**SELF-START MANUAL
FOR
DIRECT USE APPLICATIONS OF GEOTHERMAL RESOURCES**

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1. Introduction

This document synthesizes the assessment process developed for evaluating nonelectric applications of geothermal resources during the Desert Hot Springs Geothermal Project. The purpose of this document is to provide interested communities and users having similar geothermal resources with a mechanism for evaluating potential nonelectric applications to meet their needs and for gaining added insight on how best to implement these applications. The contents of this document are presented in a generalized form to highlight the assessment and implementation processes. Where appropriate, the findings of the Desert Hot Springs Geothermal Project are cited to further exemplify the options, selection process, and rationale for decision making evolved during this study.

The following sections present the process essential to resource assessment and acquisition, candidate application screening, community needs assessment, community acceptance testing, market assessment, regulation, environmental reporting and permitting, siting, technology status, and financing options. A compilation of supplementary information append this document. Included in this compilation is information related to energy information data bases which can be utilized to supplement the contents of this document (Appendix 1).

Section II presents a discussion of how geothermal resources can be used and what resource considerations are relevant to application feasibility determination. It includes discussion of geothermal resources, assessment and exploration steps, potential nonelectric applications, critical brine characteristics that impact use, necessary tests for determining brine characteristics, and resource development and management options.

Section III describes the process for determining community needs and for testing public acceptance of candidate projects. Potential sources of historic data are also presented for assessing socio-economic characteristics of the community.

Section IV outlines the guidelines and process for assessing the market potential of candidate applications and sources of pertinent information. Examples of market information compiled for the DHS study append this discussion.

Section V summarizes the regulatory and environmental infrastructure and procedures associated with geothermal project implementation. Included is discussion of environmental issues, potential mitigating measures, and guidelines for the preparation of environmental reports.

Section VI provides a compilation of site selection criteria, addressing such variables as load centers, users, load variation, centralized vs. decentralized systems, resource acquisition, and environmental consideration.

Section VII presents a brief discussion on the state of technology readiness and design options available as a function of resource characteristics. Contents include examples of the type of equipment required for given applications, representative manufacturers, and associated costs.

Section VIII discusses project financing alternatives, including requirements and organizations from which funding or financial assistance could be solicited for R&D projects, demonstration programs, and commercial undertakings.

11. Geothermal Resource

A. Geothermal Energy

Geothermal energy is the natural heat of the earth. Most of the geothermal areas that have been exploited are local hot spots in regions where the temperature gradient is $\sim 1\frac{1}{2}$ - 5 times the worldwide average of $25\text{--}30^\circ\text{C/km}$ ($75\text{--}85^\circ\text{F/mile}$). These areas of high geothermal heat flows (anomalies) are usually associated with volcanic or tectonic (crustal movement) activities. In these areas, heat is transferred toward the earth's surface from geologically recent intrusive flows of molten rock (magma) through fractures in the earth's crust.

The most useable systems are those in which water (originating as surface water) moves downward through the fractures, is heated by contact with the hot rock, and finally moves upward again through fractures to shallower depths where it is trapped by an impermeable layer (caprock). In some regions, surface evidence of geothermal reservoirs exist in the form of hot springs and fumaroles (steam vents).

B. Resource Assessment and Exploration

There is a logical progression of assessment and exploration steps (each of which becomes progressively more sophisticated and expensive) to locate an exploitable geothermal resource and to assess its type and magnitude. This progression of steps is presented in Table 1, along with information to be derived, typical mapping areas, and attendant costs for applicable assessment and exploration steps. Because nonelectric applications generally require lower temperature resources than electric applications, the extent of assessment may be significantly reduced in order to obtain the same level of confidence for acquiring a suitable resource for nonelectric applications. Additionally, in areas with surface evidence of geothermal resources, much information can be readily acquired through surface measurements and the assessment can proceed directly to geophysical surveys for determining target areas for drilling.

It should be noted that (1) costs noted in Table 1 are not additive, (2) the potential user would always select the necessary steps depending on available data and nature of development, (3) costs shown are rough order-of-magnitude only, and (4) extant data are available at no or nominal cost through a number of government agencies (e.g., see Appendix 1).

Drilling costs vary significantly with casing size, depth, and type of subsurface deposits encountered during drilling. In Desert Hot Springs (where subsurface deposits to 1,500 feet consist of alluvium, conglomerate, and fanglomerate), a 500-foot well with 8-inch casing will cost $\sim \$10,000$ to $\$15,000$. The same depth well with a 12-inch casing will cost $\sim \$12,000$ to $\$23,000$. The estimated cost for a 1,500-foot well with an 8-inch casing varies from $\$21,000$ to $\$49,000$. A 1,500-foot well with 12-inch casing will cost $\sim \$54,000$. By comparison, a 5,000-foot completed wildcat well* will cost in excess of $\$400,000$. Production wells of similar characteristics cost two-thirds as much as wildcat wells.

*A wildcat well is a potentially producing well drilled in an unfamiliar area where no previous deep wells exist.

TABLE 1
PROGRESSION OF ASSESSMENT AND EXPLORATION STEPS *

	STEPS	INFORMATION GAINED	COSTS
A.	<u>Preliminary Analysis:</u>		
1	Examination of Available Data	Regional Structural, Stratigraphical and Topographical Information	Nominal - mainly research time.
2	Airbourne Survey if Above Step is Inadequate	Generalized data including Location of Local Features Where More Surveying Should Be Performed (e.g. Faults, Circular Features, etc)	\$10,000-\$20,000 for 10 x 10 Mile Area
3	Geological Survey (Reconnaissance)	Thermal Area Boundaries and Structural, Stratigraphical, and Petrologic models	a) Survey & Analysis of Existing Data, Preparation of Area Maps = \$10,000-\$20,000 b) Field Survey, Collection of Samples, Interpretation of Data, Report and Preparation of maps \$16,000/10 Sq. Miles
B.	<u>Surface Exploration:</u>		
4	Geophysical Survey (and above)	Definition of Target Areas For Shallow and Deep Drilling	a) <u>Gravity Survey</u> Minimum Cost is \$5,000 to \$8,000, \$50/Point/Gravity Station, 2-3 Points/Sq. Mile Rec'd b) <u>Resistivity Survey</u> 2 Line Miles/Day At \$1,200/Day including Data Interpretation c) <u>Magnetotellurics</u> \$2,000/Day or \$1,000 Per Line Mile including Data Interpretation
C.	<u>Slim Hole Drilling:</u>		
5	Hydrological Survey	Hydrological Model of Aquifer	a) Sample Collection = \$200-300/Day. b) Collection, Analysis of Data and Reporting = \$20,000/10 Sq. Miles
6	Geochemical Survey	Probable Existence and Characterization of the Reservoir	Collection, Laboratory Analysis and Reporting < 100 Samples = \$350/Sample > 100 Samples = \$250/Sample
7	Thermal and Other Measurements in Shallow Holes	Thermal Gradients, Heat Flow and Stratigraphical Control	Drilling, Data Collection Processing, Interpretation and Report. = \$10/foot of Drilled Depth
D.	<u>Confirmation:</u>		
8	Deep Drilling - Discovery & Full Flow Testing	Resource Temperature, Flowrate, and Lifetime	Drilling, Data Collection Processing, Interpretation and Reports a) 1,000-2,000 feet deep \$20/foot complete b) 5,000 - 8,000 feet deep large diameter \$100-\$120/ft complete

Notes: The costs shown are average costs for ideal conditions. The cost can vary up to 4 times higher than those shown depending on terrain, climate and underground conditions. For a definitive location, exact costs should be obtained from qualified professionals.

*THIS DATA SHOULD BE USED AS A VERY ROUGH GUIDE ONLY.

C. Critical Brine Characteristics

Potential nonelectric applications of geothermal energy, as a function of resource temperature, are presented in Figure 1. Important properties and constituents of the geothermal fluid that can impact use and economics are the ionic, gaseous, and mineral content of the geothermal fluid. The types of tests required to determine these properties and concentrations of critical constituents are presented in Table 2, along with associated costs and typical organizations qualified to conduct these tests.

For indirect use (where the heat must first be extracted from the fluid by means of a heat exchanger before it can be used), the primary brine characteristics are acidity and H_2S content, both of which in excessive quantities can cause severe corrosion problems if the plumbing materials are not properly selected. TDS, silica, and Ca^{++} are additional characteristics that can cause scaling and severely deteriorate heat transfer and flow.

For geothermal resources with large concentrations of H_2S or CO_2 , open system utilization (that would permit atmospheric discharge) may be precluded due to the toxic nature of these gases.

In direct uses (where the geothermal fluid can be utilized directly, such as in various agribusiness applications), the critical constituents and concentrations are largely determined by specific application, siting, and effluent disposal considerations. (See Sections V and VI for further discussion.)

Irrigation water quality criteria for typical agricultural applications are presented in Table 3. The thresholds listed are for guideline purposes only, since permissible limits vary widely with different crops, soils, and climatic conditions. Additionally, the tolerance thresholds would change significantly if the operation were to be conducted by solution culturing (hydroponics).

Comparable constituent thresholds are given in Table 4 for a representative aquaculture application. Here again, although an abundance of data may exist for the culturing of finfish, many of the shellfish species that are potential target opportunities lack corresponding data. For example, the Malaysian freshwater prawn (*Macrobrachium*) was identified as a prime candidate for raceway culturing in the Desert Hot Springs Geothermal Project. However, there is a dearth of information concerning this species' threshold for ammonia toxicity as well as tolerance and uptake of fluoride. As a consequence, the undertaking recommended was to pursue a pilot research project that could gravitate into a commercial-sized operation, once the necessary data were developed and demonstrated to be favorable.

Other brine composition issues that arise stem from effluent disposal considerations and incremental increases in constituent buildup that site-specific basin or discharge standards will allow. (See Section V for a further exposition on fluid handling and disposal issues and techniques.)

Fig. 1 Required temperature of geothermal fluids for various nonelectrical applications²

TABLE 2

**GEOCHEMICAL TESTS, CRITICAL CONSTITUENTS,
AND BRINE PROPERTIES**

Type of Test*	Critical Constituent/Property	Units
Mineral Content	Calcium	mg/l
	Magnesium	mg/l
	Sodium	mg/l
	Potassium	mg/l
	Carbonate	mg/l
	Bicarbonate	mg/l
	Sulfate	mg/l
	Chloride	mg/l
	Nitrate	mg/l
	Fluoride	mg/l
Heavy Metal Content	Boron	mg/l
	Silica	mg/l
	Cadmium	mg/l
	Arsenic	mg/l
	Mercury	mg/l
Gas Analysis	Hydrogen Sulfide	mg/l
	Ammonia	mg/l
	Carbon Dioxide	mg/l
	Radon	pc/l
General Analysis	Temperature	°F
	pH	
	Conductivity	μΩ/cm
	TDS	mg/l

* A number of qualified testing laboratories service a localized and broad territorial market. For the City of Desert Hot Springs Geothermal Project, Truesdail Laboratories, Inc. was retained to provide this service. Associated costs were \$600.00 for a single-sample test.

Table 3
QUALITY CRITERIA FOR IRRIGATION WATER^a

Criterion	Class 1 ^b Excellent to Good	Class 2 ^c Good to Injurious	Class 3 ^d Injurious to Unsatisfactory
Conductance ^e EC X 10 ⁶ at 25°C	Less than 1,000	1,000 - 3,000	More than 3,000
Chloride, epm ^f	Less than 5	5-10	More than 10
Percent sodium ^g	Less than 60	60-75	More than 75
Boron, ppm ^h	Less than 0.5	0.5-2.0	More than 2.0

- a. The values shown should be used as a guide only, since permissible limits vary widely with different crops, soils, and climatic conditions.
- b. Class 1. Excellent to good--regarded as safe and suitable for most plants under any condition of soil and climate.
- c. Class 2. Good to injurious--regarded as possibly harmful to certain crops under certain conditions of soil or climate, particularly in the higher ranges of this class.
- d. Class 3. Injurious to unsatisfactory--regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant.
- e. Specific electrical conductance (K x 10⁶ at 25°C). This measurement is reported in reciprocal ohm per cm., multiplied by 10⁶ (1,000,000), and provides an index of total dissolved electrolytes or total salinity.
Dividing the conductance (EC x 10⁶ at 25°C) by 10 gives an approximation of the salt content in milligram equivalents per liter. Multiplying the conductance (EC x 10⁶ at 25°C) by 0.7 gives a rough estimate of parts per million (ppm) total salts.
- f. Chloride is expressed as equivalents per million.
- g. Sodium percentage is computed by the formula $\frac{\text{Na} \times 100}{\text{Na} + \text{Ca} + \text{Mg}}$, when these are expressed as equivalents per million.
- h. Boron content is expressed in parts per million.

TABLE 4

Favorable Ranges and Lethal Limits of Various Water Quality Factors for Larval Striped Bass³

Parameter	Favorable Range		Lethal Limits	
	Lower	Upper	Lower	Upper
Temperature (°C)	16.0	19.0	14.0	24.0
Dissolved Oxygen (ppm)	5.0	--	1.7	--
pH	7.5	7.9	5.3	10.0
Sulfates (ppm)	--	200.0	--	250.0
Chlorides (ppm)	--	950.0	--	1000.0
Dissolved Solids (ppm)	100.0	900.0	--	--
Zinc (ppm)	--	--	--	0.28
Copper (ppm)	--	--	--	0.05
Aluminum (ppm)	--	--	--	0.02

D. Criteria for Resource Development Options

Depending on the character of the resource, environmental concerns, and application needs, the geothermal resource may be developed and managed in a variety of ways. Assuming the brine composition, subsurface geology, and reservoir yield will permit it, the geothermal fluid may be extracted from a production well and the effluent disposed of through a percolation basin. In reservoirs where the hydrologic yield is inadequate or where land subsidence may be a problem, fluid disposal may be effected by injection well(s). In instances where the resource temperature is adequate but the hydrologic yield and static water level are of concern, downwell heat exchangers may be in order. However, this option is accompanied by higher capital equipment outlay and source temperature reduction (i.e., -15°F).

Extraction rate and field development strategies depend upon such considerations as the areal extent of the aquifer, hydrologic yield, ongoing operations, and existence of hot springs. Petroleum reservoirs are pumped to depletion at some preselected efficiency rate. In the management of geothermal reservoirs, field development strategies are dictated by the economics of resource lifetime and the need for replacement wells to enable the payback of capitalization costs. Accordingly, most geothermal fields are not necessarily managed by the maximum efficiency rate of fluid withdrawal, but rather by the match-up to the user's needs. In addition, in areas of ongoing use or surface manifestations (e.g., hot springs), extraction rates and step-out well placement strategies are governed by the need to protect these operations from the standpoint of both static water level (supply) and resource temperature (prevent quenching of the source temperature).

In addition to the physical constraints, there are a number of institutional factors which influence these decisions. These factors are discussed in Sections V and VI.

111. Community Needs Assessment

Once an indigenous geothermal resource has been identified, the question arises as to what are the most appropriate uses to which it may be put. The answer is controlled by two factors: 1) what is technologically and economically feasible given the characteristics of the resource, and 2) what is most desirable in terms of the needs of the community. The steps required to evaluate technological feasibility are discussed elsewhere in this report; this section discusses community needs assessment. The goal of the assessment is to identify community needs which may be fulfilled, totally or partially, by using geothermal resources. For example, utilization of the indigenous geothermal resource may result in overall energy cost savings.

The first question to be answered is, "What are community needs?" In general, community needs are an aggregate of individual needs, for example, housing, jobs, transportation, electricity, water, etc. Although needs tend to be personalized, averages based on the manifested needs of a large number of people may be used as indicators of overall community needs. Thus, a community needs assessment is based on trends in the socio-economic characteristics of the community. Changing needs are evidenced by shifts in the age-sex composition of the population; the increase or decrease in the overall number of jobs and their location; the mix of job skills in the resident population; the number and type of industries in the community and the region; the availability of housing, schools, cultural facilities, water, power and other utilities; and the like. Fundamentally, a community needs assessment seeks to understand the people and their lifestyle, and what is required to support them.

An assessment of community needs encompasses five tasks, each of which is discussed below. The first task is to gather historic data on the evolution of the local community and the region. Very often this data exists in a readily useable form in the supporting documentation to local, county and state general plan elements, and in somewhat less detail in publications of the U.S. Bureau of the Census, including any special census which may have been taken in the local area. The historic trends analysis may be performed by the local planning department or the local economic development council.

Examples of the types of data available and what may be developed are presented in References 4 & 5. References 4 & 5 are two Community Economic Profiles, one for the City of Desert Hot Springs and one for the City of Palm Springs, both prepared by the Riverside County Department of Economic Development.

Often there is a significant period between the time data is gathered to be used to prepare general plans and other similar documents and the time at which decisions are to be made. Therefore, it is necessary to update the historic data to reflect current conditions. The updating may be accomplished by having the local planning department make current estimates as to population, housing, and socio-economic characteristics, by obtaining similar estimates from county, regional, or state agencies.

Most frequently, the estimates provided are merely of total population and housing within and without incorporated areas. The local agency undertaking the community needs assessment will have to disaggregate the data into the appropriate categories. Current economic data may be obtained from the U.S. Bureau of Labor Statistics, or from the economic development council of the local region. An example of a socio-economic analysis may be found in Appendix 2, again based on the City of Desert Hot Springs.

The final step in the data analysis portion of the assessment is to project community needs into the future, in particular, into the time frame wherein indigenous geothermal resources might be utilized. Once again, this information may be obtained from the general plan, from population and housing projections made by county, regional and state officials, or by local government staff projections. The objective is to answer the question: "What are the most pressing community needs in any given time frame wherein geothermal resources might be utilized in meeting these needs?"

It should be recognized that the data analysis will identify community needs based on evolving trends within the community. This does not mean that the needs are perceived or even recognized, nor that citizens do not have other needs considered to be more pressing. Therefore, the next step in the assessment is to test the tentative conclusions, that is, to validate as being true needs those identified by an analysis of data and trends. There are two ways to accomplish this: the first is the traditional public attitude survey which is issue specific relative to the proposed utilization of geothermal resources, and second, to perform a general community assessment to identify the entire spectrum of needs. A copy of the public attitude survey used in the City of Desert Hot Springs, California, and the analysis of it may be found in Appendix 3. In either case, it will usually be necessary to retain consultants to prepare, administer and analyze these community surveys. Quite frequently the state agency responsible for making population estimates has on its staff persons trained in survey research who may be made available to the local community. Another source of assistance is the local University. For those needs where there is a concurrence between the data and trend analysis and the community needs assessment, it is clear that these are the highest priority needs in the community. In those areas where there is a disparity between the two, it is incumbent upon the local government officials to ultimately rank order, or prioritize the community needs. Thus, the last step in the Community Needs Assessment is to prepare a prioritized list of community needs. This list will be used in making the comparative technology assessment of candidate applications once identified.

In the City of Desert Hot Springs much of the historic, current and projected socio-economic data existed in the local planning department and the Riverside County Planning Department. Further economic data was obtained from the Riverside County Department of Economic Development. From this data it was clear that energy costs were a significant portion of the cost of living of the large number of retired and semi-retired persons in the community. Also, there was an identified need for jobs. Based on this, the technology evaluation was focused on potential applications of the geothermal resource which could reduce energy costs and/or provide more jobs in the community. (See Appendix 2 for summary of the Desert Hot Springs community needs analysis.)

IV. Market Assessment

To provide continuing benefits to any community, the candidate application must be economically self sustaining, that is, it must be profitable. Some applications such as greenhouses have demonstrated economic viability based on conventional power sources. The potential application of geothermal resources here is to replace partially or in full the energy currently derived from traditional sources. Other applications are partially derived from the character of the geothermal resources themselves, such as aquaculture. Where markets for the commodities produced using geothermal resources exist, they must be identified and the factors controlling access to them evaluated. Where markets are uncertain, a new or expanded market may have to be created.

There are two general sources of market information: 1) data compiled by the U.S. Department of Commerce and the U.S. Bureau of the Census, and 2) daily, weekly or monthly market reports usually issued by the wholesale distributors of commodities. Virtually every commodity has specialized information sources which may be ascertained by contacting the U.S. Department of Commerce, or a wholesale distributor group.

The technology assessment calculates the quantity of each commodity to be produced in a candidate application. The question to be answered here is whether a market exists for the commodity so produced. Answering that question requires analyzing historic and current trends in the consumption of the commodity, both in terms of price and quantity. If consumption of a commodity has and is increasing, it should be relatively easy to introduce more production. If consumption is falling, care must be taken to make sure that a continuing market will exist.

One of the factors to be assessed is the number of existing competitors and the likelihood of additional ones. Data on existing suppliers may be obtained by talking to wholesale distributors of the products.

Market surveys are usually the responsibility of the developer of the use. Developers in turn often contract these analyses to marketing consulting firms. What follows is a discussion of a simplified procedure for market assessment. The example used is giant Malaysian prawn, Macrobrachium rosenbergii.

The first step in the analysis was to contact the U.S. Department of Commerce National Marine Fisheries Services to obtain overview publications and those specifically describing the shellfish market. Examples of overview publications may be found in References 6, 7, and 8 and examples of shellfish publications in References 9, 10 and 11.

The next step was to contact wholesale distributors of shellfish. The Los Angeles association identified several proprietary market research newsletters, as an example of which may be found in Reference 12. It should be noted that these reports are usually available to subscribers only. (See Appendix 4 for representative plots of data developed from these sources.)

