact points for coordination between various state (and sometimes federal) agencies involved in geothermal development.
- Active Outreach: Conducting a coordinated effort of public outreach. Mr. Douglas Nielsen, a communications specialist, joined the Geothermal Commercialization Project in November to work specifically in expanding and refining the outreach program.

The Utah Geothermal Commercialization Project is considering a number of outreach mechanisms to enhance the existing program. Because of the regulatory nature of the Division of Water Rights, outreach mechanisms must be carefully selected. Several planned outreach mechanisms are summarized below:

- Increased User Assistance: Expansion of user assistance to technical and economic analysis, particularly on an intensive level for specific projects.
- Publications: Publication of the Institutional Handbook and the State Geothermal Map, in preparation by the UGMS, both of which will aid greatly in outreach activities. A number of pamphlets and brochures on specific subjects are also planned.

- Use of Planning Results: Use of Site Specific Development Analyses and Technical and Economic Analyses as user assistance tools, both directly and indirectly.
- Outreach Coordination with Other Programs: Coordination, through weekly semi-formal contacts, with the outreach efforts of UURI and the UGMS, as well as EG&G Idaho, Inc. when applicable.

2.7.2 Summary of Contacts and Results

A detailed description of outreach activities by the Utah Geothermal Commercialization Program will not be included in this report. Contacts listed in the Midterm Progress Report, issued in July, 1979, will also not be duplicated in this report. A few of the more significant projects with which the program has been involved will be summarized.

A project which may prove to be a major geothermal development in the state is an alcohol distillation plant currently planned for the Cove Fort - Sulphurdale area. The plant will utilize the hot water which was found by Union Oil Company during drilling operations at the Cove Fort Unit. The Utah Geothermal Commercialization Program assisted the developer, R & R Energies, Inc. in contacting the resource owners, Forminco, Inc. The resource will probably be cascaded through several uses, including sulphur drying.

Project personnel have also interacted closely with groups involved in active geothermal projects, particularly the PON projects at Monroe, Sandy City, and Bluffdale. The project has become involved in assisting on heat pump projects, ranging in scope from individual homes to major urban redevelopment complexes. The results of some of these contacts are difficult to assess, while with others it is apparent that the State Team has been instrumental in the progress of the project.

2.7.3 Overall Prospects for Future Geothermal Activity

Interest in geothermal energy utilization is growing rapidly in Utah Use of the resource for electrical production was bolstered by the unitization agreement at Roosevelt Hot Springs, although it was set back somewhat by the cessation of Union's operations at Cove Fort. The most visible progress has been in direct use.

The district heating system at Monroe and the space heating project at the State Prison progressed during the period. Major milestones were achieved by the drilling of production wells for greenhousing projects at Sandy City, Bluffdale, and Newcastle. The alcohol distillation plant at

Cove Fort became a viable project and entered into a planning and funding phase. Interest in other areas has burgeoned, not only in the form of speculative projects but also in firm development plans and commitments.

The interest in direct use has been complemented by a rapidly growing interest in and utilization of groundwater heat pumps, which may become a widely-used energy source in areas of the state where groundwater is available.

In summary, it is apparent that geothermal utilization will continue to expand in Utah. It appears now that it will be only a short time before the emphasis in outreach will shift from soliciting interest in geothermal utilization to keeping up with assistance requests.

3.0 Summary of Major Findings and Recommendations

The recommendations of the Utah Geothermal Commercialization Project are much the same as those outlined in the Midterm Progress Report of July, 1979. Summaries of the most urgent and substantive recommendations are included here.

- Geothermal legislation for Utah should be passed. Whether the legislation is in the form of the current bill or a modified version, it should attempt to effectively address major issues. The legislation should define geothermal resources in terms compatible with nature and with other standard definitions (such as the definition in federal law) and such that development, both electrical and direct use, will be facilitated; it should clarify ownership of the resource; it should clarify and specify the regulatory authority of the State Engineer; it should clarify the relationship between geothermal resources and water in such a way as to facilitate development of both high and low temperature resources; it should define and clarify the relationship between geothermal rights, water rights, and correlative (property) rights; and it should clarify and specify the authority of the State Engineer to unitize. Legislation is also needed which would specifically authorize geothermal or other heating systems, and remove small distributors of direct heat resources (including groundwater) from being classified as utilities.

- The state should formulate guidelines for reinjection, both in connection with spent geothermal fluids and with heat pump applications. These guidelines should reconcile environmental, hydrologic, and statutory requirements in a reasonable and economic way. Policy issues should be resolved, particularly those associated with direct use and heat pumps.

