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**DIRECT USE APPLICATIONS OF GEOTHERMAL
RESOURCES AT DESERT HOT SPRINGS,
CALIFORNIA**

**FINAL REPORT, MAY 23, 1977 — July 31, 1978
VOLUME I: SUMMARY OF FINDINGS**

**Chris C. Christiansen
Program Manager**

July 1978

**Work Performed Under
DOE contract EG-77-C-03-1329 and
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**City of Desert Hot Springs
California**

**Donated By:
Herbert Rogers Jr.
Rogers Engineering Co.**

**U.S. DEPARTMENT OF ENERGY
GEOTHERMAL ENERGY
AND THE
CALIFORNIA ENERGY COMMISSION**

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VOLUME I: SUMMARY OF FINDINGS
FOR PERIOD MAY 23, 1977 - July 31, 1978**

**Chris C. Christiansen
Program Manager**

**City of Desert Hot Springs
11-711 West Drive
Desert Hot Springs, CA 92240**

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FOREWORD

This report presents the results of an engineering and economic analysis of direct use applications of geothermal energy resources at the City of Desert Hot Springs, California.

The findings of this analysis are reported in two volumes as follows:

Volume I - Summary of Findings

Volume II - Appendixes

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I. Introduction

Under the sponsorship of the Department of Energy (DOE) and the California Energy Commission (CEC), a study was conducted to evaluate potential applications of an identifiable geothermal energy resource in terms of engineering, economic, and institutional considerations and to formulate the preliminary design and implementation plan of the most promising demonstration or industrial development project. The purpose of this study was to determine potential options that DOE and CEC may exercise in developing low and moderate temperature hydrothermal resources as an economically and environmentally acceptable alternate energy source and in enhancing the development of a coherent geothermal industry.

The effort focused on a reservoir-specific application study for the City of Desert Hot Springs (DHS) and how that example study relates to regional needs. In this manner, the study will contribute to solving the major problems associated with implementing nonelectric geothermal systems for a large segment of the user community.

II. Summary

The study progressed along the following programmatic lines. First, the geothermal resources underlying the City of Desert Hot Springs were described in terms of anticipated geophysical, geochemical, and hydrological characteristics, based upon existing well log data, geologic surveys, and limited wellflow tests. Concurrently, the needs of the City were determined on the basis of its general plan, the City's 1976 census, load survey and a public acceptance survey. Then a broad range of potential nonelectric applications was surveyed in individual as well as energy cascading systems to identify the matchup of the resource and needs of the city. Applications investigated included space conditioning, space/water heating, car wash, agriculture/horticulture, and aquaculture operations.

The list of applications so derived were assessed in light of technological, socio-economic, environmental, institutional, and market considerations to determine target opportunities for DHS as well as on a broad regional basis. Those systems which survived the initial screening were subjected to detailed parametric studies focused on determining tradeoffs among performance, cost, size, compatibility with off-the-shelf hardware, etc. Based on these considerations, the field of candidate systems was narrowed to a few of the most promising systems.

A detailed analysis of the engineering and economic aspects of these systems was then performed. Factors considered included technological problems and risks, status of supporting technologies, net energy ratios, costs, market, displacement of fossil fuels, and economic benefit to the community.

Concurrently, a more detailed assessment was made of socio-economic changes, legal-institutional issues and requirements, project management systems, and surface and subsurface effects resulting from project implementation. An outgrowth of these activities included the formulation of selection and ranking criteria.

Based upon the findings of these activities and the criteria developed, a ranking of the most promising candidate systems was developed. The resulting recommendations were presented to city officials, citizens' advisory groups, and the general public, and European cucumber greenhouse and prawn raceway culture operations were selected as the most promising private enterprise-initiated follow-on projects. At this meeting, the city also adopted plans for implementing future projects of city-initiated ventures.

The study culminated in the formulation of the preliminary engineering design, management plan, and contingency plans of the follow-on project selected. As a direct aid to other users and communities desiring to exploit their geothermal resource, a self-start manual was also prepared. This would enable interested users and communities having similar geothermal resources to readily evaluate appropriate nonelectric applications to meet their specific needs and to gain added insight into how best to implement these applications.