Other publications and information are usually available from the Agricultural Extension Service associated with universities having agricultural research programs.

Once the data on shrimp markets was gathered, an analysis was performed, first, to understand the overall trend in the consumption of shellfish products in the United States, and, second, to assess prices and quantities consumed of shrimp and lobster in particular. As is frequently the case with the introduction of new products, there is no structured market. Therefore, the market survey is analogized from the new products' likely competitors. In the case of Macrobrachium, the competitors are lobster and shrimp.

For the Desert Hot Springs Geothermal Project, the market analysis for the Malaysian freshwater prawn yielded the following findings:

The creation of a market for Macrobrachium in Southern California is a function of two factors: the first is the introduction of the Macrobrachium at a price sufficiently below the then current price for shrimp and lobster, and second, introduction at a time when lobster and shrimp prices are high. These prices must reflect all costs associated with production and marketing of the new product, including transportation costs. The lower the price of the Macrobrachium compared to shrimp and lobster, the greater portion of the market which will be captured. Conversely, the closer the price of Macrobrachium to saltwater shrimp and lobster, the smaller portion of the market it will capture. Arguments advanced relative to the requirements of product differentiation, alternative names, competitors in the field, etc., impact creation of the market only in the initial phases of product introduction. To induce people to try Macrobrachium for the first time, the price may have to be significantly lower than existing shrimp and lobster prices to overcome the cultural inertia of consumer buying habits. Once the Macrobrachium are more well known, the price may rise closer to that of shrimp and lobster without yielding market share.

Macrobrachium faces obstacles typical to new product introduction. The answer to a question of the existence of a market must be articulated in terms of prices, quantities and timing.

For a complete exposition of the market assessment of Macrobrachium prawn, refer to the Desert Hot Springs Geothermal Project final report SAN/1329-4. 14

V. Regulatory, Environmental Procedures and Management Options

A. Introduction

Development projects of any kind have always been subject to regulation, but today there are many more regulatory agencies to satisfy than ever before. Usually a development project must comply with the regulations of several agencies prior to the commencement of construction and operation activities. This section attempts to clarify the regulatory requirements of geothermal development by identifying the major regulatory issues involved in non-electric geothermal utilization and by illustrating how these major regulatory issues are implemented in a city in California.

1. Regulatory Overview

Regulatory agencies are established to protect the health, safety and welfare of the general public. Each agency develops regulations and guidelines in their area of expertise to meet this goal. These regulations are enforced by requiring individuals or developers who may threaten the health, safety and welfare of the general public through their activities to acquire assurance from the appropriate regulatory agencies that their activities are not harmful. Agencies make this determination by requiring individuals and developers to apply for permits. The application process involves describing the activity in question in as much detail as the regulatory agency requests. The agency judges the activity on the basis of this information and approves or disapproves it by granting or denying the permit. Often permits are granted on conditions that the individual or developer conform to specified requirements delineated on the permit by the agency. Sometimes several agencies are involved in the review of a single permit. Usually many agencies require permits of a single activity.

2. Major Regulatory Issues

The general regulatory issues developers of non-electric geothermal resources must address and the general types of agencies who regulate these issues are listed in Table 5. A flow chart depicting permit requirements is shown in Figure 2. They are discussed generally in this section for applicability to every state with geothermal resources. Specific examples of these regulatory agencies and their regulatory processes will be given for geothermal development in Desert Hot Springs, California. The first issue to be discussed is "use rights". A list of agencies responsible for geothermal regulations in other states appears in Appendix 5.

B. Use Rights

Once a specific use has been identified, the first step a developer faces is to find a suitable site, both in terms of the proposed use and surrounding development. A project proposing to utilize geothermal resources usually must be sited near the resources to minimize the loss of thermal efficiency and the cost of installing pipeline. The appropriateness of the proposed project regarding surrounding property uses depends on its compliance with the area's zoning, or a determination resulting from local government review.

TABLE 5

GENERAL ISSUES AND REGULATORY AGENCIES OF
NON-ELECTRIC GEOTHERMAL DEVELOPMENT

Use Rights	Planning Departments
Well Development	Geologic and Mining Agencies
Air Quality.	Environmental Protection Agencies, Air Quality Agencies
Water Quality.	Environmental Protection Agencies, Water Quality Agencies, Health Agencies, Wildlife Protection Agencies
Public Health.	Public Health Agencies
Ecological Protection.	Fish and Game Agencies
Historic Preservation.	Historical Protection Agencies
Environmental Review	Planning Department, Funding Agencies

Figure 2
Flow Chart of Regulatory Requirements
For Non-Electric Geothermal Development

Municipal and county land use plans divide an area into zones, each allowing specific types of development. In this manner, residential areas can be protected from intrusion by industrial activity and commercial business can be concentrated in one area convenient to consumers and businessmen alike. A new development project in an area must consult with the local planning department to see if the site chosen for the project is zoned for that particular type of activity. If it is, the developer may proceed with his project without obtaining a use permit. Zoning bestows blanket approval of specified uses in particular areas, and can be thought of as large, all-encompassing use permits.

If the proposed use does not comply with the area's zoning, or the area has "open zoning", (the area has not been zoned), a conditional use permit (CUP) must be obtained. When the zoning conflicts, a change of zoning must occur prior to project development. However, this is a lengthy process. The requirement to obtain CUPs allows local government agencies to review projects which have unidentified impacts, and gives them the opportunity to prevent projects with adverse impacts from entering the community.

Presently there are no zoning ordinances which require geothermal development projects to obtain CUPs solely because they utilize geothermal resources. A geothermally heated health spa, for example, can locate in a commercially zoned area without obtaining a CUP. It is viewed as a commercial activity in a commercially zoned area. However, in the future, geothermal development may be required to obtain CUPs as local governments feel it requires more control.

CUPs may be required by either county planning departments or city planning departments. To determine which agency has jurisdiction in any particular case, the developer must ascertain whether or not his property is within a city's limits. If the property lies within a city's limits, the CUP is acquired through a city planning department; if not, the county planning department will have jurisdiction.

It is also probable that the proposed site is within the jurisdiction of other agencies. Both state and federal governments own parcels of land which may be suitable for geothermal development. Each agency may have procedures to approve specific land uses. The California State Lands Commission has a review procedure in which permits are required for every project phase, including exploration and development. At each step they determine whether the use is appropriate for the area. In other states, comparable State agencies should be contacted. Other agencies which have land that may be available for geothermal development are:

- U.S. Bureau of Land Management
- U.S. Forest Service
- Military Branches

A summary of property rights and regulation of geothermal resources in California, Nevada, Arizona and New Mexico is included in Appendix 5 of Reference 14.

In Desert Hot Springs conditional use permits for projects within the city limits are obtained from the City Planning Department. The City has areas zoned for industrial, commercial and residential development, and some open zones in which the use is not designated. The residential and commercial zones occupy land closest to the geothermal resources. The closest land zoned for industrial uses is half a mile away from the resource. An industrial development wishing to utilize the geothermal resource may need to acquire a change of zoning. It is possible to site a project in the appropriately zoned area and pipe the resource to it, but this will add expense and decrease the efficiency of the geothermal system.

A developer wishing to initiate the permitting process should contact the local planning office for information. If they are not the agency responsible for issuing use permits in that area, they will be able to direct the developer to the agency which does have permitting authority.

Planning agencies have a key role in the environmental review process required of some development projects.

C. Environmental Review

One result of society's growing awareness of the finite nature of many natural resources is the National Environmental Policy Act (NEPA). NEPA is a body of Federal legislation requiring the inclusion of environmental impacts into cost/benefit analyses determining project feasibilities. The Council of Environmental Quality (CEQ) was also established by this legislation to implement NEPA requirements. Basically, NEPA requires in-depth reports to be written describing projects and delineating their impact on the environment. These reports are called Environmental Impact Statements (EIS) and are required of all projects which are, "major federal actions significantly affecting the quality of the human environment". This phrase has been interpreted to cover consideration of:

- 1) the overall, cumulative impact of the action proposed and further actions contemplated
- 2) the potential that the environment may be significantly affected even if the action is localized in impact
- 3) any action whose environmental impact is likely to be highly controversial
- 4) individually limited effects of many decisions about a project which become cumulatively significant, such as when:
 - a. one or more agencies over a period of years put into a project individually minor but collectively major resources
 - b. a minor decision establishes a precedent or a decision in principle about a larger course of action
 - c. several agencies are involved.

Projects which do not need EIS's include:

"Continuing administrative or maintenance activities, such as purchases for supplies, personnel-related actions, emergency repairs to public service facilities, general policy and procedure making, feasibility or planning studies."16

These projects are "categorically exempt" from the EIS requirement.

The CEQ developed guidelines for EIS's which delineate the information to be included (Table 6). The EIS procedure is shown in Figure 3.

Responsibility for EIS preparation falls to the "lead agency" of a project, the agency having the greatest legal authority over it. Usually planning agencies fill this role because of their authority over use permits. The EIS process shown in Table 6 is initiated when an application for a CUP enters a planning office. The EIS, if required, can be prepared by either the planning agency or a contractor, but both will be prepared at the developer's expense.

Projects proposed for development in Desert Hot Springs do not fall into any of the categories requiring NEPA compliance. However, if funding for any of these projects is received from Federal agencies, and this is very likely, NEPA requirements must be met. In this case the Federal funding agency would perform lead agency duties.

NEPA may also become involved through the U.S. Environmental Protection Agency (EPA). This possibility will be discussed in conjunction with "water quality". For additional information on NEPA, the CEQ should be contacted.

Many states have adopted environmental legislation of their own. California is one of these. The title of California's environmental legislation is the California Environmental Quality Act (CEQA). CEQA requires an environmental report called an Environmental Impact Report (EIR). CEQA and NEPA require the same basic information in their impact reports but in slightly different formats. The information to be included in CEQA is listed in Table 7. CEQA procedures are listed in Figure 4. Because of the slight variation sometimes a single project must prepare both an EIS and an EIR. Efforts to streamline this process are being developed. CEQA specified that federal EIS may be used for a state EIR if sections on mitigation measures and growth inducing impacts are added.

CEQA is applicable to projects located in California and are:

"discretionary projects proposed to be carried out or approved by public agencies, including, but not limited to, the enactment and amendment of zoning ordinances, the issuance of zoning variances, the issuance of conditional use permits, and the approval of tentative subdivision maps."17

TABLE 6 16

INFORMATION REQUIRED IN ENVIRONMENTAL IMPACT STATEMENTS

Environmental Impact of the Proposed Action

Any adverse environmental effects which cannot be avoided should the proposal be implemented

Alternatives to the Proposed Action

The relationship between local short-term users of man's environment and the maintenance and enhancement of long-term productivity

Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented

FIGURE 3*

SUBMISSION AND REVIEW PROCEDURE FOR LOCAL EIR's

* Management Information Service Report, International City Management Association, June 1975, Volume 7, Number 6

TABLE 7.17

INFORMATION REQUIRED IN ENVIRONMENTAL IMPACT REPORTS

Required Information

Project Description

Description of the existing environment

All of the environmental impacts of all phases of the project, described in detail

Any adverse environmental impacts which cannot be avoided if the proposal is implemented

Mitigation measures proposed to minimize the impact

Alternatives to the proposed action

The relationship between local short-term users of man's environment and the maintenance and enhancement of long-term productivity

Any irreversible environmental changes which would be involved

The growth inducing impact of the proposed action

Organizations and persons consulted

References and appendices

Comments and responses

FIGURE 4 *

* Review procedures related to projects requiring review at the state level under OMB Circular A-95, NEPA, CEQA, Section 0911 of SAM; projects (local or state) utilizing state funds and tentative subdivision maps reviewed pursuant to S & P Code.

All other projects, i.e., private development and public work projects using no state or federal money are not required to be submitted for review at the state level.

** For local and state projects under A-95, Part I, and subdivision maps, the review period is 30 days. For state activity under CEQA, the review period is 45 days. For direct federal development projects, the review period is 60 days.

* Environmental Impact Review, An Introduction to the Federal and California Processes, by Ruthann Corwin, Environmental Information Clearing House, Sept. 1974

As in NEPA, responsibility for CEQA conformance is delegated to a lead agency, usually the appropriate planning department. This responsibility is transferred to a State funding agency if one becomes involved.

Developers in states other than California can determine whether their state has adopted an environmental review process by contacting a comparable State environmental protection agency or energy commission.

D. Well Development ¹⁸

Drilling and utilizing wells to extract water, oil and other fluids, or for exploration is regulated by state agencies dealing with geology, mining and other extractive industries.

Once use permits have been obtained, and environmental review is complete, the developer of geothermal resources must gain access to it by either drilling a new well, or by upgrading and reusing an existing one. The drilling and use of geothermal wells is carefully regulated for the following reasons: to protect geothermal resources from becoming contaminated; to prevent other aquifers from being contaminated; to protect public health; and to provide geologic information.

In the State of California, the Division of Oil and Gas (DOG) is the responsible agency for permitting and licensing all well development. The DOG has explicit permit requirements and procedures requiring a sequence of permits describing all phases of well development. The permitting procedure includes the following:

- 1) Notice of Intention to Drill a Geothermal Well (NOI)
- 2) Cash bond
- 3) Agent designated as legal representative

If the permit is granted:

- 4) Well summary
- 5) Well history
- 6) Monthly Geothermal Resources Report or
Reinjection Well Report

When well is no longer required:

- 7) Notice of Intention to Abandon Well

The forms listed above can be obtained from any regional office of the DOG, along with the type of detailed information required on each form.

Regional office locations can be obtained from the State Office of DOG.

E. Air Quality ¹⁹

Air quality is generally regulated by the Federal Environmental Protection Agency (EPA). The EPA sets national air quality standards. Some states have their own air quality agencies and at the sub-state level regional air quality management agencies. States without their own air quality agencies are subject to regulation by the EPA.

All new development projects must meet air quality standards. Federal, state and regional agencies have adopted standards in response to legislative mandate to prevent further air quality deterioration. Because chemical processes involved in air pollution are still relatively unknown, air quality standards are being revised continually, making complete understanding of the law very difficult.

California is one of those states with both state and regional air quality management agencies. The standards at the sub-state levels are typically more stringent than those at the state level, and standards of agencies at the state level are more stringent than federal air quality standards. A developer who complies with the standards of the regional air quality agencies is therefore usually meeting state and federal standards.

In Desert Hot Springs, air quality standards are set by the Southern California Air Quality Management District (SCAQMD). A developer must obtain a Permit of Construction and a Permit to Operate from them. These permits are National Pollution Elimination and Discharge Permits (NPEDP) and are granted by the EPA in states without their own air quality agencies.

Permits are granted on the SCAQMD's assessment of the proposed project, and the anticipated quantities of air pollutants it may release during construction and operation stages. It is not anticipated that any of the proposed development projects which may be undertaken in the City of Desert Hot Springs will exceed the SCAQMD's air quality standards. The air quality standards of the EPA and the State of California Air Resources Board (ARB) are listed in Table 8.

One of the primary concerns of air quality agencies regarding geothermal development is the quantities of hydrogen sulfide, H_2S , they release. Quantities greater than 0.03 ppm/hr are restricted. The resource in Desert Hot Springs now releases lower quantities of hydrogen sulfide than 0.03 ppm/hr. Because air quality standards are changing or being reinterpreted so rapidly, developers are advised to consult with regional air quality management districts, state air quality agencies, or the EPA, early in project planning.

F. Historic Preservation²⁰

Preservation of the country's historic and archeologic past, like environmental preservation, is an important aspect of project planning. The National Historic Sites Act and the National Historic Preservation Act established a legal obligation that all proposed projects must identify any historic or archeologic sites which may be disturbed by the project. The National Historic Preservation Act established the Advisory Council of Historic Places to implement the law. The Council has written guidelines delineating the assessment process by which historic sites are identified and the impact on them evaluated. This process is similar to the environmental review processes of NEPA and CEQA discussed previously. Both NEPA and CEQA have requirements that the historic and archeological impact of any project be assessed along with the environmental impacts. Usually an EIR or EIS including the impact on historic and archeological sites will satisfy the requirements of the national historic preservation legislation, and in this way the preparation of two documents is avoided.

TABLE 8

AIR QUALITY STANDARDS OF THE EPA AND CALIFORNIA'S ARB ²¹Environmental Protection Agency Standards

	<u>Tons per Year</u>
Nitrogen Oxides (NO_x)	100
Organic Oxides	100
Particulate Matter	100
Sulfur Oxides (SO_x)	100
Non-methane Hydrocarbons	100
Carbon Monoxide (CO)	1,000

California Air Resources Board Standards

	<u>Lbs. per Hour</u>
Nitrogen Oxides (NO_x)	15
Organic Oxides	15
Particulate Matter	15
Sulfur Oxides (SO_x)	15
Non-methane Hydrocarbons	15
Carbon Monoxide (CO)	150

A list of places with historic and archeological significance called the National Register of Historic Places is maintained by the Advisory Council of Historic Places. These sites are protected against adverse impact from future development projects. Many more sites have been nominated for inclusion in the register, and these sites too are protected.

In the State of California a process similar to that required by federal law has been adopted to protect sites of historic or archeological significance. The agency responsible for implementing this law is the State Office of Historical Preservation. There are also regional offices, one of which is the Archeological Research Unit, University of California, Riverside. To assess the impact of a project on historical and archeological sites, a developer in Desert Hot Springs should contact the Archeological Research Unit at the University of California, Riverside. Sometimes literature searches are sufficient to determine the extent of a project's impact on archeological or historic sites. However, in the City of Desert Hot Springs, there are four sites eligible for inclusion in the National Register of Historic Places, which implies there may be other sites of historic or archeological significance which have not yet been identified. Because of this, an archeological survey of the area would undoubtedly require some field work. This too could be performed by the regional Archeological Research Unit at Riverside.

To determine the location of the nearest regional historic and archeological agency, a State agency comparable to California's Office of Historical Preservation should be contacted. In states without their own historic agencies, the Federal Advisory Council on Historic Places will have authority over historic and archeological sites.

G. Public Health²² and Ecological Protection²³

Public health and ecological protection are regulated by state and regional public health agencies and by state fish and game agencies.

Public health agencies are generally concerned over the possibility that geothermal resources will contaminate public water supplies. Geothermal resources piped from their source to the location of utilization may require pipelines adjacent to municipal water supply pipelines. Existing pipelines have established right-of-ways through the city. It may be easier to share their right-of-way, from a regulatory standpoint, than it is to establish a separate right-of-way. Thus, the danger of contamination is created.

Health agencies are also concerned with the quality of products for human consumption. Several of the utilization options of geothermal resources may involve agricultural activities such as aquaculture and greenhouse vegetables. Geothermal fluids often contain minerals and chemicals which are harmful to health in significant quantities. Through biological processes, produce grown in contact with geothermal water may absorb harmful minerals and chemicals and may become contaminated. Even when the geothermal fluids have low quantities of harmful elements and are considered safe for human consumption, plants and animals cultured in contact with it may concentrate them to dangerous levels.

Agencies concerned with the well being of wildlife become involved with geothermal development because it has the potential for disturbing stream channels and the general hydrologic balance of an area which in turn would disturb wildlife. Any development project has the potential of disturbing stream channels sited on channel banks or if the activities require crossing the channel in any manner. Geothermal development located on stream banks may require channel crossing with roads and pipelines. Wildlife protection agencies discourage channel development or require that precautions are taken to minimize impacts on stream channels and the wildlife they may support.

The hydrology of an area may be finely balanced. Extracting geothermal fluids may disrupt this balance. Therefore, wildlife depending on the hydrological pattern of an area could be adversely impacted by geothermal development even though they have no direct contact with these resources. Wildlife protection agencies require a development which may alter hydrology supporting wildlife to supply the wildlife with water by some other means.

These agencies typically do not have permitting authority, but review the environmental impact reports and permit applications of other agencies with regard to water quality and wildlife impacts. Agencies that do have permitting power can deny permits to applicants who do not meet health and wildlife agency requirements.

In California these agencies are the Department of Health and the Department of Fish and Game. Local health departments are also involved. In states without health or wildlife protection agencies comparable Federal agencies like the EPA will provide public health and wildlife review.

In Desert Hot Springs the development projects proposed do not involve health and wildlife agencies in more than an advisory and review role. The water quality of the geothermal resource is relatively good in Desert Hot Springs, there are no continually running streams supporting wildlife -- the ecology of the area is adapted to exist with very little water, and geothermal distribution systems seem to be fairly simple at this stage of technology description.

H. Water Quality

Water quality is regulated by state water boards and agencies. In states without their own water quality agencies, the EPA has this responsibility.

There are several aspects of water quality associated with geothermal development. The general concerns of public health and wildlife protection agencies have been discussed previously. There are two very specific water quality issues associated with geothermal development which will be discussed in this section. These are drilling sumps and geothermal waste disposal.

During well drilling, a lubricant called drilling mud is used to prevent the drill bit from becoming stuck. After drilling this mud must be disposed of. The most common method of disposal is a drilling sump, or pit.

Drilling sumps are regulated by solid waste management boards. In California, the Solid Waste Management Board decides how drilling sumps should be managed to prevent the pollution of water supplies and the creation of health hazards. However, regional solid waste management boards are responsible for implementing their requirements. In some cases, the local public health agencies implement solid waste regulations.