- The DOE State Coupled Resource Assessment program in Utah should be expanded by DOE if possible. A large share of information dissemination, user assistance, and outreach effort falls on the Resource Assessment Team at UGMS simply because it is the repository for much of the geothermal data and expertise in the state. Even when contacts are made through the state Commercialization Team or the User Assistance program at UURI, they usually resort to the Resource Assessment Team at UGMS for data. The tasks and funding by DOE should take this into account. The demand for specific data will certainly increase, particularly for areas not yet investigated. In both outreach and commercialization activities the Resource Assessment Program plays a vital role which should be reflected by appropriate funding and tasks.

Chapter 11

Wyoming Geothermal Commercialization Planning

WYOMING GEOTHERMAL COMMERCIALIZATION PLANNING

SEMI-ANNUAL PROGRESS REPORT

July - December, 1979

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Work performed under Contract No. DE-FC07-79ID12013
U. S. Department of Energy
Idaho Operations Office

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1.0 INTRODUCTION

The University of Wyoming in cooperative agreement with the United States Department of Energy began the Wyoming Geothermal Commercialization and Utilization Program in December of 1978. The program evolved to become the Wyoming Geothermal Commercialization Program which is administered by the Wyoming Geothermal Commercialization Office, (GCO). The GCO is located on the campus of the University of Wyoming in Laramie.

The purpose of the Wyoming Geothermal Commercialization Program is to match geothermal resources with potential users and applications. The program also is to be a clearing house of geothermal development information and a link to Wyoming geothermal resource data.

The objectives of the GCO are: (1) To bring about a general understanding of geothermal energy and its potentials in Wyoming. (2) To create a working relationship with other agencies involved in geothermal development, both state and federal. (3) To develop usable plans to predict geothermal development over the next 40 years. (4) To maintain regional ties with other states and contribute to the accomplishment of national geothermal energy goals of the United States Department of Energy. (5) To assess the institutional barriers to development of geothermal energy.

The GCO approach is primarily a planning and advocacy effort. The office in cooperation with state agencies, businesses and concerned citizen groups uses a variety of publications and information sources to develop an awareness of geothermal energy. Additionally the specific development plans provide a general view of the future for geothermal energy in Wyoming.

2.0 TASK DESCRIPTIONS

2.1 PROSPECT IDENTIFICATION

-PROVEN - NONE

-POTENTIAL

TABLE 2-1

Name	Estimated Temperature °C at Depth	Probable Depth
Auburn Hot Spring	130	5,000
Little Sheep	85	4,000
Saratoga Hot Spring	85	3,000
Fort Washakie	100	2,500
Big Spring/Thermopolis	100	3,000
Astoria Spring	70	2,000
Midwest	120	10,000
Countryman Well	50	5,000
DeMaris	50	4,000