III. CONCLUSIONS AND RECOMMENDATIONS

As a result of the engineering and economic analysis conducted, the applications investigated were grouped into the following categories:

Projects Not Recommended

- Car Wash
- Agribusiness Energy Cascading System
- Space Conditioning Utility Network

Conditional Projects

- Energy Cascading System for Mobile Home Park
- Space Conditioning of Community Center
- Space Conditioning of Multi-Use Center and City Hall
- Space Conditioning of Industrial Complex
- Space Conditioning of Angel View Clinic
- Space Conditioning of Spa-tel
- Space/Water Heating of Public Building Complex

Recommended Projects

- European Cucumber Greenhouse Operations
- Raceway Culturing of Malaysian Freshwater Prawns (pilot research program)
- Expanded Spa Utilization

Projects not recommended were selected on the basis of the following rationale. The car wash operations were discarded because the current trend is away from hot water usage to a cold water-detergent wash. The energy cascading agriculture/aquaculture concept was discarded on the basis of disease control, chemical contamination interactions, and effluent disposal considerations. Current economics and hydro-logic yield estimated for the DHS geothermal resource render a community-wide space conditioning network infeasible at the present time.

Projects grouped in the conditional category were classified accordingly because of the following reasons. Based upon present energy rates and 180°F. inlet water availability, capital investment in a 100-unit mobile home park energy cascaded system is not justified. However, projected inflation rates or the discovery of a hotter temperature resource would markedly enhance the project's economic viability. The balance of the conditional projects would satisfy the more fundamental need of space conditioning or space/water heating but were judged infeasible based upon known geothermal resource characteristics and economic considerations. Here again, the economic viability would markedly change with 1) the discovery of a higher temperature resource at or near the user site at greater well depth, 2) natural gas deregulation, 3) threats of gas quotas, 4) curtailment of natural gas, or 4) significant energy cost escalations.

There are no insurmountable impediments to future nonelectric geothermal development in DHS from a regulatory or environmental standpoint. Three projects emerged as economically viable follow-on activities at DHS. On the basis of market, market penetration capability, income, and year-round operational characteristics, greenhouse operations of European cucumbers emerged as a viable undertaking. Raceway culturing of freshwater prawns also appears lucrative for similar reasons. However, because of the number of uncertainties still associated with culturing of *Macrobrachium* in geothermal fluids, the recommended follow-on activity is centered about a pilot research program which can escalate into a commercial undertaking once the feasibility of direct use aquaculture has been empirically substantiated. The distribution of capital costs observed in the mobile home installation also suggests that a new spa installation with close-coupled chilled/hot water space conditioning system may be a very attractive possibility.

All of the recommended projects that emerged as economically viable follow-on activities at DHS are most likely to be private enterprise-initiated projects. Projects that would satisfy the more fundamental need of space conditioning are grouped unfortunately in the category of conditional projects, awaiting the discovery of a higher temperature resource ($>250^{\circ}\text{F}$) of significant yield.

Notwithstanding, the undertaking of any follow-on project must proceed with utmost care because of 1) the finite yield of the hydrothermal resource ($\sim$ half of the estimated yield is presently used to support the spa operations), 2) dearth of resource characterization and environmental background data, and 3) the City's primary desires to protect the ongoing spa operations.

In view of these considerations, the City of Desert Hot Springs has elected to pursue follow-on activities in:

- o Resource Characterization

- Request the California Division of Mines and Geology to evaluate the DHS hydrothermal resource.
- Apply for an EDA technical assistance grant for exploration, slim hole drilling, and characterization of geothermal resources at greater well depths.

- o Planning Grant

- Apply for a DOE planning grant to enable the establishment of the energy element of the general plan, ordinances, and resource management policies.

- o Follow-on Projects

- Assess project options based on resource confirmation data and pursue city-initiated project(s) as appropriate.

- Projects to be assessed should include space conditioning applications that utilize geothermal as well as hybrid (e.g., fossil fuel or solar augmented) energy systems.

The intent of these follow-on activities is to confirm the existence or nonexistence of a hotter, yet-to-be-discovered resource and to define the potential projects and resource management techniques that could be implemented in the event a suitable resource is discovered.

In the following sections, a discussion of the analyses that led to these conclusions and recommendations are highlighted. Additional expository remarks append each of the major study elements.

IV. RESULTS AND DISCUSSION

A. Community Needs Assessment

In order to tailor, to the greatest extent possible, the use of the indigenous geothermal resource to the needs of the community, an assessment of site-specific needs, markets, and regional requirements was undertaken. The results of this assessment lead to the following findings.

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 subdivided, 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.

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.

A series of public attitude surveys further revealed the following trends. 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 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.

See Appendix 3 for a further exposition of work and findings resulting from this activity.