In Desert Hot Springs, the County of Riverside's Solid Waste Management Facilities Agency implements the State's regulations. The developer must submit an application to this agency, the agency reviews it and then sends it to the State Solid Waste Management Board for review. After review, the permit requirements are written by the local solid waste agency, who incorporates the comments of the State agency, and given to the applicant.

To acquire permit forms and detailed information local health or solid waste management agencies should be contacted.²⁴

The second aspect of water quality deals with the geothermal water itself. Without adequate disposal, geothermal water may contact the source of drinking or potable water in an area, contaminating it. There are several ways geothermal waste water may be disposed of after use.

- 1) Evaporation Ponds
- 2) Percolation Basins
- 3) ReInjection
- 4) Municipal waste water treatment facilities

Evaporation ponds may require large areas of land depending on the quantity of water discharged. These ponds must be lined preventing seepage into the soil. The quality of lining is dependent on the possibility of contaminating potable aquifers. If the pond is not thought to be located over a fresh water aquifer, a lining of bentonite drilling clay may be acceptable. If potable water underlies the pond, a more impermeable substance like plastic will be required. For odor control the Biological Oxygen Demand (BOD) will be limited to 40 mg/l and there must be assurance that algae growth will be limited. The salts left behind must be disposed of in an industrial waste disposal site.

Percolation basins allow liquid wastes to sink through the soil. Particulates are filtered from the water by entrapment with the liquid eventually reaching underground aquifers. However, salinity is not removed from the water in this fashion, and saline water will remain saline even when it reaches underground aquifers. Enough saline water percolating into an underground aquifer will eventually increase the salinity of the aquifer. Only water of quality equal to that in the underground aquifers will be allowed to be disposed of in percolation basins, unless it can be proven to the Water Quality Control Board (WQCB) that the water is sufficiently cleansed by passing through the soil before it reaches underground water.

Reinjection is another method of wastewater disposal involving use of a well, down which wastewater is pumped into porous strata. Again, the water to be reinjected must be of quality equal to that in the aquifer into which it is being pumped. When disposal aquifers are near the surface, as in Desert Hot Springs, the fluid will escape to the surface through small fissures, if the pressure of reinjection is not controlled. Reinjection pressures are carefully regulated by the Division of Oil and Gas, whose regulations were discussed earlier.

It may be possible in some areas to dispose of the geothermal water through the municipal sewage treatment facility. State solid waste agencies would in this case have to approve any expansion of the existing sewage treatment facility to accommodate geothermal waste water. If required, they would assess a new waste treatment facility for its compliance with the general plan of the area. The capacity of all waste management facilities must comply with the area's General Plan.

Agencies responsible for regulating waste water disposal in California are the State Water Resources Control Board, and at the sub-state level regional water quality control boards. The policy and regulatory decisions are made by the State agency and are implemented by the regional agencies. The state agency reviews wastewater discharge permits submitted to regional agencies by project applicants, and make recommendations which the regional agencies incorporate into the permit requirements.

The basic policy of water quality agencies is one of non-degradation. This means that the discharge of water from any facility shall not degrade, or lower the quality of the water into which it is discharged. In agency review of waste discharge permits, it is ascertained whether the proposed discharge plan will dispose of the water without degrading the quality of the surrounding water bodies; the requirements imposed on the applicant ensure that degradation will not occur as a result of project activities.

In Desert Hot Springs the agency responsible for issuing waste discharge permits is the Regional Water Quality Control Board, Region 7.²⁵ This agency recently prohibited the discharge of geothermal water into the municipal water treatment facility. High levels of total dissolved solids, fluoride chloride and sulfates in the geothermal water were adversely impacting or degrading the water in the potable water aquifer into which all wastewater was disposed after treatment via percolation ponds. The treatment process does not remove the salinity from the water. Health spas in the City tend to recycle their geothermal water so there is very little to dispose of. However, projects unable to recycle their water or who find disposal less expensive than recycling will have to satisfy the Water Quality Control Board and the State Water Resources Control Board that their disposal plan will not degrade the water supply of the area in any way.

Developers may obtain more information on the types of requirements the water quality control boards demand and information on how to file for a permit of waste discharge by contacting the regional water quality control board in their area.

1. Local Government's Ability to Manage Geothermal Resource Utilization

Having decided that indigenous geothermal resources may effectively be used in a community, the local government must assess its policies towards and ability to manage either or both the resource and its uses. There are any number of possible local government regulatory schemes appropriate for geothermal resources. They may be conceptualized on a continuum ranging from no regulation to total regulation. It may be argued that no regulation is impractical based on the evolving societal concern with environmental quality. Therefore, at a minimum, local government would undoubtedly be concerned with potential environmental effects due to the development and use of geothermal resources, and, as a consequence, would impose a minimum set of regulations to insure that potential impacts are mitigated. One mechanism for environmental regulation is nuisance regulations commonly found in local zoning ordinances. These nuisance regulations are based on performance standards specifying, for example, the quantity and quality of air pollutants which may be emitted, maximum noise levels, the amount of glare and light permitted to cross project boundaries at night, and other similar restrictions. Therefore, the lower bound of the regulatory continuum, from a pragmatic perspective is nuisance regulation.

Analogously, total regulation of the geothermal resources is not practical even were it possible. The fundamental problem is the detailed level of information which would be required. The complete character of the geothermal resource would have to be known; no one has this information at present, and it is unlikely that such information could be obtained because geothermal resources are too variable, even within the same anomaly.

Local government must make a policy decision whether the purpose of the regulation is 1) to control the surface manifestations, that is, the land use associated with the development of geothermal resources, or 2) whether the concern is with the resource itself. If the concern is solely with surface manifestations, the regulatory scheme need not address itself to the condition of the resource itself. In this case, decisions on use of the resource remain entirely with developers of the resource. If the concern is with the resource itself, the regulatory structure will of necessity take a different form which is discussed below. In either case, however, the local government must develop and implement a regulatory scheme which not only meets its objectives, but also is legally feasible and economically efficient. Legal feasibility means that the local government must have the power to impose the regulations; economic efficiency is the criteria that the benefits of regulation must exceed the costs of that regulation. Regulation concerned with the resource itself set the practical upper limit on regulation. In the discussion which follows, it is assumed that the regulations implemented will include performance standards of control nuisances which may accompany exploitation.

If the object of the regulatory scheme is to control the potential impacts of exploitation on other uses of the land, then it may be argued that an existing structure of general plans and zoning ordinances is sufficient to provide the necessary regulation. The local government could create a geo-

thermal zone which would overlay the boundaries of the resource, to the extent that they are known, within which any type of geothermal development would be allowed as long as the performance standards for the zone were met. Or, the zoning ordinance could require each proposed use of geothermal resources be subject to a conditional use permit process in which local government reviews individual applications on their own merit. Here, the developer files an application describing his proposed use, the local government reviews it, holds public hearings, and ultimately makes a decision to issue a permit or deny the application. The permit may impose additional conditions to be met beyond the performance standards for environmental effects. Examples of these conditions are restrictions on the hours of operation, posting of bonds, etc. There are a number of possible regulatory schemes which would provide varying amounts of control over the use of geothermal resources as they impact surface uses. There are a number of reasons why local government may be concerned with the geothermal resource itself and not just the surface manifestations of its use. One reason, for example, for being concerned with the reservoir itself is that increased utilization of an identified resource may impact existing uses of the resource, such as natural geothermal springs used for therapeutic purposes and forming the basis of a tourist economy. Increased utilization of these resources could significantly impact the preexisting uses, thereby disrupting the local economy. If the policy object of local government is to control the resource itself, the most efficient method is to obtain absolute control of the resource. Although this is theoretically desirable, given the unsettled nature of laws defining exactly who owns geothermal resources, it is highly unlikely that a local government will be able to acquire such broad rights to the resource. Therefore, a regulatory scheme which seeks to control the geothermal resource itself must be implemented within the context of the existing structure of property rights. It is clear that local government has the power to control the drilling of geothermal wells. It has not been judicially established that local government has the right to control operation of the wells, nor that they do not have the right. The question has not been adjudicated. Regardless, through its power to control well drilling, both the number of wells and their location, local government may, in fact, acquire control over the resource. This may be accomplished by requiring that a permit be obtained for drilling wells, and that information be provided to the local government on the mass flow rate and the temperature profile of the brine extracted. The developer makes application to the local government to drill a number of wells and extract a given quantity of fluid sufficient to implement his proposed use. The quantity restriction is a condition imposed on the granting of the permit to drill. With each succeeding application, the local government must make a judgment whether or not that additional use will impact the overall characteristics of the reservoir. If it does not, then the permit may be granted as long as any other conditions are met; if it does, then the local government has the power to deny the permit to drill. Thus, the local government uses its right to control development on the surface of the land to effectively exercise control over the geothermal reservoir.

To implement a regulatory scheme such as has been described above requires local government to collect data on all existing uses, monitor closely, and carefully evaluate proposed uses to assess potential impacts on the reservoir areas of great uncertainty. Geothermal reservoirs may, and

often do, change from well to well. Even with careful data collection, monitoring, and evaluation there is no guarantee that the reservoir will not degrade. These actions should, however, provide forewarning of changes taking place within the reservoir. The cost of monitoring and information reporting may be passed directly to the developer through a permit and use fee tied to the volumetric extraction of the geothermal resource.

The City of Desert Hot Springs, California, has an economic base largely dependent upon tourism, people coming to the city to enjoy the climate and the perceived therapeutic value of the geothermal spas. A major concern of the City is to ensure that additional uses of the resource do not affect the tourism economy based on the availability of geothermal water. To protect this industry, local government must exercise control over the resource itself. Conservation of the resource is paramount, both quantity and temperature. To achieve this goal, it may be necessary to require reinjection of geothermal fluids. There may have to be a centralized reinjection system. Costs to develop and operate such a system may be passed on to resource users through a volumetric disposal fee imposed as part of the permit to drill geothermal wells. Since the City boundaries do not totally encompass the reservoir, any resource management scheme would have to be jointly implemented by the City and the County of Riverside. The city has not yet considered what policy will be adopted, however, a management scheme based on these concepts will be required to enhance conservation of the resource.

J. Conclusions

The regulations discussed here cover only major regulatory issues, and represent the requirements of California more than those of other states. However, these issues are acknowledged by all states and the Federal government as issues important to the health, safety and welfare of the general public. Because of this universality, the regulatory issues discussed here are generally applicable to all states regarding non-electric geothermal development. (See Reference 26 for regulations applicable in other states.)

The generality of the issues extends its applicability, however, it detracts from the usefulness of this document as a complete guide to developers. The actual development of a geothermal system may involve agencies and requirements not included specifically, however, these additional agency requirements are not expected to exceed the major issues discussed here. The regulatory requirements delineated for the City of Desert Hot Springs could only be more complete by giving each responsible agency more information on the development projects. While it is acknowledged that the discussion of regulatory issues in this section is incomplete with regard to all regulatory procedures for non-electric geothermal development, all major issue areas are included, and further regulatory definition can not be achieved without additional technological description.

In summary, it is vital that local government clearly define its objectives before making decisions on regulation of geothermal resources. The benefits of any management scheme must outweigh the costs of that regulation, a concept which encompasses an infinite number of regulatory schemes. The

details of any regulatory scheme may be investigated after the local government policy has been determined. Existing land use plans and zoning ordinances provide interim control while the policy is being developed. Thus, the evaluation of potential uses of an indigenous geothermal resource must consider how it will be managed and to what end.

VI. Siting Considerations

A. Introduction

The first step in the placement of a geothermal project is to identify those site-dependent factors which would limit the scope of the enterprise to be undertaken. Once the range of feasible applications is established, the next phase is to look at individual potential applications which will fit within the given constraints. The designer can then evaluate the individual geothermal use systems (i.e., cooling and heating) for each project and make a logical determination of the optimal site for a given application. The project developers should obtain the services of various scientific experts such as a hydrologist and a geologist. They can identify any naturally occurring physical items which may impact or be impacted by the project. It will also be necessary to deal with local officials and historical experts in outlining any man-made factors which may affect the siting of a project. This analysis should be coordinated by the developer with an evaluation of the legal, economic, institutional, and environmental aspects of the proposed applications. It would be best to coordinate these efforts as early as possible so that any duplication is minimized. The methodology which follows should enable the geothermal project designer to proceed in a systematic fashion so that the result of each siting step is based on the information developed in the previous step. The siting steps are outlined as to what information is needed, where it should be obtained, how it should be utilized, and who would be the appropriate person to perform the task. If all the phases are followed the developers should be able to site an application in the shortest possible time, based upon a logical and reviewable record.

B. Characterization of the Resource

As a first step, the geothermal resource must be delineated both with respect to areal extent and heat content. The reason for doing this is to identify the types of applications that might be feasible in a given area and also to indicate the approximate location of the project. This can be performed by a qualified hydrologist. He should evaluate existing well records, talk to officials of the local water district, and make any necessary pump test measurements. (Pump tests give valuable information on the capacity of the reservoir and on the rate at which water is transmitted.) Generally, most low temperature applications (i.e., direct uses such as an aquaculture business) require water temperatures of at least 80°F - 100°F. Therefore, the hydrologist should map the range of the geothermal resource with these temperatures. The hydrologist should also identify resources in the 125°F - 150°F range if water heating and space heating options are being considered. Furthermore, if cooling or refrigeration is desired, temperatures of at least 250°F (and preferably higher) should be identified. If temperatures of the resource are less than this these uses should not be considered unless a hybrid energy system (e.g., fossil fuel or solar augmented systems) is used in conjunction with geothermal energy.

The yield of the aquifer is also an important factor in determining the feasibility of a given project. For instance, if the estimated safe yield is large, a district space conditioning network might be considered. For more limited safe yields, as in the case of Desert Hot Springs, the aquifer might only support the space heating of an industrial complex, hospital, or other similar project. The hydrologist should be able to evaluate the yield. Local water districts, local private drilling and pump companies, and present users should have most of the necessary information. Published data and well tests should provide valuable input as well. The hydrologist should review local records of precipitation, runoff, and evaporation to get some insight into the water entering the aquifer. He will also wish to evaluate outflow, sewage, evaporation, and well water removal records in order to identify any items of water depletion. He will then be able to estimate the yield of the geothermal aquifer.

It may be desirable to place a project in an area which is suitable for recharging the geothermal aquifer. The decision of whether or not to recharge is very important in terms of geothermal development. Factors entering into this are the characteristics of the geothermal aquifer and the presence of any seismic activity in the area. Recharging spent geothermal water will tend to raise the yield of the aquifer, mitigate any above ground disposal problems, and will minimize any subsidence potential. However, it may be found that the sum of the projected water removal rate plus quantities currently removed for other purposes does not exceed the natural rate of water entering the aquifer. Then recharging may not be necessary. Also, if there is no current subsidence or seismic activity in the area, the necessity to recharge is minimized. The hydrologist in conjunction with a geologist should be able to make this determination. The attitudes of the local sewage or water district will also be important in making this decision since they may regulate the quality of the water that is added to the local sewage system.

Another important water related siting criteria which can be identified by the hydrologist is the presence of any potable aquifers which are in the vicinity of the geothermal aquifer. A potential geothermal use project should be placed in a location that will minimize any potential contamination of potable aquifers should an accident occur.

C. Geologic Factors

Non-geothermal geologic factors which can influence the siting of a project include the presence of stream or river beds. These should be avoided so that fragile and complex ecosystems are not adversely affected, and also so that channel flows are not abruptly altered. Such features can be identified by a geologist who can perform the necessary literature searches and on-site surveys. Other items which should be avoided by a project are unstable foundation conditions, landslide prone areas, and potentially active seismic faults. These items can also be identified by the geologist. Avoiding such features will decrease the probability of creating additional seismic activity when water is taken from the ground. Any subsidence or landslide potential in the area will also be minimized. Also, if one of these phenomena were to occur it would not be prudent to site a project in a area where it is likely to be adversely impacted.

Once all the previously outlined factors have been identified, the geothermal designer should be able to realistically estimate the type of project that could best utilize the available resources. He will also have an educated insight as to the approximate areas that would be best for siting with respect to the nature of the resource and geological characteristics.

D. Man-made Characteristics

Concurrent with natural resource delineation, any relevant man-made characteristics which may further limit project placement should also be identified. Such characteristics include sites of historical or archeological significance as well as any zoning ordinances or restrictions in the vicinity of the geothermal resource. Historical or archeological sites can be identified by a state archeologist. He would perform a literature search and, if necessary, conduct a survey of the proposed project site. If a site of historical or archeological importance will be adversely affected by a project, it may be necessary to comply with the historical provisions of the California Environmental Quality Act.* This could result in time consuming legal entanglements. Therefore, it is best to site a project so as to minimize any such impacts. Existing residential and commercial areas, congested sections, and main thoroughfares in the vicinity of the project should also be located. The purpose of this is to identify those areas where constructing a new project might cause noticeable conflicts with businesses and residential areas. Such areas should be avoided if possible so that the project is as inobtrusive as possible.

The size of each proposed application is another consideration. As more land is needed for an application, the probability increases that placement, zoning, and archeological site issues will present potential obstacles. Conversations with local planners responsible for zoning ordinances and other important local officials should provide beneficial input as to which factors are most sensitive to project placement. These meetings which should also include the geologist, the archeologist, and the hydrologist may also provide information concerning potential mitigating actions should a potential project threaten to intrude upon an important physical item.

E. Individual Project Applications

Once the man-made factors have been identified, the project designers can concentrate on the individual potential applications which fall within the bounds of the already defined physical characteristics of the resource and the surrounding vicinity. In evaluating each specific application it is perhaps best for the designers to first differentiate between those applications which have stringent temperature constraints (such as cooling, refrigeration, or multiple uses) and those projects which do not (such as space heating only or direct uses). Projects falling into the latter category will have more flexibility in siting,

*See Section V for a discussion of the requirements for complying with the environmental and historical aspects of the California Environmental Quality Act when building a geothermal development project.

while those in the former may have to be placed adjacent to the hottest sources, or else the hot resource may be piped to the user. In cases when the user is placed some distance from its source, the chances of disrupting residents and businesses during construction are higher, since long sections of pipe may be needed in addition to typical construction procedures. Additionally, during accident conditions, large areas could be impacted, especially if cooling systems which use toxic ammonia are implemented. In the case of Desert Hot Springs, any project with air conditioning would have to be located very close to the hottest available resource. Since the hottest resource there is already marginal, any additional temperature losses caused by piping would eliminate cooling as a feasible geothermal use. The decision of whether or not to recharge the aquifer also may affect siting since, if recharging is decided upon, additional disruptive piping may be required. The designers should consult with the previously indicated local officials and scientific specialists in deciding on the optimal site.

If a geothermal use is projected for an already existing facility, some siting problems may be alleviated. A facility may be chosen adjacent to the hottest resources and/or near the optimal recharge area if necessary. Zoning ordinances should be no problem in such a case, and any impacts on sites of historical or archeological importance would be minimized. However, if the area is built up there could be bothersome intrusions to adjacent businesses and homes during retrofitting installations and well drilling. Future facilities which do not currently exist can be planned with geothermal use in mind.

In general, recent sites of construction or those with centralized systems (e.g., heating or air conditioning) lend themselves more readily to retrofit. Additionally, in any installation an attempt should be made to review the load variation and to maximize the utilization rate of the system. This may necessitate the coupling of two or more load centers to make the operation an economically viable undertaking.

F. Conclusions

In conclusion, there appear to be a set of driving factors which when identified should enable the developer to choose the optimal site for locating geothermal projects. The important drivers include a delineation of the resource, geologic characteristics of the area, the presence of zoning constraints, and sites of historical or archeological significance. The drivers which relate to the projects themselves are whether or not the proposed facility currently exists, potential temperature constraints, distance from the source, size of the tract needed, and the presence of congested areas. It may be possible to place these drivers into a matrix for several proposed applications so that they may be easily compared when making the placement decision. In order to adequately perform this analysis it is important to obtain the services of a hydrologist, an archeologist, and a geologist. It will also be necessary to meet with local government officials and planners in the early phases of the project so that it may proceed in an efficient manner. Appendix 6 presents an example of how this methodology was actually applied to the City of Desert Hot Springs, California.

VII. Technology Status

It is difficult to make a general assessment of the technology status of a generic geothermal project due to the many variables involved and myriad of possible applications. However, utilizing the processes detailed in the previous section, it is possible to identify specific potential applications consistent with a given set of resource properties, community needs, and various other identified constraints. Then, once the number of potential applications have been reduced, the technology status can be reasonably assessed. Thus, the recommended approach will be to first screen the various applications based upon the available geothermal resource data. Then further screening can be performed consistent with community needs, siting, and other pertinent constraints. The last step will be to evaluate the technologies currently available to supply the needs of the final selected system(s), and identify potential manufacturers, specifications, and price ranges for specific components in a geothermal system.

A. Geothermal Resource Screening Step

The first logical screening step is to focus attention on the results of the Geothermal Resource Investigation (Section II). This step will identify the specific temperature range, chemical properties, and size of the resource. The temperature limitations of the resource are a major factor in reducing the number of potential applications. For example, if only low temperature geothermal fluid is available (for the purposes of non-electric applications addressed by this report, low temperature is assumed to be less than 125°F), then the potential applications would be aimed primarily at direct uses, such as spa pools, aquaculture, soil warming and irrigation. Hence, these applications would not require a technological assessment of heat exchangers. For medium temperature resources (approximately 125°-200°F), additional possible applications are introduced in the areas of space and hot water heating, animal husbandry, and some low temperature agriculture drying processes. For temperatures above 200°F, the possible applications increase greatly: space cooling and refrigeration, fresh water distillation, food canning, various evaporation and crystallization processes, high rate agriculture drying, and many other process heat applications become feasible. Identifying the available temperature isotherms (isothermal boundaries) will also aid in siting considerations as discussed in Section VI.