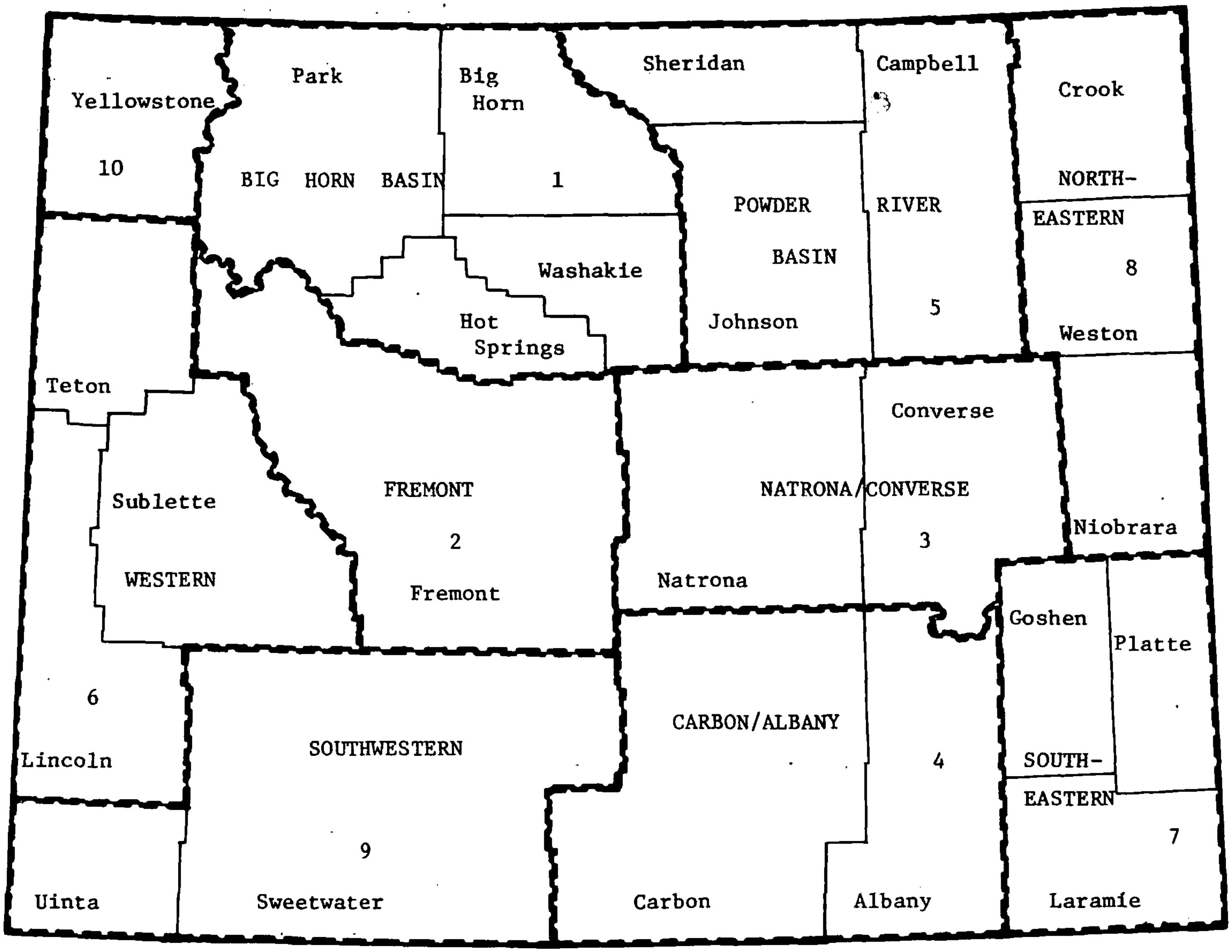
-INFERRED

Name	Estimated Temperature °C at Depth	Inferred Depth
Immigrants	50	4,000
Buffalo	90	8,000
Casper	80	6,000
Douglas	80	6,000
Evansville	80	5,000
Gillette	130	10,000
Glenrock	84	7,000
Lusk	50	4,000
Mills	80	5,000
Moorcroft	80	5,000
Mountain View	80	5,000
Newcastle	50	4,000
Paradise Valley	80	5,000
Sheridan	80	5,000
Storey	80	5,000
Upton	50	6,000
Bairoil	100	6,000
Deaver	80	5,000
Lyons Valley	60	5,000
Meeteetse	100	6,000

2.2 AREA DEVELOPMENT PLANS

2.2.1 STATE PLANNING REGION (see map)

WYOMING GEOTHERMAL PLANNING REGIONS



Scale: 1 in. = 50 mi.
1 cm. = 31.69 km.

Note: Numbers in regions indicate ADP priorities.

TABLE 1

	Investment Cost 1979 $'s	Federal Tax 1979 $'s	Tax Credit 1979 $'s	Temperature of Resource (^0F)	Depth in Feet	Resource Shipping Distance in Feet	Cost of Geothermal Per MMBTU 1979 $'s	Cost of Alternate Fuel Per MMBTU 1979 $'s	Year on Line
Thermopolis (Private Developer)	8,016,686	482,000	1,536,000	100	3,000	0	3.46	3.13	1983
Thermopolis (City Developer)	9,759,602	0	1,603,000	100	3,000	0	2.81	3.13	1981
East Thermopolis (Private Developer)	949,275	58,000	171,000	100	3,000	0	4.21	3.13	1987
East Thermopolis (City Developer)	1,102,104	0	127,000	100	3,000	0	3.22	3.13	1981

2.2.2 SPECIFIC AREA DEVELOPMENT PLANS

-COMPLETED

*Big Horn Basin Area Development Plan - Summary

The Big Horn Basin Area Development Plan covers Big Horn, Hot Springs, Park and Washakie counties in northcentral Wyoming. These four counties cover an area of 12,583 square miles.

The primary geothermal resource areas which have been identified by the Wyoming Geothermal Commercialization Office in cooperation with the University of Wyoming Department of Geology and are located near Cody (Park County) and Thermopolis (Hot Springs County). In addition, two geothermal springs have also been identified in Big Horn County. The geothermal resource data for the Big Horn Basin is based on sixteen springs and four hot wells in this region.

The principal work for this ADP was conducted on inferred resource information for Cody and Thermopolis. The proposed application in each case was for geothermal space heating. The New Mexico Energy Institute has generated the following figures in regard to geothermal district heating of Thermopolis and East Thermopolis (Table 1).

There are also lower temperature geothermal waters in the Big Horn Basin. Some of the suggested uses for these resources included smaller scale space heating projects, industrial and food processing procedures, agricultural and livestock production, and greenhouse operation.

Growth trends for the Big Horn Basin were surveyed to enable prediction of energy consumption within the area. The population growth rate for the state of Wyoming is 2.9% per year, while the growth rate for the Big Horn Basin is 1.4% per year.