B. Geothermal Resource Characterization

In order to assess the nature and extent of the DHS geothermal resource, the types of projects the resource can support, and how the resource must be managed to sustain these operations, an effort was initiated to determine (1) the areal extent of the geothermal aquifer system, (2) a safe yield for the hydrothermal resource, and (3) potential areas of recharge and reinjection.

1. Approach

In characterizing the geothermal resources underlying the City of Desert Hot Springs, the task was attacked from three different vantage points. First, an initial literature review was required in order to understand the concepts and theories as they pertain to the upper Coachella Valley. Second, field work was conducted to collect, synthesize, and analyze geologic and hydrologic data that would enable the delineation of the areal extent of the aquifer, hydrologic characteristics, and potential areas of recharge. Finally, analysis of precipitation and runoff data was conducted to determine a hydrologic budget for the area.

2. Summary of Results

Little in-depth research has been conducted in the Desert Hot Springs area of the Coachella Valley. However, from existing well log data, geologic cross sections were constructed to identify the probable aquifer material. The thickness of the aquifer system estimated from a geologic cross section that bisects the Desert Hot Springs area is 1000 feet. There are no wells in the area for which well logs are available that indicate the depth to bedrock (nonaquifer material) and the deepest well is ~800 feet. Hence, the 1000 foot aquifer thickness appears to be the best estimate available and valid for purposes of this study.

Pump tests were conducted to determine the coefficients of transmissibility and storage, static water level, specific capacity, and resource temperature. A temperature isotherm map for the DHS project site was constructed utilizing temperature graduations representative of agribusiness and space conditioning temperature thresholds (Figure 1).

The surface extent determined by the 90°F isotherm is 5.45 square miles. Two hot spots predominate in this region; a southeastern pocket within Desert Hot Springs and the Dillon Road area (outside the city limits). This indicates that these two systems may be isolated somewhat from each other; most likely by the source of their water supply and heat.

FIGURE 1 . TEMPERATURE ISOOTHERMS IN THE DESERT HOT SPRINGS AREA

The results of the computations for the safest safe yields of all temperature isotherms considered are presented in Table 1. The coefficient of transmissibility (20,000 gpd/ft) indicates an aquifer of sufficient capability to support an industrial municipal, or irrigation project, whereas the storage coefficient (1.4×10^{-4}) indicates the system is an artesian aquifer (i.e., one under a pressure head from the overlain material).

In locating potential sites for groundwater recharge or reinjection, four requirements must be met.

- a. An area of lower temperature than the production zone.
- b. An area of high permeability.
- c. An area where there will be no degradation of groundwater.
- d. An area where the water will return to the system.

Of the sites investigated, the Blind Canyon area appears to meet the four parameters of consideration. A fault is located in the area which would serve as a conduit to return the water to the system at a rapid rate. A recharge basin would be desirable over a reinjection well due to the fault locality. Such a system of effluent disposal and aquifer recharge should be readily effected for applications of indirect use. For direct use applications of geothermal fluids, waste treatment may precede disposal, depending upon the character of the water supply over which the percolation basin is sited.

3. Conclusions

The Desert Hot Springs hydrothermal resource is a relatively new and undefined reservoir that has enjoyed limited usage to date for spas and hotel pools. Very little geologic, hydrologic, and geochemical work has been performed in the area.

However, based on the additional work conducted on this study, a determination was made of the areal extent, hydrologic characteristics, safe yield, and potential sites for recharge of the DHS geothermal resource. The results of this work indicate the capability to support a greater development and utilization; nearly one-and-a-half times the present rate of use for agribusiness applications.

A need exists to undertake a slim hole drilling program to determine the characteristics of geothermal resources at greater well depths. If resource temperatures in excess of 250°F can be acquired with sufficient yield, space conditioning applications for residential and industrial installations may be possible. Such an undertaking would satisfy a more fundamental need of the community and enjoy widespread support.

TABLE 4

Safest Safe Yield of Representative Temperature Isotherms and Project Sites

<u>Temperature</u>	<u>Desert Hot Springs (City Limits)</u>	<u>Dillon Road Area</u>
90°F	2,100 acre ft/yr	
120-150°F	2,800 acre ft/yr	2,400 acre ft/yr
150-180°F	2,700 acre ft/yr	2,400 acre ft/yr
> 180°F		2,300 acre ft/yr

Notwithstanding, additional tests are needed to better define the geologic, hydrologic and geochemical characteristics of the DHS hydrothermal resources so that it may be managed as a nondepletable, non-polluting alternate energy source.

(See Appendix 4 for additional expository remarks.)