In the case of Desert Hot Springs, the maximum known temperature of the resource is 208°F. However, this temperature is not generally encountered. More typical high-end well temperatures are in the range of 150°-200°F. From a survey made in 1975 of some 219 geothermal wells in Desert Hot Springs,²⁷ approximately 80 percent had temperatures less than 140°F and only 6 percent were greater than 180°F. Thus, the available resource temperature at Desert Hot Springs precluded the feasibility of space cooling or refrigeration applications. It might be added here that the above data were based on shallow wells (100-800 feet), and it may be possible to encounter higher temperatures at greater depths which could change this conclusion.

The chemical analysis of the water sample will determine whether the particular application can utilize the fluid directly, such as in various agriculture or aquaculture uses, or whether the heat must first be extracted from the fluid by means of heat exchangers before it can be utilized. This heat exchange process could take place aboveground at the geothermal site or by means of a downhole heat exchanger in the source well. There are also cases where this latter alternative would be recommended for indirect applications, such as for locations where the extraction of geothermal fluid might cause seismic disturbances or where the fluid is found to be too corrosive for compatibility with other system components.

In cases where the geothermal fluid does come in direct contact with the general system components such as piping, valves, pumps, and heat exchangers (where required), the results of the chemical analysis will affect the final material selection. In situations where the fluid is highly corrosive, special materials will have to be specified for these components, tailored to the particular resource properties and temperature. For example, if the resource temperatures were under 200°F but highly corrosive, a fiberglass-type pipe might be called for--similar to that used with hot chemicals. Numerous manufacturers, who market a complete line of fiberglass pipe and fittings, are identified in Appendix 7. In addition to this specific area, Appendix 7 also includes a general listing of components and their manufacturers, along with price ranges and some specific material information that should be useful in matching the resource to the component.

In the case of Desert Hot Springs, the chemical analysis showed that the geothermal fluid was of very high quality (actually used as potable water in some areas of the city until mid-1977) and would therefore require few, if any, special considerations with regard to component compatibility. In talking to residents there who have been utilizing geothermal fluid for many years, the only material compatibility problem mentioned was that of reduced pump life, and that was primarily attributed to quality control problems with the new pumps. The new replacement pumps appear to fail much more rapidly than the original units.

The final phase of the resource investigation would identify the safe yield of the aquifer. The yield of the aquifer directly impacts the size of the proposed geothermal application. If the estimated safe yield of the resource were quite large, then a full range of applications could be considered from small private ventures to possibly a city-wide space conditioning network. If the estimated safe yield were very limited, then the selection of a feasible project might be confined to spa use, a specified private venture, or other limited use. In the case of the City of Desert Hot Springs, the estimated safe yield was adequate to support a medium-sized industrial complex, but insufficient to support a major space heating network for the entire city. Another possibility, however, was a limited heating network for selected city facilities.

B. Additional Screening Steps

Once the first order screening has been completed based upon the results of the geothermal resource investigation in Section II, then additional screening can be performed based upon information gained through the community needs assessment (Section III), market assessment (Section IV), regulatory and environmental constraints (Section V), and various siting considerations (Section VI). While the purpose of the initial screening was to identify how the resource could be utilized based upon its physical properties and limitations, this latter screening will scrutinize the remaining applications to determine which are desirable from a standpoint of the community needs, desires, and physical makeup. That is, while a particular project may be technically feasible for a given geothermal resource (such as a district space conditioning network), it makes no sense to perform a detailed technological assessment of the project if the people in the community would not support such a venture. Thus, the criteria in each of the above areas (Sections III-VI) can be evaluated either separately or collectively to further screen the acceptable candidates for a proposed geothermal application.

The City of Desert Hot Springs offers an example of how community needs and desires can impact the selection of an acceptable geothermal project. Based upon the results of early, but limited, community surveying and interviews, it was clear that the residents of Desert Hot Springs viewed the city as primarily a resort and retirement community. These feelings eliminated such potential applications as heavy industrial or agriculture uses, and favored instead more aesthetic applications (greenhouses) or possibly the replacement of fossil fuel with a cheaper energy source to aid the fixed-income oriented population.

C. Discussion of Low Technology Items

Once the screening has been completed and the final application(s) selected, a simplified schematic of the geothermal system can be constructed to facilitate the identification of the general component needs of the system. For the purposes of this report the technology assessment discussion will be divided into two subsections: low technology items (e.g., piping, valves, pumps and other components), and high technology items (i.e., geothermal-powered air conditioning/refrigeration systems and the organic Rankine heat engine used to provide mechanical shaft power).

As a general rule, most of the low technology items for nonelectric geothermal applications are considered to be current state-of-the-art. For certain special applications (particularly with high salinity brines), research is currently in progress to develop new or improved components, such as heat exchangers, that will perform better than present models under adverse operating conditions. However, for the purposes of this report, the discussion will be limited to commercially available components and systems.

The actual list of manufacturers for the various categories of low technology items is contained in Appendix 7. Also included in the listing are general remarks pertaining to each component and typical component costs. Any references to a specific manufacturer are not

meant to indicate an endorsement of that manufacturer over another company marketing a similar product. The list is intended as a representative guide to available equipment and is by no means considered to be a comprehensive survey of the equipment supply field. The costs given were obtained from vendor quotes or standard estimating data and are expressed in 1978 dollars.

In purchasing any geothermal equipment, it is highly recommended that suppliers be used who are experienced with the requirements and needs of the geothermal industry. This can eliminate many potential hardware/resource interface problems. Also, as a general rule, copper, bronze and zinc should be avoided in areas that come in direct contact with the geothermal fluid because of the corrosive effect on these materials of hydrogen sulfide (H_2S). In addition, all copper components of electric motors must be coated with epoxy for protection against the H_2S in the atmosphere.

D. Discussion of High Technology Items

1.0 General Discussion

For the purposes of this report, the high technology items are defined to be those geothermal-powered systems that are purchased basically as a self-contained unit rather than assembled from components such as listed in Section VII C. Specifically, the two items of interest are the geothermal-powered absorption chillers (used for either air conditioning or refrigeration) and the geothermal-powered organic Rankine heat engine (used to produce usable shaft power for pumping, etc.).

As indicated by the high technology designation, neither item could be purchased with the same ease that the low technology items could be. While both systems utilize current technology and can be purchased from numerous manufacturers today (Trane Air Conditioning, York Division Borg-Warner, and Arkla Industries Incorporated, to name three absorption chiller manufacturers; and Kinetics Incorporated, Mechanical Technology Inc., and Barber-Nichols Engineering Company to name three organic Rankine engine manufacturers), neither system has achieved a true off-the-shelf status. There are two basic reasons for this. First, while interest has burgeoned in recent years in low temperature heat utilization areas (e.g., geothermal, solar and industrial waste heat), the actual hardware applications have been much less evident. Until these industries truly commit to the field projects, there will be no stimulus to motivate manufacturers into a high production mode. Second and of particular interest to geothermal applications, the inherent problems of matching the particular resource characteristics with the hardware may prove to be a deterrent to off-the-shelf use for the foreseeable future.

2.0 Absorption Chillers

The most common chiller system used with low temperature heat sources (flat plate solar collectors, waste heat or geothermal) is the absorption-type unit. Considerable research has been done and is currently being performed in the area of geothermal absorption refrigeration. One representative example of work in this area is the completed ERDA study by Aerojet Energy Conversion Company, "Geothermal Absorption Refrigeration For Food Processing Industries."³⁵

Figure 5 shows a simplified schematic for an absorption chiller system. Starting at the generator, the hot geothermal fluid is used to heat a mixture of the refrigerant and absorbent (under pressure) until the refrigerant (with a lower boiling point) is driven off in vapor form. The vapor is then condensed back to a liquid at constant pressure, with the use of cooling water. Next, the liquid passes through a pressure reducing valve into the evaporator, where it vaporizes and causes the cooling effect. The low pressure vapor is then returned to the absorber where it is absorbed by the concentrated absorbent solution. Finally, the mixture of refrigerant and absorbent is pumped back to the generator, under pressure, to complete the cycle.

Absorption-type chillers are not a new invention by any means. Natural gas fired units were used in Servel refrigerators over 40 years ago. What is new is the low temperature application that has blossomed in the 1970's with the emphasis on solar research. Geothermal applications of the absorption chiller have also been around for a number of years. One notable example is the 130-ton lithium bromide absorption unit installed in the 100-room Tourist Hotel in Rotorua, New Zealand in 1969.²⁸ The geothermal inlet water temperature for this application was 250°F.

The absorption chiller is tailored to the range of the inlet heat source by the selection of the refrigerant and absorbent pair. While the mathematical combinations of chemical pairs number over 100, only a couple warrant serious consideration for inlet temperatures in the neighborhood of 200°F. These are the lithium bromide-water combination in which the water acts as the refrigerant, and the ammonia-water combination in which the water acts as the absorbent. While both pairs are technically proven and found in the field today, the lithium bromide type is much more common and preferred for the following reasons: it is less complex (the ammonia-water system requires an extra stage to separate the water vapor from the ammonia vapor because their boiling points are too close together), cheaper and easier to maintain. Also in the event of an accident, lithium bromide is as harmless as table salt in contrast to the toxic nature of ammonia.

For applications that require freezing temperatures, only the ammonia-water unit could be used, since water is the refrigerant in the lithium bromide-water system. However, where only relatively low or medium temperature geothermal fluid is available ($\leq 200^\circ\text{F}$), as in the case of Desert Hot Springs resource temperatures, the use of absorption chillers for even air conditioning uses failed to be economically viable (although technically feasible).

Figure 5
Absorption Chiller System Schematic

Figure 6 demonstrates how the performance of a lithium bromide unit varies with decreasing inlet water temperature. Note that while the unit performs at its rated capacity at 240°F, it drops to only 50% of its rated capacity at 200°F and 17% at 170°F (the lower operating limit). Hence, if an installation required a cooling capacity of 50 tons, a 100-ton unit would be required if the available inlet water temperature were 200°F. Figure 7 shows the effect of economies of scale as a function of increasing machine size. As would be expected, the cost per ton decreases dramatically as the units increase in size. For larger units, the cost per ton continues to decrease but at a much slower rate. For a 1000-ton unit, the installed cost would be down to approximately \$95 per ton.

3.0 Organic Rankine Heat Engines

The other high technology item considered here is the organic Rankine engine (ORE). As mentioned earlier, the ORE is a mechanical heat engine, powered by the hot geothermal fluid and capable of providing shaft power for mechanical work. The shaft power could be utilized for powering a pump or could be coupled with a conventional vapor compression unit (in place of the electric motor) to provide air conditioning or refrigeration.

Figure 8 depicts a simplified schematic for an ORE. The geothermal fluid enters the boiler and vaporizes the organic working fluid. The pressurized vapor then expands through a turbine arrangement (expander) and produces usable shaft power. Next, the low pressure vapor is condensed with the aid of cooling water. Finally, the liquid is pumped back to the boiler, under pressure, to complete the cycle.

As in the case of the absorption chillers, the real question with ORE units today in low temperature applications is not the technical feasibility but the economic feasibility. While recent years have seen a heightened interest in ORE production and research, the units have still not reached a true production status level to cause a major breakthrough in the production cost. However, a recent article in Geothermal Energy Magazine indicated that Kinetics Corporation of Sarasota, Florida was ready to begin mass production of a 10 kW Freon Rankine Cycle power generating unit.²⁹ The cost for the complete unit, skid-mounted and ready for hot inlet and cooling water hookup, is \$12,500 or \$1250 per kW.

In order to compare this cost with the cost of the absorption chiller units mentioned earlier, two points must be considered. First, the cost of \$1250 per kW for the ORE does not include the cost of the compressor and control equipment. In a retrofit situation, it should be possible to remove the motor in the existing vapor compression unit and utilize the remaining equipment. Second, in converting the 10 kW of shaft power into cooling energy with the vapor compression unit, a coefficient of performance (COP) of around 2.5 is possible. Hence, for

FIGURE 6
AVERAGE ABSORPTION CHILLER PERFORMANCE

* DATA TAKEN FROM TECHNICAL BROCHURES AND MEMORANDUMS OF TRANE AIR CONDITIONING AND YORK DIVISION OF BORG-WARNER CORPORATION.

FIGURE 7

AVERAGE ABSORPTION CHILLER COSTS

* DATA TAKEN FROM TECHNICAL BROCHURES AND MEMORANDUMS OF TRANE AIR CONDITIONING YORK DIVISION OF BORG-WARNER CORPORATION AND ARKLA INDUSTRIES, INC.

Figure 8

Organic Rankine System Schematic

the retrofit situation and an assumed COP of 2.5, this results in an equivalent air conditioning cost with the ORE of \$1758 per ton versus \$1050 per ton for an equivalent sized absorption chiller unit. Naturally the cost would be higher without the benefit of retrofitting.

In summary, Table 9 presents a subjective comparison of the advantages and disadvantages of each of the above mentioned systems as used to provide air conditioning and/or refrigeration. Where refrigeration is not required, the Lithium Bromide system appears to be the best choice for straight air conditioning.

E. Examples of Geothermal Systems in Operation

The foregoing discussion has dealt with the technology currently available for general geothermal applications. In the way of some specific and more concrete examples, Table 10 shows some of the varied applications in which geothermal energy is currently being utilized in the United States. The listing is by no means complete, but is intended to show some representative areas of interest.

TABLE 9

**SUBJECTIVE EVALUATION OF VARIOUS GEOTHERMAL-POWERED
AIR CONDITIONING AND REFRIGERATION OPTIONS**

	Lithium Bromide- Water System	Ammonia - Water System	Organic Rankine Engine
Production Status (State-of-the-art)	Yes	Yes	Questionable
Cost	Least Expensive	Less Expensive	Most Expensive
Complexity	Least Complex	Less Complex	Most Complex
Freezing Capability	No	Yes*	Yes*
Safety	Very Safe	Potential Haz- ards	Very Safe
Reliability/Maintainability	High	Medium	Unknown

*Yes if the geothermal resource temperature is at least 200°F, and preferably greater.

TABLE 10

EXAMPLES OF COMMERICAL AND INDUSTRIAL GEOTHERMAL APPLICATIONS

<u>AREA</u>	<u>COMPANY OR COMMUNITY</u>
Greenhouse Tomatoes	Oregon Desert Farms, Inc., Lakeview, Oregon
Dairy (Milk Pasteurization)	Medo-Bel Creamery, Klamath Falls, Oregon
Aquaculture (Catfish)	Fish Breeders of Idaho, Inc., Buhl, Idaho
Aquaculture and Agriculture R&D Experiments	Idaho National Engineering Laboratory, Raft River Geothermal Test Site, Idaho
Aquaculture (Malaysian Prawn)	Oregon Institute of Technology, Klamath Falls, Oregon
Water and Space Heating (District)	City of Boise, Boise, Idaho
Water and Space Heating (Hospital)	Presbyterian Inter-Community Hospital, Klamath Falls, Oregon
Spa Use (Motels)	City of Desert Hot Springs, Desert Hot Springs, California
Water and Space Heating (O.I.T. Campus)	Oregon Institute of Technology, Klamath Falls, Oregon
Water and Space Heating and Spa (Motels)	City of White Sulfur Springs, White Sulfur Springs, Montana

VII. Project Funding Alternatives

A. Government Funding

Federal and state government agencies responsible for energy development and regulations make funding available to private individuals and developers who propose projects which may assist the agencies in realizing their chartered goals. Funding is a strong incentive for private individuals to become involved in and support governmental programs. A project which can visibly benefit society is a good candidate for government support. The development of geothermal resources in Desert Hot Springs may be a project of this type. It may decrease the energy costs of heating homes, replace fuels such as oil and gas which are becoming scarce, and attract new business to the area with the availability of low-cost geothermal energy. By supporting such projects, government agencies can not only attain their goals, but can maximize the benefits which accrue to society in general.

Persons or entities seeking funding (partial or full) for energy development projects must apply to the appropriate governmental agencies. The intent of this analysis is to inform those interested in developing geothermal energy of funding programs which may be available to them.

Various government agencies were contacted in order to identify agency interest and ability to support geothermal development projects. Another purpose for making these contacts was to gain some insight into the application and funding processes. The funding agencies contacted included:

- U. S. Department of Energy (DOE)
- U. S. Economic Development Administration (EDA)
- U. S. Housing and Urban Development Agency (HUD)
- U. S. Farmers Home Administration (FmHA)
- California Energy Commission (CEC)

These agencies may be willing to support various or all parts of geothermally related development projects. However, due to limited sources of funding these agencies typically award grants or loans on a competitive basis.

Information on the various funding programs is presented in Tables 11 through 19. Only those programs applicable to geothermal development are included. The agencies contacted represent a cross section of agencies with funding available, but do not comprise a complete list. The programs are separated into three categories: research and development, governmental financial assistance, and private capital funding. The following information is delineated for each addressed program:

- Program title and purpose
- Application period
- Application process
- Extent of funds available
- Eligibility of applicants and projects
- Financing options
- Factors specific to Desert Hot Springs

Table 11

Research, Development, and Demonstration Projects

DEPARTMENT OF ENERGY (DOE) - DIVISION OF GEOTHERMAL ENERGY
DIRECT USE PROGRAM

- **Purpose of Program:** The purpose of the Direct Use Program is to stimulate the increased use of the hydrothermal resources of the U. S. To accomplish this, this program funds engineering and economic feasibility studies as well as actual field experiments (demonstration projects). Generally, studies are awarded as a result of a Program Research and Development Announcement (PRDA), while field experiments are funded via Program Opportunity Notices (PON).
- **Application Period:** Applicants typically have 45-60 days to prepare proposals in response to a PRDA and 60-90 days for a PON.
- **Application Process:** Solicitations for PRDA or PON funding are publicly announced in the Commerce Business Daily.
- **Extent of Funds Available:** Variable. The first PON (PON EG-77-N-03-1553) funded 8 projects for a total of approximately \$2 million for initial project phases for the 1978 fiscal year. These projects are expected to last from 1 to 5 years.
- **Eligibility - Projects and Applicants:** Feasibility studies and field experiments are funded as a result of a competitive selection process. Eligibility is stated in the PON or PRDA. Generally, all non-profit organizations, universities, individuals, and organizations in the private sector can apply. In the past, industrial process heating, heating and cooling for homes and buildings, and agribusiness applications have been acceptable projects for program support.
- **Financing Options:** A PON requires cost sharing by the applicant. However, a specific percentage share is not stipulated. More favorable consideration is given to an applicant that offers the highest cost share, all other factors being equal. A PRDA provides government funding via the contract mechanism. Cost sharing is not required by a PRDA. Funding is done on a cost plus fixed fee basis.
- **Factors Specific to DHS:** The current DHS project is funded under a PRDA.
- **Contact:** Ms. Marilyn Eggers, U. S. Department of Energy - Division of Geothermal Energy, San Francisco, California, phone no. (415) 273-7943.

TABLE 12

Research and Development

DEPARTMENT OF ENERGY (DOE) - LOW TEMPERATURE
STATE COOPERATIVE PROGRAM³¹

- **Purpose of Program:** The goal of this program is to evaluate the extent and nature of low to moderate temperature geothermal resources suitable for direct use purposes. This is performed in two phases. The first is to inventory those resources suitable for direct heat applications. This leads to an expansion of the low temperature data base and, in conjunction with USGS, a low temperature resource map is published. The second phase is to identify within individual states, the resource areas that should receive high priority with respect to early development.
- **Application Period:** It can take as long as 1 year to get such a program started.
- **Application Process:** The appropriate state agency (State Geologist in California) in cooperation with local officials develops a plan and then applies to DOE. Then a memorandum of understanding between all the appropriate federal and state agencies is drawn up. In each locality different agencies will be involved. Some of these agencies are the Bureau of Land Management, Forest Service, United States Geological Survey, Department of Energy, Bureau of Reclamation, State Energy Commission, and the Bureau of Mines. This memorandum outlines the responsibilities of the various agencies. Next, the working proposal is approved.
- **Extent of Funds Available:** Generally \$100,000 - \$300,000 is available for each state. Therefore, each state can only look at 3 or 4 sites.
- **Eligibility - Projects and Applicants:** The purpose of the program is to confirm low temperature reservoirs. Application should be made by the appropriate state agency.
- **Financing Options:** This program is a cooperative venture and is funded on a variable cost sharing basis.
- **Factors Specific to DHS:** California is about to get approval to participate in this program. This funding interfaces with the PON and PRDA programs and provides them with preliminary data. The City of Desert Hot Springs has applied to the California Division of Mines and Geology requesting the resource characterization of its indigenous geothermal resource be performed as a part of this program.
- **Contact:** Mr. Roy Mink, U. S. Department of Energy-Division of Geothermal Energy, 20 Massachusetts Avenue N. W., Washington, D. C. Phone No. (202) 376-4914.