Employment and energy consumption rates in the Basin indicate that the mineral industry and its related service industries account for 12% of employment and 92% of total energy consumption. The top six industries in terms of energy consumption per employee are: Food Processing (SIC 200), Oil and Gas Extraction (SIC 13), Hotels and Motels (SIC 70), Service Industries (SIC 7,8), Bentonite (SIC 1452), and Medical and Health Services (SIC 80).

In addition to the cost estimates generated by NMEI, this office also estimated the drilling and distribution costs for district heating of Thermopolis and/or Cody. The costs were estimated on the basis of eight miles of pipeline and two production wells with one re-injection well. Transportation pipe is a double insulated asbestos concrete variety. Table 2 covers the drilling and distribution costs for district heating.

TABLE 2

DRILLING AND DISTRIBUTION COSTS FOR DISTRICT HEATING IN CODY OR THERMOPOLIS

Distribution		$2,000,000
Drilling		
Wells	$82,500	
Casing	28,350	
		110,850
Turbine Submersible Pump (2)	80,000	
Re-injection Pump (2)	36,000	
Recirculation Pump (2)	32,000	
		148,000
Resource to User Cost		$2,258,850
Retrofit 20 Municipal Buildings		200,000
		$2,458,850

In Table 3, the completed system cost is projected and an amortization is applied. The total cost of the delivered heat is an amazingly competitive $3.30/MMBTU.

TABLE 3

ESTIMATED COST PER MMBTU DELIVERED
CODY AND/OR THERMOPOLIS (1978 Dollars)

Plant and Start Up	$2,500,000
Cost of Financing $2,500,000 for 25 years at 8%	788,619
Yearly Operations Cost of $50,000 per year for 25 years	1,250,000
TOTAL ESTIMATED COST	$4,538,619

Total Estimated Cost $4,538,619/25 years = $181,545/year

Estimated Yearly Cost $181,545/year x 1 year/55,000 MMBTU delivered = $3.30/MMBTU

Present uses of existing geothermal resources in the Big Horn Basin were surveyed, as was the space heating potential of the privately owned wells in the Thermopolis area. The Area Development Plan concludes with a site data summary for each of the springs and wells in the four county region.

*Fremont County Area Development Plan - Summary

The Fremont County Area Development Plan covers all of Fremont County in westcentral Wyoming including a total land area of 5,975,630 acres. The primary geothermal resource areas which have been identified in this region consist of six springs and one well.

Most of the known resources in Fremont County are towards the cooler end of the thermal spring spectrum. The Fort Washakie Hot Springs in the

Wind River Indian Reservation in Fremont County are the hottest springs presently known in this region, but are to be examined in a separate report. The Countryman Well, southeast of Lander, probably offers the greatest potential for geothermal development in this region. The temperature of this well is 38^0 C (100^0 F) and is presently used for space heating of a greenhouse. The New Mexico Energy Institute generated a study of a small housing development (population: 30) utilizing the geothermal resource for space heating and produced the following figures:

1. Total Investment Cost = $55,377 (1979 Dollars)
2. Federal Tax = $ 4,000
3. Tax Credit = $11,000
4. Resource Shipping Distance = .5 miles downslope
5. Year on Line = 1981
6. Cost of Geothermal = $4.10 per MMBTU (1979 Dollars)
7. Cost of Alternate Fuel = $5.00 per MMBTU

In addition to development of the Countryman Well, possible uses for lower temperature waters elsewhere in the county were suggested.

The Wyoming Geothermal Commercialization Office surveyed growth trends in Fremont County to enable prediction of energy consumption within the area. Population growth rate for the state of Wyoming is 2.9% per year, while the growth rate for Fremont County is 2.5% per year.

Employment and energy consumption rates for the county indicate that the mineral industry and its related service industries, trucking and warehousing, and electric, gas and sanitary services account for the largest percentage of energy consumption for the county. The public utilities industry (SIC 49) is the largest energy consumer for Fremont County with a total of 7,494.0 MMBTU consumed per employee. Fremont

County's high per capita energy consumption is primarily attributable to the large volume of electricity generation and distribution, predominantly energy intensive mineral industry, and the relatively cold winters.

Some of the energy needs of Fremont County cannot be offset by geothermal resources, although it was recommended that at least six industries look towards geothermal resources to offset some of their energy demands. They are: agribusiness, gas and oil extraction industries, certain drying process manufacturing industries, lumber and all industries and homes requiring space heating. Aside from these and above mentioned recommendations, this ADP includes a comparison of predictions of future resident and work populations made by various agencies, site data summaries for all springs and wells in the county, a brief discussion of land ownership in this large region and related maps and graphs to accompany the main text.