C. Geothermal Applications for DHS

In attempting to assess the potential for expanded use of the geothermal resource at DHS, the following basic approach was undertaken: an estimate was made of the average heating and cooling loads at DHS, based on local area weather data and a Southern California Edison (SCE) analytical model of a typical Southern California residence; a list of potential geothermal applications for DHS was compiled for later screening (based on various technical, economic, social and environmental factors) to the most likely candidates; and a general assessment was made of available geothermal equipment to determine what potential technical or economic problems might exist for a heating or cooling system at DHS. The results of each of these areas are summarized in the following paragraphs, while the complete effort is documented in Appendix 5.

Even a cursory look at the DHS area readily establishes the qualitative need for an economical space cooling alternate to electric powered air conditioners. However a detailed analysis was conducted to determine some quantitative estimate. In evaluating the space conditioning loads for DHS, a 1974 SCE study of an average Coachella Valley home was used, and updated by factoring in a current SCE rate schedule. This study reinforced the obvious feeling that a large amount is spent annually on space cooling (\$541), but also highlighted the less obvious fact that a substantial sum is also spent on space heating (\$300) in this high desert community. Considering the average monthly space conditioning costs of \$70 (and more for larger homes) at today's electric rates, coupled with the current trends of increasing electric energy costs, there appeared to be ample incentive to investigate geothermal space heating and cooling applications for DHS.

Figure 2 shows the various geothermal applications that were considered for DHS. These options were screened by considering various technical, economic, social and environmental factors, to determine where the best fit might be for DHS. The most promising options appeared to be in the areas of a space/water heating project, a geothermally heated greenhouse, a geothermal aquaculture operation or possibly an energy cascading mobile home park. These selected options are discussed in considerable detail in the Sections D through G, respectively. In addition, the continued expansion of the existing and successful Spa industry at DHS is an obvious conclusion, but one that was not officially addressed by the study.

The conspicuous omission from the above group is the presence of space cooling. Unfortunately, the area where the need is the greatest (i.e., air conditioning in a desert community) was eliminated, with the possible inclusion in the energy cascading system, due to economic considerations. Geothermal-powered air conditioning is technically feasible with inlet water temperatures as low as 170° F, but economic operation is currently out of the question for DHS resource temperatures (208° F maximum known). At some future date, however this conclusion could be changed by one or more of the following events: the discovery of a hotter resource at greater depths (current geothermal wells at DHS are all shallow - 200 to 800 feet deep), continued escalation of electric energy rates, and future breakthroughs and progress in low temperature space cooling technology.

FIGURE 2

GEOHERMAL APPLICATIONS FOR DHS

D. Space/Water Heating

A search was made for space and water heating applications, as a separate entity, after space cooling was eliminated due to the technical and economic factors outlined in Section IV.C. Therefore, an investigation was made of existing facilities as well as proposed projects to try to match the requirements with the available heat source, i.e., space heating with the geothermal resource.

The ideal project for geothermal space and/or water heating would be a large public facility located near the hotter ($\geq 150^{\circ}\text{F}$) geothermal resource isotherms, and with a heating system that was designed for or could be easily retrofitted (i.e., central heating) for geothermal use. The advantages of such a choice are numerous:

- (1) high visibility to the community,
- (2) large enough to take advantage of economies of scale and increased efficiency inherent with larger equipment,
- (3) minimal thermal losses between the geothermal source and the potential user,
- (4) maximum equipment performance resulting from the selection of the hottest resource temperature, and
- (5) maximum utilization of existing equipment (for retrofit situations).

Since no single application was found at DHS with all these attributes, the final project selection would obviously require a certain degree of compromise. The five candidates eventually selected for study as geothermal space and/or water heating projects were the following:

- (1) Angel View Crippled Childrens' Clinic
- (2) Proposed Multi-Use Center
- (3) City of Desert Hot Springs City Hall
- (4) Municipal Heating System
- (5) Car Washing System

1.0 Angel View Crippled Childrens' Clinic

The Angel View Clinic is situated near the higher temperature geothermal resource of 150°F . The building is currently heated by means of oil-fired heaters. The study considered replacing these heaters with geothermal water heaters located at three points in the building.

The study revealed that the current annual operating cost of \$3,850 was far lower than the annual capitalized cost plus operating cost of the proposed geothermal system (\$9,768), and therefore this would not be an economical project. Two factors that penalized the study against the geothermal system were the decentralization of the Angel View heating system and the fact that the present system was assumed to have no capital outlay.