TABLE 13

Government Financial Assistance DEPARTMENT OF ENERGY (DOE) - GEOTHERMAL LOAN GUARANTY PROGRAM³⁰

- Lenders are guaranteed against loss of principal or interest on loans made to qualified borrowers for the purpose of:
 - 1 - Development, construction, and operation of facilities for demonstration or commercial geothermal plants
 - 2 - Acquiring rights in geothermal resources
 - 3 - Research and development for extraction and utilization technologies
 - 4 - Determining and evaluating the resource base
- Application period: Application must be made prior to September 3, 1984
- Application process time: Between 120-240 days, depending on the type of project, completeness of data submitted, and extent of environmental considerations
- Extent of guarantee: 75% of total project costs
- Guaranty period: Up to 30 years
- Maximum guarantee
 - 1 - Single loan: \$25,000,000 for non-electric
 - 2 - Combination of loans for one qualified borrower: \$50,000,000 for non-electric
- Terms and conditions for loan guarantees are specified by DOE
- Guaranty fee: A fee of no more than 1% annually on the average outstanding loan value will be charged to the lender and may be passed on to the borrower
- Interest rate: Reasonable and prevailing rates are charged as determined by the Secretary of DOE in consultation with the Secretary of Treasury
- DOE may pay the lender the interest due if the borrower cannot pay and if it is in the public interest to let the borrower continue to pursue the project
- Regardless of land ownership, participants in DOE's geothermal loan guaranty program are required to prepare and submit environmental reports per DOE document ERHQ-0001, "Guidelines to the Preparation of Environmental Reports for Geothermal Development Projects"
- Based upon the participant's environmental report, DOE will conduct an environmental impact analysis and publish its findings in the form of either an impact assessment (EIA) or impact statement (EIS)
- Contact-Mark N. Silverman, DOE San Francisco Operations Office, 1333 Broadway, Oakland, California 94612 (415) 273-7151

TABLE 14

Government Financial Assistance

ECONOMIC DEVELOPMENT ADMINISTRATION (EDA) - TECHNICAL ASSISTANCE
GRANTS³²

- **Purpose of Program:** To assist in dealing with impediments to economic programs ranging from overcrowded central-city environments, to thinly settled areas. The program attempts to evaluate the feasibility of combining natural, human, and other resources in a variety of productive enterprises. Support is given to pilot or demonstration projects that are important in testing or launching programs of wide application.
- **Application Process:**
 - 1) Submit project description to EDA Los Angeles office
 - 2) Meet with EDA officer to discuss project, and to determine appropriateness and capability of applicant to implement the project
 - 3) Submit grant application to EDA Los Angeles office
 - 4) EDA review
 - 5) Grant approved
- **Extent of funds available:** \$25,000 - \$80,000
- **Eligibility: Projects and Applicants**

Favored projects include: Technical assistance projects in which projected employment gains are relatively specific and realistic, and are realizable in the near future. The applicant should show evidence of strong leadership and financial capability, the capability to share part of the project cost, and be able to portray definitive project benefits. Assistance for tourism is considered only if the proposed project shows substantial economic impact.
- **Financing Options:** Costs of technical assistance programs of proprietary benefit to a private individual are expected to be repaid to the Federal government through arrangements agreed upon between the government and the private beneficiary. Cost sharing must be 25% of gross project costs.
- **Factors specific to DHS:** Projects involving tourist attractions are not thought to be eligible for this grant, because not enough jobs or economic development is generated. This may impact grants for health spas.
- **Los Angeles Office Economic Development Administration**
11777 San Vicente Blvd.
Los Angeles, California
(213) 824-7521

TABLE 15

GOVERNMENT FINANCIAL ASSISTANCE
FARMERS HOME ADMINISTRATION (FmHA)-
COMMUNITY FACILITY LOANS³³

- Purpose of Program: To construct community water and waste disposal systems, community centers, fire stations, health care, and other community facilities.
- Application Period: An application takes 3 months to process providing that a preliminary engineers report accompanies the application, that the facility is properly designed, and that any applicable statutes are met.
- Application Process: The applicant must first apply with the State Clearinghouse. The application is then routed to the appropriate state agency. This agency then coordinates funding with FmHA.
- Extent of Funds Available: This depends on the project. However, FmHA is currently funding one community service project for \$5 million.
- Eligibility - Projects and Applicants: Public agencies or nonprofit corporations. Local or county governments are examples of public agencies. Nonprofit corporations would have to be organized under state statutes. An example of a nonprofit corporation would be a water district.

Be unable to obtain needed funds from other sources at reasonable rates and terms.

Have legal authority to borrow and repay loans, to pledge security for loans, and to construct, operate, and maintain the facilities or services.

Be financially sound, and able to organize and manage the facility effectively.

Base the project on taxes, assessments, revenues, fees, or other satisfactory sources of money sufficient to pay for operation, maintenance, and reserve, as well as retire the debt.

Be consistent with available comprehensive and other development plans for the community, and comply with Federal, State, and local laws.

- Financing Options: FmHA has several ways to fund these loans. Grants which may be used to bring a specific weak economic situation to within reasonable limits. There are also two types of insured loans available: (1) long-term revenue sharing loans and (2), general obligation bonds. Maximum term on all loans is 40 years at an interest rate of 5 percent.
- Factors Specific to DHS: DHS currently has a community facility loan for its sewer system.
- Contact: Vivian H. Andrews, County Supervisor, FmHA , 21160 Box Springs Road, Suite 105, Riverside, California 92507.

TABLE 16

Government Financial Assistance

**ECONOMIC DEVELOPMENT ADMINISTRATION (EDA) - PUBLIC WORKS
GRANTS AND LOANS³²**

- **Purpose of Program:** To acquire and develop land and improvements for public works, public service, or development facility usage and to acquire, construct, rehabilitate, alter, expand, or improve such facilities, including related machinery and equipment.
- **Application Period:** 3 months
- **Application Process:**
 - 1) Project applicants present project to county lead agency for review
 - 2) Overall Economic Development Program (OEDP) review
 - 3) EDA priorities projects
 - 4) Applications requested (30 days)
 - 5) Regional office processes (30 days)
 - 6) EDA Washington office review (30 days)
- **Extent of funds available:** 60% of total project cost which usually ranges between 0.5 and 1.0 million dollars
- **Eligibility - Applicants:** States, local subdivisions of states, Indian tribes, economic development centers, private or public nonprofit organizations, or associations representing an EDA-designated area or economic development center.
- **Projects:** Industrial parks, water and sewer facilities, facilities to stimulate economic development.
- **Financing Options:** Cost sharing must be 40% of total gross project cost in Riverside County. Different in each county depending on economic conditions.
- **Factors Specific to Desert Hot Springs:** Because of the City's small population, it may not have the resources necessary to support lengthy application processes or to fulfill the requirements for cost sharing unless it were able to undertake public works programs in small modular increments.
- **Los Angeles Office - Economic Development Administration**
11777 San Vicente Blvd.
Los Angeles, California
(213) 824-7521

TABLE 17

Government Financial Assistance

ECONOMIC DEVELOPMENT ADMINISTRATION (EDA) - PLANNING GRANTS³²

- **Purpose of Program:** Grants may be used for initiating, planning, and programming economic development activities by states, Economic Development Districts, and other sub-state planning and development organizations, cities, and redevelopment areas. The goal is to develop a capability for economic development planning that is comprehensive in scope, is coordinated with other programs, and looks toward the effective use of the resources in creating full-time permanent jobs for the unemployed and under-employed, especially in economically stricken areas.
- **Application Process:** (see process for Technical Assistance Grant)
- **Extent of Funds Available:** Up to 75% of planning program cost
- **Eligibility - Projects and Applicants:** Sub-state level applicants must have a continuous process involving public officials and private citizens in: analyzing local economies, defining development goals, determining project opportunities, formulating and implementing a development program.
- **Grants may be used for:** administrative expenses, planning and programming of economic development projects within a district, assistance (nonfinancial) to communities and development organizations within a district.
- **An application by a sub-state organization must have the endorsement of the state in which the applicant is located.**
- **Funding Options:** Cost sharing must be 25% of total gross project cost.
- **Factors specific to Desert Hot Springs:** A Planning Grant is sometimes awarded to a project which serves as the feasibility study for a Technical Assistance Grant. It is not a grant to plan technology implementation. The Desert Hot Springs study may be past the stage in geothermal development when EDA may feel a planning grant is in order.
- **Los Angeles Office - Economic Development Administration**
11777 San Vicente Avenue
Los Angeles, California
(213) 824-7521

TABLE 18

GOVERNMENT FINANCIAL ASSISTANCE
FARMERS HOME ADMINISTRATION (FmHA)-
FARM OPERATING LOANS³³

- **Purpose of Program:** To buy livestock, equipment, feed, seed, fertilizer, birds, or supplies for farm, and home operations; refinance debts or pay interest on them; assist with payments on equipment; make minor real estate improvements; improve forest lands; establish nonfarm enterprises to supplement farm income.
 - **Application Period:** It takes from 60 to 90 days to process an application.
 - **Application Process:** The applicant must first have been unable to obtain financing from banks. Then he can apply directly to FmHA.
 - **Extent of Funds Available:** The extent of funds available depends on repayment ability and on the type of project the applicant is considering.
 - **Eligibility - Projects and Applicants:** Operators of not larger than family farms. Eligible operators must be U. S. citizens, with good credit, and farm experience. FmHA will not finance experimental farms. Projects funded would have to present a record or marketability. The aquaculture option might be fundable under this program if a good market and feasibility could be demonstrated.
- Be unable to obtain financial help from other agencies (lending)
- **Financing Options:** These are two types of insured loans available:
 - (1) Annual operating loans which must be repaid within 1 year;
 - (2) Loans for capital goods which have a payback period of from 3 to 7 years. Both types of financing are similar to bank loans.
 - **Factors Specific to DHS:** The scarcity of water in the DHS area may make it difficult to obtain these loans.
 - **Contact:** Vivian H. Andrews, County Supervisor, FmHA
21160 Box Springs Road, Suite 105
Riverside, California 92507

TABLE 19

GOVERNMENT FINANCIAL ASSISTANCE
FARMERS HOME ADMINISTRATION (FmHA)-HOME OWNERSHIP LOAN

- Purpose of Program: To buy, build, improve, repair, or rehabilitate rural homes and related facilities and to provide adequate water and waste disposal systems. Funds may be used to modernize homes - add bathrooms, central heating, modern kitchens, and other improvements such as driveways and foundation plantings. Borrowers may buy an existing house and lot or buy a site on which to build a home. Under certain conditions, funds may be used to refinance debts on a home.
- Application period: Housing loans take 6 to 8 weeks to process
- Application process: Apply directly to the Farmers Home Administration county office serving the area in which the house or farm service buildings will be located.
- Extent of funds available: Loans may be made for up to 100 percent of the FmHA appraised value of the site and the new home if construction inspections were made by FmHA, Veterans Administration, or Department of Housing and Urban Development Homes over one year old and improvements to them also may be financed with 100 percent loans.
- Eligibility: Families with adjusted income less than \$15,600
 - Be without decent, safe and sanitary housing
 - Be unable to obtain a loan from private lenders on terms and conditions that they can reasonably be expected to meet.
 - Have sufficient income to pay house payments, insurance premiums and taxes and maintenance, other debts and necessary living expenses. Persons with inadequate repayment ability may obtain cosigners for the loan.
 - Be U. S. citizen or legal entry to U. S.
 - Possess the character, ability, and experience to meet loan obligations.
 - House must be modest in size and price.
 - House must be in a rural area or town with a population less than 10,000 and not a suburb of a larger town.
- Financing Options: Maximum repayment period is 33 years
8 1/2 percent interest will be charged on all loans
- Contact: Vivian H. Andrews, County Supervisor, FmHA, 21160 Box Springs Road, Suite 105, Riverside, California 92507.

B. Private Capital

Private capital financing is available from several sources to supplement or to take the place of government financial assistance programs. Conventional lending institutions, such as banks, do not generally provide risk capital unless the borrower has sufficient equity to cover the loan. To date, only three commercial banks, Bank of America, Bank of Montreal, and Nevada National Bank, have participated prominently in any form of geothermal project loan. Although both corporate and project loans are available from commercial banks, the geothermal industry seems to prefer project loans.

Within this market, commercial banks have participated by lending up to 75% of project costs under the protection of the DOE Geothermal Loan Guarantee Program. However, none of the commercial banks have extended loans for field experiments. Furthermore, these institutions prefer to deal with total discipline companies and have constrained their activities to loans greater than \$1,000,000 for one-shot ventures. (For projects with follow-on potential, project loans as small as \$500,000 may be possible.) Wildcatting (high risk exploration) projects are not accepted by commercial banks at this time without a DOE loan guarantee.

The Bank of America, for example, views the geothermal industry as embryonic, but has adopted a progressive posture. They have expressed a willingness to be involved in a wide variety of geothermal resource projects for both electric and nonelectric applications under the DOE Loan Guarantee program, so that they may develop a better understanding of the relationships, if any, between the various geothermal resources. They are further hopeful that enabling technologies will be developed prior to the September 3, 1984 expiration date of the DOE Geothermal Loan-Guarantee Program so that further confidence can be built into the geothermal industry.³⁴

The perspective of investment bankers and other forms of private placement agencies is somewhat different. These agencies evaluate the economics of a particular loan and guarantee or collateral behind the loan and make investment decisions in the form of conventional financing for non-government and government-related undertakings. Although higher risk loans are available through these organizations, these types of loans are becoming increasingly difficult to obtain. This is due to the uncertainty of high technology readiness in a timeframe meaningful to geothermal development projects.

Investment bankers tend to favor making project loans. However, they are not adverse to corporate loans. The market trend is easing with respect to obtaining project loans as operations become more established. Conversely, the newer the technology, the more difficult it is to get project loans; hence, there has been some movement towards corporate loans or loan guarantees.

In general, the financial market is not adverse to project loans, and equity or debt loans have become more risk adverse and more conservative. Generally, the equity market favors capital gains and the debt market favors returns on investment. However, in today's marketplace even the equity market is looking for some return.

Equity investors generally look for a 10-20% combination of dividends and capital gains, but are not realizing it in today's marketplace. Venture capital generally focuses upon small companies looking at high return on investment (e.g., $\leq$ 5-year payback period). Project financing's lower limit centers about \$3-5,000,000 for either debt or equity loans, thereby favoring large scale commercial undertakings.

Private placement by domestic and foreign investors encompass both exploration and applications, although commercial banks are not geared to do the former. Developmental work investment decisions, however, center around tax shelter decisions and the geothermal industry does not share the same tax incentives as do coal, oil, and gas.

Alternatively, if the user qualifies, revenue bonds can be issued for project financing.

APPENDIX 1

ENERGY INFORMATION DATA BASES

ENERGY INFORMATION DATA BASES

A. Technical Information Center

The Technical Information Center (TIC), Oak Ridge, Tennessee maintains the world's largest and most comprehensive bibliographic data bases on energy. Subject categories and information germane to geothermal energy are:

1. Geothermal Energy

- ° ~ 7,700 subject categories with emphasis on exploration and exploitation of geothermal resources.
- ° Publications:
 - Geothermal Resources (TID-3354-R-1)
 - Geothermal Energy Update (monthly abstract journal)
- ° Inquiries should be addressed to:
Lila B. Smith, Chief
Advanced Energy Systems Section
Science and Technology Branch
DOE Technical Information Center
P. O. Box 62
Oak Ridge, TN 37830
Telephone: (615) 483-8611, ext. 3-4426

2. Energy Policy and Management

- ° ~ 14,900 subject categories embracing all phases of energy analysis and development
- ° Publication:
 - Legal and Institutional Impediments to Geothermal Energy Resource Development - A Bibliography (TID-3365)
- ° Inquiries should be addressed to:
Lee M. Thompson, Assistant Chief
Science and Technology Branch
DOE Technical Information Center
P. O. Box 62
Oak Ridge, TN 37830
Telephone: (615) 483-8611, ext. 3-4426

3. Environmental Sciences

- ° ~ 29,600 subject categories on the effects of any energy-related activity on the environment.
- ° Publication:

- Inquiries should be addressed to:

Sidney F. Lanier, Chief
Environmental, Biomedical, and Safety Section
Science and Technology Branch
DOE Technical Information Center
P.O. Box 62
Oak Ridge, TN 37830
Telephone: (615) 483-8611, ext. 3-4426

4. Physical Research-Geosciences

- -1,700 subject categories on geology, hydrology, geophysics, seismology, tectonics, magnetism, volcanology, physical survey methods, mineralogy, petrology, rock mechanics, geochemistry, and oceanography.
- Publication
- Inquiries should be addressed to:

Charles E. Stuber, Chief
Physical Research Section
Science and Technology Branch
DOE Technical Information Center
P.O. Box 62
Oak Ridge, TN 37830
Telephone: (615) 483-8611, ext. 3-4426

5. TIC Guides

- Subject Categories (TID-4584)
- Energy Information Data Base (TID-4585)
- DOE Energy Information Base: Serial Titles (TID-4579)
- DOE Energy Information Base: Subject Thesaurus (TID-7000)
- DOE/RECON User Manual (TID-4587)

6. DOE/RECON System

- The DOE data bases can be accessed by the DOE/RECON System, an interactive on-line retrieval system consisting of 40 dedicated terminals on three telephone circuits
- On-line access is limited to DOE and qualified contractors
- For individuals and organizations ineligible for on-line access, RECON search services are available for a fee through the Western Regional Information Service Center and the DOE energy information centers in San Francisco and Denver.

- ° Inquiries should be addressed to:

Charles M. Gottschalk
DOE Office of Technical Information
Washington, DC 20545
Telephone: (301) 353-4035

B. National Geothermal Information Resource

The National Geothermal Information Resource (GRID) of the Lawrence Berkeley Laboratory maintains a comprehensive compilation of worldwide literature and data designed to assist in the research and development of geothermal energy for both electrical and nonelectrical uses.

- ° Information in the GRID files includes:

Exploration - resource data including geological, geochemical, and geophysical methods, as well as drilling, resource assessment, and land-use factors involved in locating and evaluating high temperature geothermal resources.

Environmental - aspects to the air, land, and water environments of geothermal energy utilization: subsidence, hydrogen sulfide.

Physical Chemistry - basic thermodynamic and transport data at elevated temperatures and pressures of sodium chlorides and other salts.

Utilization - development and production of a geothermal reservoir for both electrical and nonelectrical uses: hot water (brine) transport; space, process, and agricultural heating; corrosion, erosion, and scaling.

Numerical Data - site-independent and site-dependent tables.

- ° Publications:

- Geothermal Thesaurus (LBL-4841)

- ° Computer-produced bibliographies and data tabulation are generated at a fixed cost of \$19 for DOE users and \$25 for non-DOE users per search.

- ° Inquiries should be addressed to:

National Geothermal Information Resource
Lawrence Berkeley Laboratory, 90-3117
University of California
Berkeley, California 94720
Telephone: (415) 843-2740, ext. 5980

APPENDIX 2

Summary Community Needs Assessment

City of Desert Hot Springs, California

A. Community Needs Assessment

1.0 Regional Perspective

The City of Desert Hot Springs lies at the north end of the Coachella Valley, a unique entity in its own right, but integrated into the social and economic fabric of the valley as a whole. The northern Coachella Valley has as its economic base recreation, tourist, and retirement oriented resort areas, while the southern Coachella Valley is primarily agricultural. For the purposes of this analysis, the northern Coachella Valley is considered to encompass La Quinta, Indian Wells, Palm Desert, Rancho Mirage, Cathedral City, Palm Springs, Desert Hot Springs, and the unincorporated portions inbetween these cities; the southern Coachella Valley is considered to include Indio, Thousand Palms, Coachella, Thermal, Mecca, and the unincorporated portions south to the northern end of the Salton Sea.

The full time resident population of the northern Coachella Valley increased from 48,600 in 1970 to approximately 69,100 at the beginning of 1977, a 42.2 percent increase. The bulk of the population increase occurred in and around the City of Palm Springs. The population increase in and around Desert Hot Springs was percentagewise approximately equal to that for the northern Coachella Valley as a whole. The City of Desert Hot Springs itself, however, grew at a slightly lesser rate of 39.0 percent over the same period. The southern Coachella Valley increased in population only about 7.2 percent, rising from 38,400 in 1970 to about 41,200 by 1977. One of the characteristics of the recreation and retirement orientation of the northern Coachella Valley is that in the winter time when temperatures are moderate, the visitor population can swell the total population to two and sometimes three times the full-time resident population of the valley. Thus, during the high season, the winter months, the population in the northern Coachella Valley as a whole can exceed 200,000 persons on a peak weekend.

The seasonality of the population in the northern Coachella Valley subjects the economic base to strong seasonal vagaries. Merchants, for example, typically receive the bulk of their revenues during the winter months, and coast at a minimal level of activity through the summer months. Some businesses even close for the summer. Since the bulk of these businesses are service oriented, there tends to be a high demand for seasonal employment. There is some evidence that these trends are changing towards a more stable full-time population, however, it is not yet significant.

One of the recurring problems in the northern Coachella Valley has been the dearth of housing for the service worker population. Historically, the workers have commuted into the more affluent areas of the valley from Banning and Beaumont in the San Geronio Pass, and from areas in the southern Coachella Valley in and around Indio, Mecca, Thermal and Coachella. Desert Hot Springs has historically played a role as a "dormitory suburb" for some of the service worker population. Over the period of 1970 to 1977, the total number of dwelling units in the northern Coachella Valley increased from about 28,800 to 44,200, a 53.8 percent increase. Most of the construction took place in and around Cathedral City, with Palm Springs increasing its dwelling units at approximately the same rate as the northern Coachella Valley as a whole. The area in and around Desert Hot Springs increased in dwelling units approximately 46.5 percent, from about

4,300 to 6,300 over the seven year period. In the City itself, however, the number of dwelling units increased only 34.6 percent over the same period. It is reasonable to conclude that the bulk of the new construction in the northern Coachella Valley as a whole in condominiums, single family homes, and apartments which are used to house transient winter or seasonal and permanent residents. Housing for the permanent worker population has traditionally been much slower in developing than has that for transients. If trends continue Desert Hot Springs will play a diminishing role in housing the service population.