-IN PREPARATION

Natrona/Converse - At the time of the preparation of this report this ADP is only marginally underway. The significant resources of the Madison aquifer combined with extensive population growths since 1970, make this an essential area for an Area Development Plan.

The resource, the Madison Formation, lies from 5,000 to 10,000 feet below the surface in the area and temperatures range from 90^0 C to 140^0 C at depth. Natrona County has experienced more than a 4% growth rate over the last ten years and Converse County has experienced more than a 13% growth rate over the same period.

Geothermal applications for residential space heating could be a major energy factor as well as an economic one to these energy "boom towns."

2.3 SITE SPECIFIC DEVELOPMENT ANALYSIS

2.3.1 CANDIDATE GEOTHERMAL SITES AND APPLICATIONS

Site Name	Resource Status	Application
Thermopolis	Potential	Residential & Commercial
East Thermopolis	Potential	Residential & Commercial
Midwest/Edgerton	Potential	Residential & Commercial
Fort Washakie	Potential	Residential & Commercial
Countryman Ranch	Potential	Residential & Commercial
Saratoga	Potential	Residential & Commercial
Astoria	Potential	Residential & Commercial
DeMaris	Potential	Agribusiness & Industrial
Auburn	Potential	Residential & Commercial

2.3.2 SITE SPECIFIC DEVELOPMENT ANALYSES

-COMPLETE OR IN PREPARATION

*Cody/Gasahol

The methodology utilized in the development of a Site Specific Development Analysis (SSDA), is a fairly comprehensive outline of development possibilities and factors. The process works admirably well when used in an optimum situation i.e. when resource data, demographics, economics, process information and desirable information is available. In the case of this study much of the information was available but significant data are lacking. First, the resource was assumed to be potential by definition at the time of the inception of the planning process in May 1979. This fact is still only an assumption although the geologists optimistic estimates of May 1979 have grown more pessimistic as time progresses. The second portion of data that is lacking is that of the process itself. Little work has been done on developing a process for low temperature geothermal resource applications for ethanol production.

Any information that is available is proprietary and cannot be released by this office.

Therefore, much of the plan contains the best estimates available to the GCO staff for development of the plan. We are a planning organization and are not funded to develop engineering studies of potential applications for geothermal energy utilization.

Data has been gathered to the extent possible, considering the constraints of time and available information, in all areas delineated in the methodology. Each of the areas are essential to a meaningful plan, yet when sections are missing or only available in part, then the usefulness of the SSDA is in jeopardy.

Geothermal fluid boosted by the application of heat pumps and fossil energy for peak demand seems to be a viable energy combination for the production of ethanol. Through the peaking process electrical energy may be generated to supplement the electrical needs of the plant.

The process is simply that of utilizing the readily available barley as a feedstock and "cooking" it to a moderate temperature. Then the natural fermentation process occurs and ethanol is produced in the mash. The ethanol is then extracted through a controlled evaporative process. This controlled evaporation can take several forms, low and high temperature evaporation. Obviously more processing time is required in the low temperature process and perhaps at greater cost. Finally the ethanol is marketed to oil refineries, where it is processed into gasohol at a 10 parts gasoline to 1 part ethanol mixture.

The Big Horn Basin is basically a rural and ranching section of Wyoming. It has a relatively small population when consideration is given to the size of the proposed ethanol plant (20 Mil gals/yr). This would become one of the largest segments of the local economy. Therefore the market area must extend beyond the limits of the basin. A statewide distribution network would be needed for the end product of gasahol, but in this case the end product will be ethanol. The logical market is an oil refinery who is currently processing gasoline. Most oil companies who refine gasoline usually have their own network of outlets throughout the region.

In this case the marketing was an easy task. Husky Oil Company of Cody, Wyoming, currently refining gasoline, has tentatively through word of mouth, agreed to purchase all of the ethanol which the proposed plant could produce. They would combine it with gasoline and distribute it through their regular channels.

Because of the limited resource data available one can in no way accurately predict the amount of energy on line as a function of time. However it appears that when comparisons are made with the energy requirements of a coal fired ethanol plant, approximately 10^6BTU/hr. would be needed for the plant. The resource temperature is hoped to be approximately 170^0 F at a depth of about 1500 feet. Considering this it seems that seven production wells would be needed to supply the plant's needs. It is doubtful that the volume at this temperature would be available.