There has traditionally been little or no industrial activity in the northern Coachella Valley. The major focus of the economy is service support to the visitor population. The second most important economic activity is agriculture. Commercial utilization of the geothermal resource underlying the City of Desert Hot Springs would in many respects be the first commercial activity not directly related to tourist trade. Although the demands for workers in the initial pilot stage are relatively small, if the activity proves commercially viable, there may be a need for larger numbers of workers in Desert Hot Springs. If this were to occur, Desert Hot Springs would become a center of employment opportunity. In particular, there may be increasing opportunities for the semi-retired and retired population throughout the valley.

Residents of other portions of the northern Coachella Valley face many of the same problems as do the residents of Desert Hot Springs with respect to energy costs brought about by extremely warm days and cool nights through much of the year. Although it may be possible to provide heating and cooling for portions of Desert Hot Springs using the geothermal resource, it is not clear that in the foreseeable future this resource could be adapted to provide the same alternate energy source for other portions of the northern Coachella Valley. The distances between Desert Hot Springs and other population centers are just too great.

In summary, from a regional perspective, commercial utilization of the geothermal resource at Desert Hot Springs could lead to the creation of a center of employment activity in the northern Coachella Valley not dependent upon tourist trade. The large number of sub-divided, yet vacant, parcels within the City limits would provide a reasonable basis for growth in housing for the worker population and also for the service population employed in other portions of the valley. If alternate energy sources were used to decrease the fuel costs for residents in the area, it should be expected that an increasing number of retirement oriented people would be attracted to Desert Hot Springs, especially those on fixed incomes. The commercialization of the geothermal resource at Desert Hot Springs is, therefore, primarily a local impact which may have beneficial effects on other factors more regional in scope.

2.0 Community Perspective

2.1 Introduction

One of the objectives of the analysis of non-electric applications of geothermal energy in Desert Hot Springs is to tailor to the greatest extent possible the use of the indigenous geothermal resource to the

needs of the community, both present residents and those who might be attracted by commercial development of the resource. With respect to community needs, two hypotheses have been prevalent from the outset of the conceptualization of the project. The first of these was that the economic base of the community was devoted virtually exclusively to tourist and recreation trade centered on the mineral spas using geothermal fluids. It has been hypothesized that the development of industrial and commercial applications based on the utilization of the geothermal resource would provide a wider economic base for the community. The second hypothesis was that the large number of older retired and semi-retired individuals, many on fixed incomes, required opportunities for part-time, flexible hour employment. It appeared that agriculture and aquaculture could be viable options to provide the community with these job opportunities. A public attitude survey, discussed below, was one of the techniques used in testing these hypotheses.

It should be acknowledged that one of the basic objectives of the analysis of potential utilization of the geothermal resource is to provide an alternate energy source for the citizens of the community. The relatively high cost of cooling in the summer and heating in the winter is typical of a desert environment. Geothermal resources may be utilized to provide space conditioning at prices competitive with traditional fossil fuel sources of electricity. The need to reduce reliance on traditional fossil fuels is ubiquitous throughout the entire nation and not a unique characteristic of the City of Desert Hot Springs. Therefore, the community needs analysis has focused on characteristics of the community unique to the City of Desert Hot Springs, namely those discussed above.

2.2 Economic Base

The historic economic base of the City of Desert Hot Springs has been the recreation and tourist industry attracted to the city by the climate of the Coachella Valley and the mineral spas derived from the underlying geothermal resource. As of April 1977, within the city there were approximately 115 hotels, motels and spas with 1,128 rooms available. Within the incorporated city there were three mobile home parks with approximately 250 available spaces, some of which were used for mobile homes and the remainder being used for recreational vehicles on a short-term basis. Considering the community area beyond the incorporated boundaries, there were an additional 22 mobile home parks with an occupancy of approximately 2,000 spaces. Many of these are long-term residents in the community whose spaces cannot be considered to be available to transients. It has been estimated that the population of Desert Hot Springs increases to approximately 12,000 during the winter season from November through May each year, a tripling of the resident population of approximately 4,300. This tourist and recreation trade accounts for a significant portion of the 6.5 million dollars of taxable sales in the City each year.

There are three firms located within the City which fall under the classification of manufacturing employers. These are two weekly newspapers and a printing shop, total employment of which is approximately 25 persons. Non-manufacturing employers are primarily the motels, hotels, spas and mobile homes/recreation vehicle parks which on the

average may employ several hundred persons. There are also several construction firms engaged in housing production throughout the Coachella Valley.

There has been a shift in the occupation of City residents during the period 1970-1976. Professional, technical and managerial categories increased significantly while white collar sales and clerical workers fell in relative proportions in the work force. Craftsmen doubled while operatives were halved. Laborers and service workers both declined. The skills mix of the population has shifted towards professional, managerial and blue collar skilled trades. The 1976 Special Census reported 1,506 as the total number of employed persons in the City. Given that the skills mix has shifted in recent years and that the employment opportunities in the major industry of tourist and recreation is of a semi-skilled nature, the bulk of the employment opportunities are considered to lie outside the City of Desert Hot Springs at present. It is suspected that these job opportunities lie in the Palm Springs, Rancho Mirage, Palm Desert, and Indio areas of the Coachella Valley. The development of commercial activities based on the utilization of geothermal resource will require skilled and semi-skilled labor. Commercial utilization of the geothermal resources would, therefore, be expected to attract additional blue collar persons to the community, accelerating and accentuating the evident shift in the skills mix of the population.

It is acknowledged that commercial development of the geothermal resource will provide a increased tax base for the city as a whole. It has not been ascertained what the effect of this commercialization would be on the tourist and recreation industries. One of the parameters in the design of the geothermal plant is to avoid potential degradation of the resource itself. It is expected that the mineral hot waters used by the spas would continue to be available. The more significant change that is envisioned is a socio-political one.

The population of the City has been growing younger. The median age in the City in 1976 was 56, down from 62 in 1970. The period 1970-1976 has seen a tremendous growth in younger persons. As an example, the 20-24 age group has doubled percentagewise while the number of children under 19 has increased dramatically. While the attraction of this younger population to the City will in the end result in a more balanced community, it will cause a realignment of existing power bases in the City away from the retired and semi-retired population.

In summation, the commercial development of the geothermal resource within the City of Desert Hot Springs will provide significant impetus to a wider and more diversified economic base within the city. Introduction of this technology will alter the existing social structure. On the one hand it may be argued that the attraction of a younger population leading to a more balanced community will help to provide a larger permanent population and smooth the vagaries of an economy based on tourist and recreation industry. On the other hand, however, the very amenities which have attracted persons to the City of Desert Hot Springs could be altered to such an extent to be significantly lessened unless proper controls are implemented. Public acceptance of increased utilization of the geothermal resource is discussed below.

It is possible to make an educated guess based on existing socio-economic data of the general opinion of Desert Hot Springs residents towards implementation of non-electric applications of geothermal energy. However, additional data was sought to more accurately evaluate the acceptability of such projects, and to assess the prevailing local opinions on geothermal development. Consequently, an issue specific survey was developed and taken. A secondary purpose of the survey was to inform the respondents that their opinions were considered in evaluating the proposed applications so as to maximize public interest in the overall project. The information requested from the respondents was of two types: 1) demographic characteristics, and 2) attitudes towards geothermal development. A copy of the survey questionnaire may be found in Appendix 3. An additional assessment, (discussed below) was used to help validate the issue specific survey.

The survey was conducted by first asking community groups who had been addressed by the project manager to participate, including the Spa-Tel owners (the Rotary Club), and others. Presentations were made to these groups to enlighten them as to the goals of the project and to heighten their interest in it. The Spa-Tel owners and one other group, attendees at a City Council meeting, were given truncated versions of the questionnaire, while the Rotary Club was given the full questionnaire. The largest group sampled was randomly selected citizens contacted by phone and asked to participate in the survey by coming to the City Hall on October 14, 1977, or November 1, 1977, to complete the questionnaire. Other persons also contacted were local government officials on the City Council, Planning Commission, the Board of Directors of the Desert Hot Springs County Water District, the President of the Chamber of Commerce, and the City Manager. The final group to participate in the survey on October 14, 1977, and November 1, 1977, was citizens informed of the opportunity via a large scale publicity effort in the local media.

Unfortunately, the response to the survey was less than expected and desired. Only 96 persons completed the questionnaires, including the shortened version. A few additional were incomplete and eliminated from the analysis. Considering that the 1976 Special Census found the population of Desert Hot Springs to be 3,362, and that some of the survey participants lived outside the City, the response rate was less than 3 percent. There are several reasons for the low response rate. First of all, the two survey dates were weekdays. Furthermore, the survey was only given at the City Hall. These two factors may have made it quite difficult for people engaged in their daily activities, particularly employment, to give up what they were doing, perhaps without compensation, travel as far as several miles to the City Hall, and then take approximately one hour to complete the questionnaire. It should be noted, however, that the questionnaire was available from 7:00 a.m. to 7:00 p.m. each day, allowing for participation before and after normal working hours. Regardless, the low response rate may thus not be indicative of large scale public apathy towards the project. A door-to-door survey conducted at least partly on weekends would probably have resulted in a larger sample. However, the time and resources were not available to perform such a survey. Similarly, it was unfeasible to conduct a mail survey. Considering the constraints associated with the actual survey undertaken, the response rate was probably not as disappointing as it seems.

The survey responses were categorized such that meaningful trends could be identified. The pivotal factors were responding group, monthly current energy costs, and location of residence. The responding groups were kept the same as the groups defined earlier, except that the citizens randomly selected and contacted were combined with the citizens who heard of the survey via the media. Energy costs of respondents were broken down into low (less than \$46/monthly), medium (\$46-90 monthly), and high (more than \$90 a month) groupings to determine whether those with higher costs had more interest in geothermal development. The last categorization combined residents with similar demographic characteristics. Four such groupings were used: those citizens who reside north of 8th Street (1976 special Census blocks 0 and 1), citizens who generally live south of 8th Street and east of Verbena Avenue (1976 special Census blocks 2 through 6), residents west of Verbena Avenue (1976 special Census blocks 7 through 9), and people who live outside the City. The goal of this division was to determine if those people residing over the geothermal resource, primarily blocks 7 through 9, would have attitudes different from those persons in other portions of the City. Another objective was to differentiate between city and non-city residents.

The major results of the survey are as follows:

64 percent of all respondents favored city and/or private ownership and operation of any geothermal energy system to be implemented. People with low energy costs varied significantly from this, 23 percent of whom had no opinion and another 35 percent of whom felt a cooperative or nonprofit corporation would be more desirable. Also, of those living outside the City, 58 percent felt that the City should not be involved in owning or managing the resource.

57 percent of all respondents felt that Federal subsidies or guaranteed bank loans should be used to finance the development of geothermal energy systems. 21 percent of the questionnaires favored private funding. Exceptions to this were the business groups (41 percent of the Rotary Club and 33 percent of the Spa-tel owners favored private funding) and those persons with high energy costs (43 percent of whom favored private funding).

Concerning payback periods, 64 percent of the survey respondents favored payback periods of 6 to 20 years if geothermal systems were installed in their residences. Those who would choose not to utilize such systems numbered only 6 percent of all respondents, all of whom were persons with low energy costs (17 percent of the low energy cost group).

79 percent of all those surveyed would not preclude any type of geothermal use, whether commercial, residential, or recreational. The business groups were somewhat more specific; 33 percent of the Rotary did not desire commercial uses and 33 percent of the Spa-tel owners did not favor commercial or residential uses. Also, 40 percent of those residing outside the city did not want the resource used commercially.

Of all those persons surveyed, 47 percent felt that greenhouses would be an appropriate commercial use of the geothermal resources. Persons in blocks 0 and 1 favored the raising of shrimp or fish products (50 percent).

When asked to choose one potential City project, 50 percent of the respondents picked geothermal development while 35 percent picked sewer projects as having a higher priority. However, the low energy cost group favored sewers over geothermal development by 46 to 38 percent, as did the Rotary group by 46 to 31 percent.

(A quantitative analysis of some more important questions appear in Appendix 3 .) It may reasonably be concluded from the survey results that persons with low energy costs are not as interested in geothermal development as those respondents with higher costs. Those persons living over the resource have a greater interest in seeing the resource utilized than do the business groups. The business and high energy cost groups favor private funding of geothermal development versus governmental or quasi-governmental. As expected, all persons stating they would not utilize a geothermal system in their homes had low energy costs. The interests of the business people were evident in the question on type of use in which a significant quantity of responses did not wish commercial uses. They would probably like to see it used as it is now for spas. 40 percent of the residents from outside of the City also did not favor commercial uses. Furthermore, 58 percent of these people did not wish to see the City involved in the ownership or management of the geothermal resource. This may indicate that the non-City people feel that if the resource is utilized commercially or operated by the City, they would not derive benefit from it. The question of choosing between competing City projects reflected the concern of the respondents for the lack of sewers in some areas of Desert Hot Springs. Even so, 50 percent of all respondents favored a geothermal project. The reasons for this include the chance to lower energy costs, the possibility of commercial viability of such an undertaking, and the opportunity to promote Desert Hot Springs as an innovator in the alternative energy field.

2.4 Environmental Response Inventory

The Environmental Response Inventory (ERI) was used as an adjunct to the issue specific survey to compare attitudes toward the environment of residents of Desert Hot Springs with norms standardized for a population comparable to the United States in general. In this context the ERI was used to explore the relationship between general values toward the environment and attitudes specific to the utilization of the geothermal resource in Desert Hot Springs.

The Environmental Response Inventory (ERI) was devised by George E. McKechnie, from the University of California, Berkeley, as an assessment instrument to measure the various ways people think and feel about the physical environment in which they live. "...a principal goal in the ERI has been to produce an assessment instrument having value for interdisciplinary studies of man and the environment; these include research in the field of architecture and urban design,

city and regional planning, and any other discipline concerned with the patterns and styles of response which individuals manifest with respect to their environment." Commercialization of the geothermal resource at Desert Hot Springs brings into play individual attitudes towards the environment as people perceive the impact of expanded use of the resource.

Norms for the ERI are based upon two unselected adult populations determined to be representative of the sample areas. The sample appears "slightly biased in terms of middle and upper income individual... and are not offered as a true random sampling of the population of the United States..."

Validation studies for the ERI remain in the preliminary stages. The ERI is still being developed as a research tool. Its use in the City of Desert Hot Springs has provided an indication of attitudes as well as being of benefit in the development of the tool itself. The results of the Environmental Response Inventory are profiled into nine areas: Pastoralism, Urbanism, Environmental Adaption, Stimulus Seeking, Environmental Trust, Antiquarianism, Need for Privacy, Mechanical Orientation and Commuality. Table 1 presents the nine scales and their major themes.

- 2.4.1 On October 14, 1977, and November 1, 1977, community leaders and residents of the City of Desert Hot Springs were invited to participate in the attitudinal survey. Announcements were made by individual phone request, and local radio and newspaper media. Approximately fifty percent of the community leaders responded (N = 19); thirty-one members of the community at large responded, some of whom were employees of the City. The total number taking the test approximated one percent of the total population of the City. Twenty-six men (62 percent of the total N) and fifteen women participated in the survey (one not indicated). The mean age of all participants was 54.4, with community leaders at 56.7 and the general public at 52.3. According to the 1976 special Census, the median age in the City was 56, comparable to that of the community leaders and very close to the general public. The socio-economic level of the sample appeared to be somewhat higher than the average in the City of Desert Hot Springs. The degree to which factors such as age, sex, socio-economic level and place of residence within the city are equally distributed, and therefore correlate, between the sample and the actual population of the City determines the validity of the sample assessed at Desert Hot Springs. If a high correlation exists a hypothesis can be confirmed regarding those issues.

A sufficiently high correlation did not exist between all factors necessary to establish validity for the statement of representativeness of the sample to the population. The correlation could be increased by more sampling, which was not done. However, trends were noted that indicated important preferences. Below is a discussion based on the arithmetic means of the ERI scales for the sampled community leaders and the general public.

2.4.2 Initial Results of the ERI

The community leaders and the general public have a preference toward the development of the environment through the use of technology (elevated Environmental Adaptation (EA) scores).

Table 1

Environmental Response Inventory Scale

Pastoralism (PA)	Opposition to land development, preservation of natural resources
Urbanism (UR)	Enjoyment of city life, high density, cultural activities
Environmental Adaptation (EA)	Use of technology to solve environmental problems
Stimulus Seeking (SS)	Interest in travel, adventure
Environmental Trust (ET)	Expresses trust vs. fear of the environment
Antiquarianism (AN)	Preference for traditional vs. modern design
Need for Privacy (NP)	Enjoyment of solitude
Mechanical Orientation (MO)	Interest in technological processes and basic principles
Communality (CO)	Validity scale

This is further evidenced by an elevated Mechanical Orientation (MO) scale which measures level of interest in technology and science. However, community leaders on both scales evidenced a somewhat stronger preference for technological development than the general public.

Interest in the development of technology gains additional strength in two opposing scales, Pastoralism (PA) and Antiquarianism (AN) which are both below the standard scan for both groups. These scores together measure the desire to preserve the environment without modification; a depressed score indicates a willingness to alter the environment, such as through increased use of geothermal energy.

There exists a slightly higher preference for urban and cultural life among the residents than among the community leaders. However, both means are in the average range. In Need for Privacy, community leaders emerge at somewhat higher than the general public, again with both groups in the average range. Community leaders have more trust in their ability to control environmental problems than do the general public. It does not appear, however, that these differences are statistically significant.

In viewing the combined means for both community leaders and the general public, the trend toward an interest in science and the development of technology with the subsequent development of land predominates. The marked depression in the Environmental Trust scale indicates a fear of natural catastrophes and, by hypothesis, the residents may be perceived as desirous of using technology to circumvent nature. In addition, the lower Pastoralism and Antiquarianism scales of the residents of Desert Hot Springs, which suggest a tendency to preserve nature and its artifacts, do not appear as important as the ongoing development of technology.

2.4.3 Summary

The results of the ERI, although statistically insignificant because of the small sample, indicate a general confirmation of endorsements of specific issues in the Public Attitude Survey. In particular, increased utilization of technological processes was generally of greater value than the preservation of the natural environment. Since Desert Hot Springs is largely a retirement community, these results are considered quite significant.

Although the study in Desert Hot Springs did not yield the level of statistical significance hoped for, it did indicate in a general way the usefulness of basic attitudinal assessment as a validation of issue specific surveys. In Desert Hot Springs one supported the other, thereby encouraging reliance on the results of the survey, the small sample notwithstanding. If the ERI had indicated basic attitudes counter to those subsumed by the issue specific survey, the results of both would be open to question. This would initially indicate a need for resurveying or a larger sample.

3.0

Agriculture and Aquaculture Labor Force

One of the early hypotheses was that the potential development of agriculture and aquaculture based on the geothermal resource underlying the City of Desert Hot Springs would provide part-time, flexible hour employment opportunities for senior citizens, many of whom are on fixed incomes. European cucumbers, tomatoes, and cut flowers, were among the most viable agricultural products for agribusiness based on the geothermal resource. Data obtained from existing European cucumber growers indicated that a work force of thirteen to twenty persons is required to service approximately 140,000 square feet of greenhouse, all of whom are assumed to be capable of carrying out any job within the greenhouse. Included in this number is a complex manager and two task supervisors. The work force employed tends to be relatively permanent. Part-time laborers are usually employed during the harvesting and packaging stages of operations. Thus, even though significant area may be devoted to the production of European cucumbers, the availability of part-time work is quite small in terms of the total number of persons who might be available in the work force within the City. Therefore, if agriculture, in particular greenhouses growing European cucumbers, tomatoes or cut flowers are developed, these facilities would tend to attract younger skilled and semi-skilled laborers on a permanent basis. The number of job opportunities on a part-time flexible hour basis for senior citizens, therefore, appears limited in the greenhouse operations.

The production of fish and prawn in aquacultural raceways is similar to that described above for European cucumbers as far as the labor force is concerned. The commercial aquaculture operation would require a number of trained semi-skilled and skilled laborers who would be responsible for the day-to-day operation of the facility. Here too the job opportunities appear to be aimed at younger permanent employees rather than senior citizens. Once the aquaculture facility is in operation, the harvesting of the fish crop would occur on a fairly continuous basis. Therefore, it appears the labor force requirements would be fairly constant over time. In this operation as well, there do not appear to be significant opportunities for senior citizen employment.

Although only two examples have been assessed, a reasonable conclusion is that job opportunities will tend to be focused on the younger permanent employee category. This will accelerate and accentuate the shift in the population towards younger persons.

4.0

Summary

One of the original purposes for the City of Desert Hot Springs undertaking this study was to "...exploit its geothermal resource to benefit its citizenry." The community needs assessment has attempted to identify the "benefits" which would accrue to the residents of the City from increased utilization of the resource in terms of the desires of the citizens.