2.4 TIME PHASED PROJECT PLANS

2.4.1 ACTIVE DEMONSTRATION/COMMERCIALIZATION PROJECTS

NONE

2.4.2 TPPP COMPLETED OR IN PREPARATION

NONE

2.5 STATE AGGREGATION OF PROPOSED USE

Project	1980 Bil BTU/yr	1985 Bil BTU/yr	2000 Bil BTU/yr	2020 Bil BTU/yr
ADPs				
Big Horn Basin	10	50	100	165
Fremont County	20	35	60	100
Natrona Converse	2000	2250	3000	5000
Carbon Albany	0	15	45	60
Powder River Basin	15	25	60	88
Western	15	25	50	75
South Eastern	0	5	10	10
North Eastern	10	25	40	60
South Western	0	0	5	10
TOTAL ADPs	2060	2430	3420	5568
SSDAs				
Cody Gasahol	0	10	25	40
Thermop. Dist. Heat	0	25	45	75
Midwest Dist. Heat	0	50	70	100
Midwest Ind. Pk.	200	1300	2930	4900
Countryman Well	10	20	40	40
Saratoga Dist. Heat	0	15	45	60
Auburn Agribusiness	0	10	60	75
TOTAL SSDAs	210	1430	3215	5290

2.6 INSTITUTIONAL ANALYSIS

Development of geothermal resources in Wyoming is regulated by federal, state, and local regulations and agencies. Because approximately half of Wyoming's lands are federally owned, federal leasing agencies play an important role in geothermal development. Primarily concerned are the U.S. Bureau of Land Management, the U.S. Forest Service, and the U.S. Park Service. The U.S. Geological Survey processes all applications. The developer leases geothermal rights from the federal government but is additionally regulated by state and local agencies. Estimated timelines involved with obtaining permits from federal agencies range from 30 days to as much as eight years.

Most of the Wyoming laws which affect geothermal development apply only broadly to the developer. For instance, the Department of Environmental Quality regulates all environmentally affected activities in Wyoming. The State Engineer issues permits to drill all water wells, including those with hot water. Also he has the responsibility to shut down drilling operations which may endanger thermal features in the state.

Few Wyoming laws deal directly with geothermal development. Wyoming Statute 41-3-901, "Definition of 'underground water,'" reads "'underground water' means any water, including hot water or geothermal steam, under the surface of the land or the bed of any stream, lake, reservoir, or other body of surface water, including water that has been exposed to the surface by an excavation such as a pit." Another law requires the State Engineer to take any actions necessary to safeguard "geothermal springs." State agency requirements can involve timelines from one day to 18 months.

Proposed legislation has been developed by the Wyoming Geothermal Commercialization Office for introduction in the 1981 session of the Wyoming legislature. Primary concern is in six areas: definitions of geothermal, regulatory agencies, "grandfather" clause, delineation of small use or large use, bonding and taxation powers, and quality and quantity protection of Wyoming waters.

Local agencies and regulations in Wyoming become involved in development of geothermal resources according to local land use controls, i.e., zoning laws, building codes, and construction permits. Primarily involved are County Commissioners and City Councils. These two bodies generally delegate authority to such boards as the County Planning Commissions, County Boards of Adjustments, and City Planning Commissions.

The timeline involved with local agencies and permits varies from a few days to several weeks.

2.7 OUTREACH

2.7.1 MECHANISMS

-EXISTING

1. Regular contact with State and Federal lawmakers regarding geothermal legislation.
2. Wyoming Energy Extension Service contacts through the seven Regional Directors to the people of the state.
3. Incoming toll free telephone line on which anyone in the state can call the GCO free of charge.
4. University of Wyoming Communications Services which provides news coverage of all pertinent issues and arranges interviews on radio and T.V. Also the Service provides a service of arranging public talks to civic groups and schools, etc.

-PROPOSED

1. Newsletter to be circulated once per month to interested parties in the state.
2. More extensive acceptances of invitations to speak at civic clubs and schools.
3. Use of T.V. and radio as is possible.
4. Development of an advisory committee whose members would come from government, industry, education, and the common citizen.

2.7.2 SUMMARY OF CONTACTS AND RESULTS

The Wyoming Geothermal Commercialization Office has maintained continued contacts with elected officials during the period July 1, 1979 to December 1, 1979. These officeholders include Senator Alan K. Simpson, Senator Malcolm Wallop, Representative Richard Cheney, Governor Ed Hershler, Albany county senators and representatives, and other Wyoming legislators.

Many contacts with other state officials and offices were initiated, continued, and responded to, including persons in the Wyoming Energy Conservation Office, State Planning Coordinator, Wyoming Department of Economic Planning and Development, the Governor's Office, Public Utilities Commission and the State Engineer.

Elwanda Burke, Operations Manager at Midwest, Wyoming, contacted this office concerning development of a heating district for the towns of Midwest and Edgerton. Correspondence has been on-going between GCO and members of the Hot Springs Community Energy Conservation Board in Thermopolis concerning possible development uses for the resource in that county. Several contacts were made with Jessie Baker of the Wyoming Woolgrowers Association concerning a presentation at that organization's annual meeting.

Contact is maintained on a regular basis between GCO and the Department of Energy in Washington, D.C., Idaho Falls, San Francisco, and Denver. Several contacts took place with personnel at the New Mexico State University Physical Science Lab, at University of Utah Research Institute and at the Geo-Heat Utilization Center at Oregon Institute of Technology. Other on-going contacts include EG&G Idaho Inc. and Western Energy Planners Ltd.

University of Wyoming campus contacts include Ed Decker and Hank Heasler of the Geology Department, Charles Folkner and Don Tiernan from Computer Services, Don Stinson, Paul Biggs, and H. L. Hutchinson from the

Department of Mineral Engineering and Larry Ostresh of the Geography Department.

Reda Pump Inc., International Business Services, Cal Gas Co., ARIX Corporation, and Northern Utilities were contacts made.

County Planning offices in Fremont and Hot Springs counties have been consulted concerning possible geothermal resources in those counties.

Three major presentations were made during the period: a two day presentation was made at the Laramie County Energy Fair; talks were given to WYOPASS in Cheyenne; and in Thermopolis a program was presented at the request of the Hot Springs Community Energy Conservation Board. Many inquiries were made as a result of the public meetings and, particularly, the Cheyenne meeting of the Wyoming Planning Association.

The GCO received several unsolicited job inquiries and applications as well as several requests for general geothermal information.

An article by Rick James, entitled "Geothermal Energy" was included in the Winter 1980 issues of Wyoming Issues.

2.7.3 OVERALL PROSPECTS FOR FUTURE GEOTHERMAL ACTIVITY

Recently the awareness of geothermal energy and its potential has increased dramatically as evidenced by the increase in inquiries received by the GCO. Significant steps have been taken at the state level to assist the continuation of this increase. The Mineral Division of the Department of Economic Planning and Development has made an informal commitment to assist and encourage geothermal development. Also the State Planning Coordinator has demonstrated his support for the GCO program on numerous occasions. Geothermal energy brings with it the opportunity for new businesses such as agriculture and large scale greenhouse operations which may not be possible economically or logistically with conventional systems. These industries can move in and establish themselves and last far beyond the current energy boom of Wyoming.

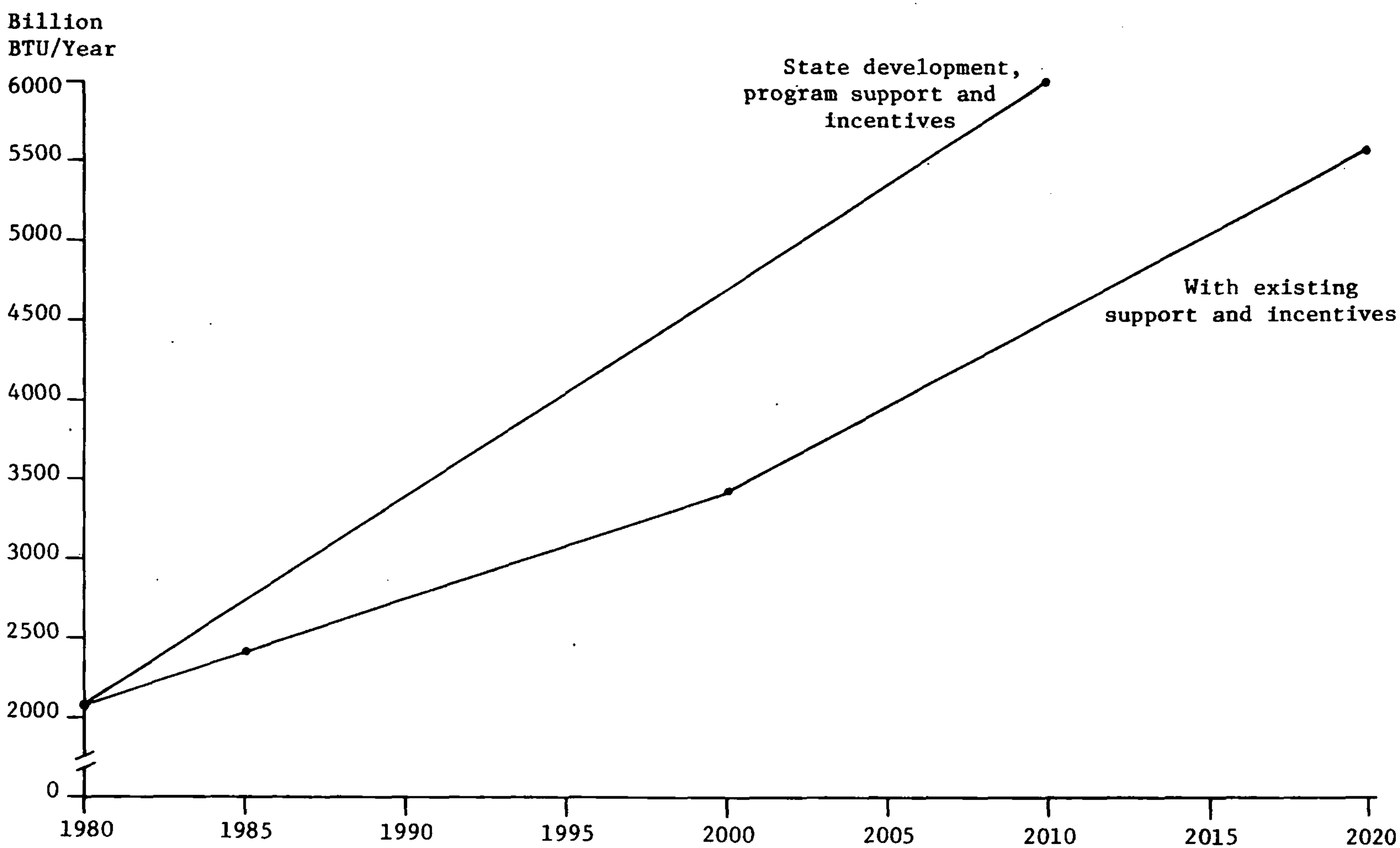
Technical advances seem to indicate that much if not all of Wyoming will have the opportunity to utilize geothermal energy in the future. The state of the art in heat pump technology is continually lowering the resource temperature at which geothermal energy can be utilized.