In general the residents of the City favor exploitation of the resource as long as the existing spa uses are protected. Community leaders, both business and government, have been the most vocal in encouraging exploitation. However, they have also been the most vocal in insuring

that the existing tourism economy is not affected. Over the long term increased utilization of the geothermal resources will have a significant impact on the community: the economic base will be increased and new residents will be attracted to the City.

Appendix 3

Desert Hot Springs Public Attitude Survey

This Appendix provides the detailed response to several of the more important questions given on the public attitude survey. As stated in the text, the survey was administered on October 14 and November 1, 1977. It was also given to three groups to whom oral presentations were made by the project manager. A copy of the Public Attitude questionnaire appears in Figure 11. Following this are the responses to the questions on ownership, financing, type of geothermal use desired, and preference for a geothermal project on a percentage basis. The responses are broken down by type of respondent (Table 1), by energy costs (Table 2), and by location of residence (Table 3).

FIGURE 1
PUBLIC ATTITUDE QUESTIONNAIRE

The City of Desert Hot Springs is studying the possibility of developing their geothermal resources for heating and cooling and for some light industrial use. The Jet Propulsion Laboratory (JPL) of Pasadena is assisting the City to assess the commercialization potential of their geothermal energy resources. JPL is responsible for the determination of public opinion regarding a geothermal energy system in Desert Hot Springs. Public input to the decision makers of the City is vital to the success of any new civic project. By filling out the following questionnaire you will be providing valuable information to the study of geothermal development and also will ensure the consideration of your opinion by City planners.

Age _____

Sex _____

Address: _____

- 1) Which income bracket indicates your family's total household annual income in 1976?
 - a. under \$4,000 _____
 - b. \$4,000-\$7,499 _____
 - c. \$7,500-\$9,999 _____
 - d. \$10,000-14,999 _____
 - e. \$15,000-\$29,999 _____
 - f. \$29,999 or over _____
- 2) Do you work:
 - a. full time _____
 - b. part time _____
 - c. retired _____
 - d. unemployed _____
 - e. retired with supplemental part time income _____
- 3) If an employment opportunity acceptable to you became available within Desert Hot Springs, would you:
 - a. consider changing jobs if you are already employed in Desert Hot Springs? _____
 - b. consider changing jobs if you are employed outside Desert Hot Springs? _____
 - c. consider accepting employment if you are not presently employed? _____
 - d. be uninterested in new employment opportunities? _____
- 4) Would you be interested in a part-time employment opportunity acceptable to you in Desert Hot Springs?
 - a. yes _____
 - b. no _____
- 5) Do you live in Desert Hot Springs:
 - a. all year _____
 - b. October-March _____
 - c. April-September _____
- 6) Is your residence a:
 - a. house _____
 - b. mobile home _____
 - c. apartment _____
 - d. other _____
- 7) Regarding your Desert Hot Springs residence, do you:
 - a. own _____
 - b. own and lease out when you are not living there _____
 - c. rent, do not own _____

- 8) How much were your utility bills last month?
	<u>Electricity</u>	<u>Heating/Cooling</u>
a. \$0-\$30	_____	_____
b. \$31-\$45	_____	_____
c. \$46-\$60	_____	_____
d. \$61-\$75	_____	_____
e. \$76-\$90	_____	_____
f. \$91-\$105	_____	_____
g. over-\$105	_____	_____
- 9) In which month of the year are your utility bills the highest?
<u>Electricity</u>		<u>Heating/Cooling</u>	
Month	_____	Month	_____
Amount	_____	Amount	_____
- 10) In which month of the year is your utility bill the lowest?
<u>Electricity</u>		<u>Heating/Cooling</u>	
Month	_____	Month	_____
Amount	_____	Amount	_____
- 11) Are you aware of the City's interest in developing their geothermal resources, (the use of hot water found underground), for commercial and residential heating and cooling?)
- a. yes _____
- b. no _____
- c. unaware that Desert Hot Springs has geothermal resources _____
- 12) Which of the following ownership/management alternatives do you prefer for a geothermal energy system in Desert Hot Springs?
- a. city ownership and operation _____
- b. private ownership and operation _____
- c. city ownership and private operation _____
- d. users coop ownership and operation _____
- e. users coop ownership and private operation _____
- f. city controlled non-profit corporation _____
- g. have no opinion _____
- 13) There are several possible ways to finance the development of geothermal energy system for the City. Which of the following methods of financing would you:
	<u>Consider Appropriate</u>	<u>Personally Use</u>
a. Federal government subsidy to the City	_____	_____
b. Federal government guaranteed bank loans	_____	_____
c. municipal financing through bond issues	_____	_____
d. private industry	_____	_____
e. have no opinion	_____	_____
- 14) There are several possible ways to finance the installation of geothermal heating and cooling systems in your residence. Which of the following methods of financing would you:
	<u>Consider Appropriate</u>	<u>Personally Use</u>
a. personal savings	_____	_____
b. conventional bank/finance company	_____	_____
c. government guaranteed loans	_____	_____
d. municipal financing through bond issues	_____	_____
e. use of other capital sources which would result in higher monthly costs	_____	_____
- (Please rank in order of preference using 1 to 5, with 1 being the most preferred and 5 being the least preferred).

- 15) If one of these systems were to be installed in your house, which of the following payback periods would you consider acceptable?
- a. less than five years _____
 - b. 6-10 years _____
 - c. 11-20 years _____
 - d. more than 20 years _____
 - e. would not choose to utilize geothermal energy _____
- 16) How do you regard Desert Hot Springs as a community now, and what kind of a place would you like it to be in the future?
	<u>Present</u>	<u>Future</u>
a. commercial, residential, and recreational	_____	_____
b. residential, recreational	_____	_____
c. primarily recreational	_____	_____
d. other	_____	_____
- 17) Geothermal development in Desert Hot Springs may impact the environment and these impacts will be mitigated. In your opinion would environment impacts make geothermal development:
- a. less attractive _____
 - b. more attractive _____
 - c. equally attractive if environmental impacts were not considered _____
- 18) How would you like to see the geothermal resources in Desert Hot Springs utilized?
- a. commercially, residentially and recreationally _____
 - b. residentially, recreationally _____
 - c. primarily recreationally _____
- 19) Which of the following commercial uses do you feel are appropriate in Desert Hot Springs?
- a. greenhouses _____
 - b. raising of shrimp and fish _____
 - c. vegetable processing _____
 - d. other (specify) _____
- (Please rank from 1 to 4 in order of preference, with 1 being the most preferred and 4 being the least preferred).
- 20) If there were only enough funds to finance one City project, in your opinion which project should receive support?
- a. geothermal development _____
 - b. sewers _____
 - c. road improvement _____
 - d. bus service _____
 - e. other (specify) _____
- (Please rank from 1 to 5 in order of preference, with 1 being the most preferred and 5 being the least preferred).
- 21) Did you attend the Public Meeting on geothermal development held on September 6, 1977?
- a. yes _____
 - b. no _____
- 22) Would you be willing to participate in a personal interview about your opinion of geothermal development in Desert Hot Springs?
- a. yes _____
 - b. no _____

TABLE 8

SURVEY RESULTS BY RESPONDING GROUP

Survey Which of the following ownership/management alternatives do you prefer for a geothermal energy system in Question 12 - Desert Hot Springs? (Percent of responding group)

	<u>Spa-Tel Briefing</u>	<u>Citizen Briefing</u>	<u>Rotary Club Briefing</u>	<u>Public Respondents</u>	<u>Community Leaders</u>	<u>Total-All Respondents</u>
A-City Ownership & Operation	---	37.0	15.4	22.1	27.3	23.9
B-Private Ownership & Operation	55.6	18.5	46.2	14.7	27.3	25.5
C-City Ownership & Private Operation	---	18.5	---	23.5	9.1	14.9
D-Users Coop Ownership & Operation	22.2	3.7	15.4	13.2	---	10.1
E-Users Coop Ownership & Private Operation	---	---	---	2.9	9.1	2.1
F-City Controlled Nonprofit Corporation	11.1	11.1	7.7	11.8	18.2	11.7
G-No Opinion	11.1	11.1	15.4	11.8	9.1	11.7

Survey - There are several possible ways to finance the development of geothermal energy system for the city. Which of the Question 13 following methods would you consider appropriate? (Percent of responding group)

	<u>Spa-Tel Briefing</u>	<u>Citizen Briefing</u>	<u>Rotary Club Briefing</u>	<u>Public Respondents</u>	<u>Community Leaders</u>	<u>Total-All Respondents</u>
A-Federal Govt. Subsidy to the City	44.4	68.0	15.4	50.0	50.0	47.8
B-Federal Govt. Guaranteed Bank Loans	22.2	4.0	17.9	6.7	10.0	9.3
C-Municipal Financing Through Bond Issues	---	12.0	17.9	21.7	20.0	15.4
D-Private Industry	33.3	16.0	41.0	18.3	10.0	20.9
E-No Opinion	---	---	7.7	3.3	10.0	6.7

Survey - If a geothermal heating and cooling system were to be installed in your house, which of the following payback Question 15 periods would you consider acceptable? (Percent of responding group)

	<u>Spa-Tel Briefing</u>	<u>Citizen Briefing</u>	<u>Rotary Club Briefing</u>	<u>Public Respondents</u>	<u>Community Leaders</u>	<u>Total-All Respondents</u>
A-Less Than 5 Years	22.2	16.7	23.1	19.4	8.3	18.0
B-6-10 Years	66.7	45.8	23.1	38.7	33.3	40.4
C-11-20 Years	11.1	20.8	23.1	22.6	41.7	23.6
D-More Than 20 Years	---	8.3	23.1	16.1	8.3	12.4
E-Would Not Choose to Utilize Geothermal Energy	---	8.3	7.7	3.2	8.3	5.6

Survey - How would you like to see the geothermal resources in Desert Hot Springs utilized? (Percent of responding group)
Question 18

	<u>Spa-Tel Briefing</u>	<u>Citizen Briefing</u>	<u>Rotary Club Briefing</u>	<u>Public Respondents</u>	<u>Community Leaders</u>	<u>Total-All Respondents</u>
A-Commercially, Residentially and Recreationally	44.4	84.6	66.7	88.2	81.8	79.3
B-Residentially, Recreationally	11.1	11.5	33.3	11.8	18.2	15.2
C-Primarily Recreationally	33.3	3.8	---	---	---	4.3
D-No Opinion	11.1	---	---	---	---	1.1

Survey Which of the following commercial uses do you feel are appropriate in Desert Hot Springs? (Percent of responding group)
Question 19

	<u>Spa-Tel Briefing</u>	<u>Citizen Briefing</u>	<u>Rotary Club Briefing</u>	<u>Public Respondents</u>	<u>Community Leaders</u>	<u>Total-All Respondents</u>
A-Greenhouses	33.3	48.0	55.6	48.2	45.0	46.9
B-Raising of Shrimp & Fish	22.2	24.0	22.2	21.4	30.0	23.5
C-Vegetable Processing	33.3	24.0	22.2	23.2	15.0	23.7
D-Other	11.1	4.0	---	7.1	10.0	6.2

Survey - If there were only enough funds to finance one city project, in your opinion which project should receive support? (Percent of responding group)
Question 20

	<u>Spa-Tel Briefing</u>	<u>Citizen Briefing</u>	<u>Rotary Club Briefing</u>	<u>Public Respondents</u>	<u>Community Leaders</u>	<u>Total-All Respondents</u>
A-Geothermal Development	50.0	57.7	30.8	51.6	50.0	50.0
B-Sewers	50.0	26.9	46.2	35.5	33.3	35.7
C-Road Improvement	---	11.5	7.7	9.7	8.3	8.8
D-Bus Service	---	3.8	---	---	---	1.1
E-Other	---	---	15.4	3.2	8.3	4.4

TABLE 2

SURVEY RESULTS BY ENERGY COSTS

Survey - Which of the following ownership/management alternatives do you prefer for a geothermal energy system in
Question 12 Desert Hot Springs? (Percent of responding group)

	<u>Low Energy Cost</u> <u>(Less than \$46/month)</u>	<u>Medium Energy Cost</u> <u>(\$46-90/month)</u>	<u>High Energy Cost</u> <u>(More than \$90/month)</u>
A-City Ownership & Operation	19.2	10.0	28.6
B-Private Ownership & Operation	7.7	30.0	50.0
C-City Ownership & Private Operation	15.4	30.0	14.3
D-Users Coop Ownership & Operation	11.5	10.0	---
E-Users Coop Ownership & Private Operation	---	---	7.1
F-City Controlled Nonprofit Corporation	23.1	---	---
G-No Opinion	23.1	20.0	---

Survey - There are several possible ways to finance the development of geothermal energy system for the City. Which
Question 13 of the following methods would you consider appropriate? (Percent of responding group)

	<u>Low Energy Cost</u>	<u>Medium Energy Cost</u>	<u>High Energy Cost</u>
A-Federal Govt. Subsidy to the City	48.0	27.8	28.6
B-Federal Govt. Guaranteed Bank Loans	8.0	---	21.4
C-Municipal Financing Through Bond Issues	20.0	22.2	7.1
D-Private Industry	8.0	27.8	42.9
E-No Opinion	16.0	22.2	---

Survey - If a geothermal heating and cooling system were to be installed in your house which of the following payback
Question 15 periods would you consider acceptable? (Percent of responding group)

	<u>Low Energy Cost</u>	<u>Medium Energy Cost</u>	<u>High Energy Cost</u>
A-Less Than 5 Years	16.7	33.3	14.3
B-6-10 Years	25.0	8.3	42.9
C-11-20 Years	29.2	41.7	21.4
D-More than 20 Years	12.5	16.7	21.4
E-Would Not Choose to Utilize Geothermal Energy	16.7	---	---

Survey - How would you like to see the geothermal resources in Desert Hot Springs utilized? (Percent of
Question 18 responding group)

	<u>Low Energy Cost</u> (Less than \$46/month)	<u>Medium Energy Cost</u> (\$46-90/month)	<u>High Energy Cost</u> (More than \$90/month)
A-Commercially, Residentially and Recreationally	80.0	83.3	84.6
B-Residentially, Recreationally	20.0	16.7	15.4
C-Primarily Recreationally	---	---	---
D-No Opinion	---	---	---

Survey - Which of the following commercial uses do you feel are appropriate in Desert Hot Springs? (Percent of
Question 19 responding group)

	<u>Low Energy Cost</u>	<u>Medium Energy Cost</u>	<u>High Energy Cost</u>
A-Greenhouses	50.0	62.5	42.3
B-Raising of Shrimp & Fish	13.6	25.0	30.8
C-Vegetable Processing	31.8	12.5	11.5
D-Other	4.5		15.4

Survey - If there were only enough funds to finance one city project, in your opinion which project should receive
Question 20 support? (Percent of responding group)

	<u>Low Energy Cost</u>	<u>Medium Energy Cost</u>	<u>High Energy Cost</u>
A-Geothermal Development	37.5	58.3	50.0
B-Sewers	45.8	41.7	18.8
C-Road Improvement	12.5	---	12.5
D-Bus Service	---	---	---
E-Other	4.2	---	18.8

TABLE 3

SURVEY RESULTS BY LOCATION OF RESIDENCE

Survey - Which of the following ownership/management alternatives do you prefer for a geothermal energy system in Desert Hot Springs? (Percent of responding group)

	<u>Blocks 0-1</u>	<u>Blocks 2-6</u>	<u>Blocks 7-9</u>	<u>Outside DHS</u>
A-City Ownership & Operation	57.1	23.5	29.4	5.3
B-Private Ownership & Operation	---	29.4	29.4	26.3
C-City Ownership & Private Operation	---	11.8	23.5	15.8
D-Users Coop Ownership & Operation	14.3	---	5.9	21.1
E-Users Coop Ownership & Private Operation	---	---	11.8	10.5
F-City Controlled Nonprofit Corporation	28.6	5.9	---	15.8
G-No Opinion	---	29.4	---	5.3

Survey - There are several possible ways to finance the development of geothermal energy system for the City. Which of the following methods would you consider appropriate? (Percent of responding group)

	<u>Blocks 0-1</u>	<u>Blocks 2-6</u>	<u>Blocks 7-9</u>	<u>Outside DHS</u>
A-Federal Govt. Subsidy to the City	57.1	46.9	25.0	44.4
B-Federal Govt. Guaranteed Bank Loans	---	---	25.0	16.7
C-Municipal Financing Through Bond Issues	28.6	9.4	18.8	22.2
D-Private Industry	14.3	18.8	31.3	16.7
E-No Opinion	---	25.0	---	---

Survey - If a geothermal heating and cooling system were to be installed in your house, which of the following payback periods would you consider acceptable? (Percent of responding group)

	<u>Blocks 0-1</u>	<u>Blocks 2-6</u>	<u>Blocks 7-9</u>	<u>Outside DHS</u>
A-Less Than 5 Years	14.3	16.7	12.5	26.7
B- 6-10 Years	42.9	33.3	43.8	13.3
C-11-20 Years	28.6	5.6	31.3	46.7
D-More Than 20 Years	---	33.3	12.5	6.7
E-Would Not Choose to Utilize Geo. Energy	14.3	11.1	---	6.7

Survey - How would you like to see the geothermal resources in Desert Hot Springs utilized? (Percent of
Question 18 responding group)

	<u>Blocks 0-1</u>	<u>Blocks 2-6</u>	<u>Blocks 7-9</u>	<u>Outside DHS</u>
A-Commercially, Residentially and Recreationally	85.7	88.2	94.1	60.0
B-Residentially, Recreationally	14.3	11.8	5.9	40.0
C-Primarily Recreationally	---	---	---	---
D-No Opinion	---	---	---	---

Survey - Which of the following commercial uses do you feel are appropriate in Desert Hot Springs? (Percent
Question 19 of responding group)

	<u>Blocks 0-1</u>	<u>Blocks 2-6</u>	<u>Blocks 7-9</u>	<u>Outside DHS</u>
A-Greenhouses	16.7	33.3	53.8	75.0
B-Raising of Shrimp & Fish	50.0	33.3	23.1	---
C-Vegetable Processing	33.3	33.3	7.7	16.7
D-Other	---	---	15.4	8.3

Survey - If there were only enough funds to finance one city project, in your opinion which project should
Question 20 receive support? (Percent of responding group)

	<u>Blocks 0-1</u>	<u>Blocks 2-6</u>	<u>Blocks 7-9</u>	<u>Outside DHS</u>
A-Geothermal Development	42.9	41.2	42.9	62.5
B-Sewers	28.6	35.3	42.9	31.3
C-Road Improvement	14.3	11.8	7.1	6.3
D-Bus Service	---	---	---	---
E-Other	14.3	11.8	7.1	---

APPENDIX 4

**REPRESENTATIVE AQUACULTURAL MARKET DATA DEVELOPED
FROM REFERENCED SOURCES**

Figure 3 Wholesale Prices of Raw, Headless Shrimp (21-25 count)

Point of Pricing: New York
1968-1975, monthly

Source: Shellfish Market Review and Outlook (April 1975)

Figure 5 U. S. Per Capita Consumption of Shrimp
(edible weight, pounds)

1947-1976, annually

Sources: (1) Basic Economic Indicators
(2) Fisheries of the United States, 1976
(3) Shellfish Market Review and Outlook (April 1975)

APPENDIX 5
RESPONSIBLE STATE OFFICE OR AGENCY²⁶

The following are responsible state offices or agencies from which information regarding current regulations can be obtained. Also see Appendix 3 of Reference 26 for compendium of State regulations compiled to date.

Alaska

Department of Natural Resources
Division of Oil and Gas
3001 Porcupine Drive
Anchorage, AK 99504

Arizona

Oil & Gas Conservation Commission
4515 North Seventh Avenue
Phoenix, AZ 85013

California

Division of Oil & Gas
1416 Ninth Street
Sacramento, CA 95814

Colorado

Oil & Gas Conservation Commission
Room 237 Columbine Building
1845 Sherman Street
Denver, CO 80203

Hawaii

State Department of Land and
Natural Resources
Box 621
Honolulu, HI 96809

Idaho

Department of Water Resources
Statehouse, Annex 2
Boise, ID 83720

Louisiana

State Department of Conservation
P. O. Box 44275
Capitol Station
Baton Rouge, LA 70804

Montana

Department of Natural Resources
and Conservation
32 South Ewing
Natural Resources Building
Helena, MT 59601

Nevada

Division of Water Resources
201 South Fall Street
Carson City, NV 89701

New Mexico

Oil Conservation Commission
P. O. Box 2088
Santa Fe, NM 87501

Oregon

Department of Geology and
Mineral Industries
1069 State Office Building
Portland, OR 97201

Texas

Railroad Commission of Texas
Oil and Gas Division
Austin, TX 78700

Utah

Division of Water Rights
Room 442 State Capitol
Salt Lake City, UT 84114

Washington

Department of Natural Resources
Division of Geology & Earth Resources
Olympia, WA 98504

Wyoming

State Engineer's Office
State Office Building
Cheyenne, WY 82001

APPENDIX 6

**SITE SPECIFIC FACTORS TO BE CONSIDERED
IN THE PLACEMENT OF GEOTHERMAL APPLICATIONS
AT DESERT HOT SPRINGS**

A. Characterization of Geothermal Resources at DHS

The minimum temperature needed for any of the applications (the aquaculture option) is about 90°F. Therefore, the extent of this isotherm for the DHS geothermal aquifer has been identified. It extends from the central portion of DHS southeast to the vicinity of Dillon Road (see Figure 1). This area which covers about 5.45 square miles contains two hot anomalies. One is at the eastern side of DHS in the vicinity of the Angel View Children's Hospital. This portion of the geothermal aquifer exceeds temperatures of 150°F. The other anomaly is near Dillon Road. Its temperatures are known to exceed 180°F.