Currently 60^0 F is the low temperature for a resource but in Europe studies and development work by the Danes and the West Germans indicates that temperature may go as low as 50^0F or 10^0 C.

Figure 1 indicates the probable growth of geothermal utilization in Wyoming over the next few decades and the pace of that growth. Also indicated is the potential for faster growth with state incentives.

Figure 1 indicates the opportunity of geothermal development to occur at a faster rate is tied to the interest which the State may develop for the existing programs and to the incentives which the Legislature may enact in the future. Preliminary estimates indicate that if State monies were made available for both the resource definition and the commercialization of geothermal energy in Wyoming that an increase in interest and in Btus on line would occur. Also, development would be bolstered if the Legislature chose to support geothermal energy through loan guarantees associated with the State's Mineral Trust Fund. Potentially with State support, the development to 6000 Btus annually would occur 25% faster than it would under the current situation.

FIGURE 1


Billion
BTU/Year
6000
5500
5000
4500
4000
3500
3000
2500
2000
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
State development,
program support and
incentives
With existing
support and incentives

3.0 SUMMARY OF MAJOR FINDINGS AND RECOMMENDATIONS

3.1 MAJOR FINDINGS

3.1.1 PROSPECT IDENTIFICATION

There are still no proven resources in Wyoming yet significant strides have been made in the area of inferred resources with twenty prospects listed (2.1 of this report).

3.1.2 AREA DEVELOPMENT PLANS

Big Horn Basin ADP, and Fremont County ADP have been completed in draft form and sent out for comment. The Converse/Natrona ADP is in process.

3.1.3 SITE SPECIFIC DEVELOPMENT ANALYSIS

The Cody/Gasahol project was not completed as there was not adequate resource and process data. But eight additional candidate SSDAs have been identified.

3.14 OUTREACH

The outreach program has taken great steps although they have been quiet ones.

Significant time has been devoted to the development of an on-going outreach strategy. This will be implemented in the next reporting period.

Also, many key people have been contacted through talks given by the GCO and by direct GCO inquiry. The publication in the Winter 1980 issue of Wyoming Issues magazine of "Geothermal Energy" an article regarding the state's potential has been a significant success.

3.1.5 PERSONNEL

During this reporting period there have been changes in personnel in the office. Karen Marcotte was hired in mid October and has contributed a complimentary influence to the office. Jim Caplan whose services will be greatly missed left our office in early November; a person to fill Jim's position was not found during 1979. Carole Aspinwall continues to coordinate our outreach activities and Rick James continues as Program Director with E. G. Meyer as Principle Investigator.

3.2 RECOMMENDATIONS

The Wyoming Geothermal Commercialization Office recommends:

1. That geothermal commercialization programs be continued until there is actual commercial activity on-going in the state and a demonstrated need for more.
2. That projects be funded and or assisted according to demonstrated need of that given state.
3. That monies in both grant and cost shared form be made available for feasibility studies and project development.
4. That the Geothermal Loan Guarantee Program be streamlined in such a way that the Small Business Administration could administer and utilize some portion of it.
5. That federal funding opportunities and methods for obtaining those funds be made available to all state teams by DOE.
6. That DOE make information on all state of the art advancements in geothermal technology available to state teams in brief form with reference to detailed information.