The geothermal aquifer lies north of the Mission Creek Fault which cuts through the center of DHS from northwest to southeast. The City's potable water supply generally lies south of this fault. The geothermal water is tapped by drilling a well down to the source and then by pumping it or a heat exchange medium to the surface, where it is used directly or indirectly. Care must be taken in locating the extraction area so that unstable foundation conditions or landslide prone areas are avoided. Natural seismicity is normally associated with geothermal resources, so the potential active faults should also be delineated and avoided. However, this may not be so important at DHS since the geothermal aquifer is not very deep. If recharge of the aquifer is to take place after use, the best area for doing this is north of the Mission Creek Fault so that the City's potable water which has lower concentrations of total dissolved solids, fluoride, chloride, and sulfates, is not contaminated. The Blind Canyon area on the north-east side of the City currently appears to be the optimal location for disposal of water withdrawn from the hot area in DHS.

The best place for recharging any geothermal water that is removed from the Dillon Road site is not as well defined since it has not been definitely ascertained as to whether this area is replenished by water which migrates southeast along the Mission Creek Fault or southward down Long Canyon. Therefore, the best current estimate for optimal recharge siting would be north of the Mission Creek Fault in the area where Long Canyon intersects the 90°F isotherm.

B. Zoning and Historical/Archeological Considerations

There are several other important considerations that relate to DHS which deserve mention before discussing the individual project options. Those factors which could pose a problem in siting any chosen application are the presence of any restrictive zoning ordinances or sites of historical/archeological importance in the vicinity of the geothermal resources.

The area surrounding the hot anomaly in DHS is primarily zoned residential. Exceptions to this are a commercially zoned area just to the west of the hottest resource up and down Palm Drive and another

commercial location at the western end of the anomaly at Hacienda Avenue (see Figure 1). The nearest industrially zoned site is about 1/2 mile south of the hot spot, east of Palm Drive. However, it should be noted that large portions of undeveloped land are near enough to the hot area in DHS that there should be no problem in placing any of the proposed applications. Furthermore, the DHS Planning Director has indicated that planning restrictions should be no major problem within the City providing the chosen application has the necessary permits.

The hot area at Dillon Road is outside the City. It is not currently zoned and is very sparsely settled. There should be no major siting problems at this location.

The last important site specific consideration is the presence of archeological or historical sites. Eight such potential sites have thus far been identified in the DHS vicinity. Only two of these are within the 90°F isotherm. One was a major Indian occupation site and lies just south of the hottest area in DHS. It contains manufacturing waste, food remains, tools, facilities, and human remains of the Desert Cahuilla. It is eligible for inclusion on the National Register of Historic Places. The other site is an aboriginal trail south of the Dillon Road area. If the first site is intruded upon by any construction, compliance with the California Environmental Quality Act may be necessary, which could cause time delays. The site south of the Dillon Road area is not as important and is located in an open area where there should be no placement conflict. It must be noted, however, that only about five percent of Riverside County has been surveyed for historical sites. Therefore, the services of an archeologist would probably be necessary for any construction undertaking.

C. Placement of Proposed Applications

From a practical point of view it would generally be best to place the chosen application as near as possible to the hottest geothermal source. Doing this would minimize thermal losses between the user and the source. It would maximize equipment performance (especially absorption refrigeration equipment) by enabling it to use the highest available temperatures. Construction intrusions caused by laying long sections of pipe from the source to the user and maintenance after implementation would be minimized. Projects which are most sensitive to this constraint are those which call for multiple uses of the heat resource or for cooling. An exception to this is the aquaculture operation which would only require 90°F temperatures. Another consideration is the size of the proposed applications. As more land is needed, the probability increases that placement, zoning, and archeological site issues will present potential obstacles.

The fact that some of the proposed applications' facilities already exist could alleviate some siting problems. The Angel View Clinic, City Hall, library, mobile home parks, and various spa-tels already exist in DHS. (See Table 1 for a list of the applications under consideration at DHS.) These facilities would have to be retrofitted for geothermal use. The clinic and several spa-tels lie right above the hot geothermal source in DHS. There they would be able to use the

Figure 1 - Desert Hot Springs, Location of Geothermal Aquifer, Major Faults, and Main Thoroughfares

TABLE 1
DESERT HOT SPRINGS
CANDIDATE APPLICATIONS - GEOTHERMAL USE

	INDIRECT	DIRECT USE
GREENHOUSE	HEATING, COLD STORAGE	---
AQUACULTURE	---	PRAWN CULTURE
INDUSTRIAL COMPLEX	HEATING, COOLING	---
ANGEL VIEW CLINIC	HEATING, COOLING, HOT WATER	---
MULTI-USE CENTER	HEATING, COOLING	---
CITY HALL/LIBRARY	HEATING, HOT WATER	---
SPA-TEL	HEATING, COOLING	SWIMMING POOL/SPA
CASCADED AGRIBUSINESS SYSTEM	HEATING, COLD STORAGE	IRRIGATION WATER
MOBILE HOME PARK	HEATING, COOLING, HOT WATER	SWIMMING POOL/SPA
UTILITY NETWORK	HEATING, HOT WATER	---
CAR WASH	HOT WATER	---

hottest possible water. Pipes from the source to the user would cause minimal, if any, impacts. Any accidental geothermal water losses would be minimized since the piping distance would be very small and since these facilities are north of the Mission Creek Fault. There would be no large problems of tearing up main thoroughfares or of violating any stream channels. These facilities also lie in the vicinity of Blind Canyon so they are near the optimal water disposal site should recharging of the geothermal aquifer be undertaken. There are also several spas at the Dillon Road site which would be in a similarly favorable location. It should be noted however, that there is some flooding potential at Dillon Road. The construction of a small dike around a facility there would mitigate any potential flooding problem.

There are several mobile home parks near the Dillon Road area, which aside from the minor flood potential, lie in a fairly good location from the point of view of utilizing and disposing of the geothermal resource. The City Hall and library lie one mile from the DHS hot anomaly. Therefore, transport of the heating medium to and from this site would result in thermal inefficiencies. However, since this option does not include cooling, the thermal losses should not be a very critical factor. This site is south of the Mission Creek Fault, and any accidental geothermal water losses have the potential for contaminating the potable water aquifer. Piping required from the source and possibly to the disposal area would disrupt Palm Drive and Pierson Blvd. during construction. Of the facilities which already exist, the location of the City Hall and library appears to be less favorable for geothermal use than some of the other options.

In considering the placement of those facilities which do not already exist, care must be taken to assure that sites of archeological importance are not interfered with during well drilling, pipe laying, and construction of the chosen application. However, as mentioned earlier, there is much open area where facilities can be located and zoning restrictions do not appear to be a major obstacle to development. Furthermore, on the positive side, these facilities could be designed with geothermal use in mind which could avoid the high costs that may be encountered if existing heating or cooling systems are retrofitted to geothermal use.

In placing some of the large facilities, such as the greenhouse, cascaded agribusiness, and industrial complex, even if suitable open space is available, there may be some bothersome noise and air emissions evident to residents of DHS during construction which could last as long as 6 to 9 months. These intrusions would manifest themselves in the form of dust, diesel fumes, and typical construction noises. The industrial complex option which currently calls for cooling has a strict requirement for being adjacent to the highest temperatures and could probably not be placed easily while trying to minimize these intrusions. This also applies to the greenhouse and cascaded agribusiness options which will include geothermal use for cold storage (refrigeration).

The utility network by its very nature would probably be set up near residences. This would cause large areal impacts during construction which would be brought about by tearing up streets. The aquaculture option has no strict temperature constraint, so its site could be chosen so as to minimize any intrusions. Of course, the size of the raceway to be built would impact its siting. The car wash does have temperature constraints, and although it would not take up a large area it would have to be placed near the hot spot in DHS in order to be economically viable. The multi-use center is currently planned to be built adjacent to the City Hall. Its location which will be south of the Mission Creek Fault, 1 mile from the hottest resource across town, place it together with the City Hall/library as an unfavorable option from a utilization standpoint.

Table 2 summarizes the findings of the siting consideration analysis. It indicates which facilities exist and where, whether they have temperature constraints, and any other important siting factors. The table also indicates which potential environmental constraints require special attention in siting the applications. A blank entry on the table indicates that a facility either does not currently exist or that there are no siting related constraints. Except for the mobile home park, the constraints apply to siting the projects within DHS. It is expected that those options that show no constraints, as well as those that do, would be planned with proper engineering and construction techniques and that stream channels would be avoided. It is also anticipated that the services of a geologist, a hydrologist, and an archeologist may be required during planning in order to ensure that any adverse impacts are minimized whenever possible.

TABLE 2

DESERT HOT SPRINGS

CANDIDATE APPLICATIONS - SITING CONSIDERATIONS

	<u>EXTANT FACILITY</u>	<u>GEO THERMAL TEMPERATURE CONSTRAINTS</u>	<u>OTHER</u>	<u>POTENTIAL ENVIRONMENTAL CONSTRAINTS</u>
GREENHOUSE	---	X	LARGE TRACT NEEDED	---
AQUACULTURE	---	---	---	---
INDUSTRIAL COMPLEX	---	X	LARGE TRACT NEEDED	ZONING, HISTORIC SITE
ANGEL VIEW CLINIC	DHS	X	---	---
MULTI-USE CENTER	DHS (proposed)	X	1 MILE FROM SOURCE	DISRUPT STREETS
CITY HALL / LIBRARY	DHS	X	1 MILE FROM SOURCE	DISRUPT STREETS
SPA-TEL	DHS	X	---	---
CASCADED AGRIBUSINESS	---	X	LARGE TRACT NEEDED	---
MOBILE HOME PARK	DILLON ROAD	X	---	---
UTILITY NETWORK	---	X	LARGE AREAL IMPACTS	DISRUPT STREETS
CARWASH	---	X	---	ZONING, HISTORIC SITE

APPENDIX 7

GEOHERMAL EQUIPMENT MANUFACTURERS AND DATA

1.0 Pumps

1.1 General

Pumps in geothermal service are basically the same design as water service pumps with several exceptions. Material must be selected to meet the corrosive attack of geothermal water and the seals must be selected to withstand the abrasive solids carried by the geothermal water. The normal materials for pump impellers in general geothermal service are Type 304 or Type 316 stainless steel. If the impeller is of welded fabrication, then the material should be Type 304L or Type 316L stainless steel.

Shaft seals for aboveground pumps may be either stuffing box or mechanical seal type. Analysis of the water will reveal the amounts of solids in the water and based on this information the need for a flush connection to the seal can be established.

The aboveground pumps are usually centrifugal type, with horizontally split casings and a separately coupled electric motor. Well pumps are usually fully submersible electric driven and completely sealed units.

1.2 Pump Manufacturers

Type of Pump

Centrifugal Pump
(aboveground)

Typical Supplier

Ampco Metal Division
Milwaukee, WI
Bingham Pump Company
Portland, OR
Byron Jackson Pump
Los Angeles, CA
Duriron Company, Inc.
Dayton, OH
Goulds Pump
Seneca Falls, NY
Ingersoll-Rand Company
New York, NY
Pacific Pump Company
Los Angeles, CA
Peerless Pump Company
Los Angeles, CA
United Centrifugal Pumps
San Jose, CA
Worthington, Corporation
Harrison, NJ

Type of Pump

Well Pump
(geothermal submersible)

Note: The first four companies
have actual geothermal
pumping experience.

Typical Supplier

Fairbanks Morse Pump Co.
Kansas City, KA
Johnston Pump Company
Glendora, CA
Peerless Pump Company
Los Angeles, CA
Reda (TRW) Pump Company
Bartleville, OK
Byron Jackson Pump
Los Angeles, CA
Worthington Corporation
Harrison, NJ

1.3 Pump Costs

Prices for both types of pumps vary depending upon the flowrate and head of the pump. For a range of pumps from 10 gpm and 50 feet of head to 5000 gpm and 500 feet, the typical prices would range from \$250 to \$20,000, respectively. An intermediate sized pump with a 500 gpm capacity and 200 feet of head would cost around \$9000.

2.0 Piping and Valves

2.1 General

The type of piping system used will depend upon the operating temperature and pressure of the system. If a low temperature and reasonably low head are typical of the system, consideration could be given to the use of plastic pipe to transport the geothermal water. Higher temperatures and heads would require the use of steel pipe and valves, of either carbon or stainless steel, or aluminum pipe and valves. Carbon steel would be the last choice of the three materials mentioned because of the need for a high corrosion allowance on the pipe wall thickness when using carbon steel.

Plastic pipes can be joined by screw joints, solvent adhesive joints or flange bolted joints. Valves are manufactured with similar end connections to match any of the above joining methods. Stainless steel piping should be welded or flange joint connected. When welding is used on piping in geothermal service the low carbon Type-L should be specified. This prevents sulfide stress corrosion due to the presence of H_2S in the water. Stainless steel pipe is subject to leaks on screw thread joints and for that reason screw threads should be avoided. Aluminum and carbon steel can utilize all three joining methods.

2.2 Piping System Manufacturers

Type of Equipment

Plastic Piping Systems

Steel Piping Systems (S.S. and Carbon Steel)

Aluminum Pipe

Typical Supplier

Johns-Manville
Denver, CO
Certain-Teed Products Corp.
Anaheim, CA
Ameron/Bondstand Co.
Los Angeles, CA
A.O. Smith Company
Milwaukee, WI
Amoco Reinforced Plastics Co.
Riverside, CA
Ershings
Bellingham, WA
Fibercast Company
Sand Springs, OK

Alaskan Copper Works
Seattle, WA
Ladish Company
Cudahy, WI
Key Pipe and Supply Company
Oakland, CA
Republic Supply Company
San Leandro, CA
Crane Company
Warrington, PA
Pacific Pipe
Oakland, CA
Esco
Portland, OR

Kaiser Aluminum Inc.
Oakland, CA
Aluminum Co. of America
Pittsburg, PA
Reynolds Metals Company
Richmond, VA

2.3 Piping System Costs

Pipe

Installed Prices

Carbon Steel, Field Fabricated

2" diameter	2.50/ft.
6" diameter	8.60/ft.
12" diameter	20.75/ft.
18" diameter	30.25/ft.

Stainless Steel, Field Fabricated

2" diameter	7.25/ft.
6" diameter	23.96/ft.
12" diameter	57.25/ft.
18" diameter	86.50/ft.

Aluminum, Field Fabricated

2" diameter	2.41/ft.
6" diameter	11.00/ft.
12" diameter	60.10/ft.
18" diameter	86.50/ft.

Valves

Carbon Steel Gate Valve Flanged Ends 150# rating

2" diameter	239.00
6" diameter	646.00
12" diameter	2042.00
18" diameter	5268.00

Stainless Steel Gate Valve Flanged Ends 150# rating

2" diameter	425.00
6" diameter	1167.00
12" diameter	5396.00
18" diameter	10500.00

Aluminum Gate Valve Flanged Ends 100# Rating

2" diameter	430.00
6" diameter	1004.00
12" diameter	3843.00
18" diameter	7800.00

3.0 Air Compressors

3.1 General

Most systems to which low grade geothermal energy would be applied consist of some type of distribution system. These types of systems will include some types of control valves. The cheapest method of controlling these valves, especially the larger sizes, is by pneumatic control. The source of the air supply would be a compressed air system.

The major problem to be considered is the corrosive attack of H_2S against copper. Therefore, the compressors should be copper free and the electric motor drivers should have epoxy coatings on the motor windings.

A typical size range for the type of distribution system control circuits considered would be 20 ACFM to 100 ACFM at 100 psig.

A typical compressor would be an air cooled non-lubricated reciprocating type with an electric motor driver. The construction material is normally cast iron with stainless steel piston and shaft. The piston rings are normally constructed of reinforced teflon.

3.2 Compressor Manufacturers

Type of Compressor

Air cooled reciprocating air compressor with electric motor driver, complete with air receiver and all controls.

Typical Supplier

Worthington Corporation
Harrison, NJ
Pur-Pax (Domain Industries)
Minneapolis, MN
Aeroflow
San Leandro, CA
Ingersoll-Rand Company
New York, NY

3.3 Compressor Costs

A typical cost of air compressor systems ranging from 20 ACFM to 100 ACFM at 100 psig would be \$8,000 to \$30,000 respectively.

4.0 Instrumentation

4.1 General

The level of complexity of instrumentation on a particular project can range from simple to sophisticated. The listings below cover a wide range of instrument types. The main problem to avoid is H_2S corrosion of copper parts. The majority of instruments used in geothermal service are stainless steel where contact with the fluid is required. All electrical contacts are normally tinned and control cabinets and panels have gasket seals and are filter air purged.

4.2 Instrumentation Manufacturers

Types of Equipment

Process Controls

Typical Supplier

Taylor Instrument Process Control
Akron, OH
Moore Products
Spring House, PA
Fisher & Porter
Warminster, PA
Foxboro Company
Foxboro, MA

Control Valves

Fisher Governor
Marshalltown, IA
Masonielon International
Norwood, MA
Hammel Dahl
Warwick, RI
Honeywell
Denver, CO
Keystone Controls, Inc.
Boston, MA

Relief Valves

Crosby Valve
Wrentham, MA
Dresser Industries Valve & Instr. Div.
Alexandria, LA

Solenoid Valves

Asco
Florham Park, NJ
Skinner Precision Ind.
New Britain, CT

Level Controls

Fisher Governor
Marshalltown, IA
Masonielon International
Norwood, MA
Moore Products
Springhouse, PA

Pressure & Temperature Gauges

Dresser Industries Valve & Instr. Div.
Alexandria, LA
Weston Instruments
Newark, NJ

Industrial Controls

Honeywell
Denver, CA
General Controls
Buffalo, NY
Robertshaw Controls Co
Richmond, VA
Johnson Controls
Rochester, MI
Square D Company
Park Ridge, IL

Types of Equipment

Relays

Typical Supplier

Cutler-Hammer, Inc.
Milwaukee, WI
Square D Company
Park Ridge, IL
Struthers - Dunn, Inc.
Pitman, NJ.

4.3 Instrumentation Costs

To try to cover the individual cost of each component would be of very little value because of the wide variation of instrument usage on different types of systems. From experience gained in many varied applications, it appears that a maximum cost of a very sophisticated system would be in the region of 5 per cent of the capital cost.

5.0 Heat Exchangers

5.1 General

Indirect geothermal applications will require the use of heat exchangers to convert the heat contained in the geothermal water to usable heat. Several types of heat exchangers are manufactured from the large high pressure TEMA type to miscellaneous specialty exchangers.

5.2 Heat Exchanger Manufacturers

Type of Equipment

Typical Supplier

TEMA Heat Exchangers

Enginners & Fabricators
Houston, TX
Struthers Wells
Warren, PA
Therma Technology
Tulsa, OK
Yuba Heat Transfer Corp.
Tulsa, OK
Welgmann & Rose
Richmond, CA
Zurn Industries, Inc.
Tulsa, OK
Nooter Corp.
St. Louis, MO

Double Pipe Heat Exchangers

Brown Fin-Tube
Tulsa, OK
Armstrong Engineering Assoc.
Winchester, PA
DeLaval Separator Company
Poughkeepsie, NY

Type of Equipment

Typical Supplier

Fin-Tube Heat Exchangers

Brown Fin-Tube
Tulsa, OK
Armstrong Engineering Assoc.
Westchester, PA
Doyle & Roth Mfg. Co., Inc.
New York, NY
Tranter Mfg., Inc.
Lansing, MI

Miscellaneous Specialty Heat Exchangers

Young Radiator Co.
Racine, WI
Thermxchanger
Oakland, CA
Trane
Conshohocken, PA

5.3 Heat Exchanger Costs

TEMA Type

Bare Exchanger

\$12 - \$20/sq. ft.

Installed Cost

\$36 - \$60/sq. ft.

Double Pipe & Finned Tube

Bare Exchanger

\$7 - \$20/sq. ft.

Installed Cost

\$10 - \$30/sq. ft.

Specialty Exchangers (20-100 Sq. Ft.)

Bare Cost

\$25 - \$40/sq. ft.

Installed Cost

\$35 - \$60/sq. ft.

Note

All above exchangers will have 304 or 304L stainless steel in contact with geothermal fluid.

6.0 Air Handling Systems

6.1 General

All space heating and cooling systems will require the use of fans to distribute the hot or cold air. The air heating and cooling systems will be either new or retrofit projects. In a retrofit project no new fan would be required because only the type of coil in the ducting system would be changed. In the case of a new installation, especially an industrial or agricultural application, new fans would be required.

The only items requiring a change from the manufacturer standard would be copper exposed parts on the fan and in the motor.

6.2 Air Handling System Manufacturers

Type of Equipment

Ventilating System Fans

Typical Supplier

American Air Filter Co.
Louisville, KY
Hell Process Equipment Co.
Cleveland, OH
Cellcote Company
Berea, OH
Buffalo Forge Co.
Buffalo, NY
Beetle Justin Plastics
Dayton, OH
Hartzell Propeller Fan Co.
Piqua, OH
Hudson Products Inc.
Houston, TX
New York Blower Co.
Chicago, IL

6.3 Air Handling System Costs

A typical cost range for fans for an operating range of 600 ACFM to 30,000 ACFM is \$500 to \$4000 respectively.

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