The detailed economics study is shown in Appendix 6A of this report.

2.0 Proposed Multi-Use Center

The City of Desert Hot Springs has proposed the construction of a new community center. The present location being considered is adjacent to the City Hall. Little firm data were available regarding the building itself, so for the purposes of this study it was assumed to be a single-level facility approximately one-hundred by one-hundred and twenty feet in size. Also, since the siting has not been finalized, it was assumed for study purposes that the new center could be located over the 150° F isotherm.

The conclusion reached after considering the economics of a new geothermal heating system versus a gas fired heating system was that gas heating, at the present time, is more economical than geothermal. Table 2 shows the comparison of the alternative systems.

Table 2. Comparison of Alternative Heating Systems for the Proposed Multi-Use Center

	<u>Geothermal System</u>	<u>Gas-Fired System</u>
Capital Cost (\$)	5,160	1,120
Annualized Capital Cost (\$)	800	267
Energy Cost/Year (\$)	195	324
Total Annual Cost (\$)	995	591

The detailed technical analysis and cost breakdown is shown in Appendix 6, Section B.

3.0 City of Desert Hot Springs City Hall

The City Hall complex overlies geothermal resource water temperatures of only 90°F which is too low to consider for space heating. Thus, if the existing City Hall were chosen as a demonstration site, it would be necessary to pipe water approximately one mile from the 150°F isotherm.

When the capitalization cost of the initial expenditure of \$29,000 for the geothermal system was evaluated against the current low operational cost, there was obviously no payback period within the life of the project, even though the operational cost of the geothermal system would be only \$6 per month versus \$62 per month for the gas system. The poor utilization factor for a single building cannot possibly justify the large capitalization costs required for the geothermal system.

4.0 Heating System for Municipal Buildings in Desert Hot Springs

The previous discussion with respect to the City Hall revealed the following facts. The City Hall is located near that portion of the geothermal aquifer which contains only 90° water. Since space heating and water heating require a minimum source temperature in the region of 150°F, the available 90°F source cannot be used. The nearest known geothermal source of 150° F would require the installation of over one mile of source pipeline.

The heating system would require a minimum of two wells (one for production and the other for injection) and yet utilizes only a small portion of the available flow rate from the source well. In addition, over two miles of pipeline and appropriate conversion equipment in City Hall would be required. In view of the limited heating season and the low heating requirements of City Hall, it is obvious that a geothermal heating system for City Hall is not an economically viable project.

Based on the above, consideration was given to what effect an additional heating load would have on the economics of the system. This additional load was achieved by considering the following additions to the City Hall:

- (a) Wardman Park - consisting of a swimming pool, recreation hall, Wardman Hall, and the Scout Hall
- (b) Elementary School
- (c) Library
- (d) Provisions for the new proposed Community Center

The maximum heating load occurs during the winter period and unfortunately presents an imbalance in annual resource utilization. This imbalance is not changed greatly by heating the swimming pool in the summer months. Without the possibility of air conditioning in the summer months, which is excluded by the limited resource temperature, there does not appear to be any way to achieve a sufficiently uniform annual load.

An economic analysis of the system over an assumed twenty year system life revealed that the system would have a net loss (in present worth dollars) of \$227,005. While the study revealed substantial operating cost savings (\$1,104 per year for the geothermal against \$3,930 for the existing system), the savings were not adequate to cover the cost of capital needed to finance the project.

Further calculations revealed that even after considering depreciation tax benefits and a fossil fuel escalation rate of 7% per year, the maximum amount which the City would be justified in investing in a heating system was \$53,800.

Appendix 6, Section C, gives a complete technical and economic analysis of the proposed network.

5.0 Car Washing System

The car wash was considered for study because inquiries made revealed that the closest car wash is located in Palm Springs, approximately 30 minutes driving time away. However, a survey of local car wash operations revealed that the majority of automatic car wash systems use cold water with cold water detergent and high speed cold air for drying.

Sufficient relative data was compiled to substantiate these findings and are presented in Appendix 6, Section D. Based on these findings the car wash study was discontinued.

6.0 Summary and Conclusions

Based upon the results of the five candidate systems studies, it was found that the economic analysis is very sensitive to capital costs (primarily piping and pumping costs), resource temperature and utilization factor. The greater the usage of geothermal fluid, the greater the amount of energy displaced and hence the better the possibility that the initial capital expense can be offset by the energy savings. This did not prove to be the case at Desert Hot Springs for the study conditions assumed. Since most of the potential applications at Desert Hot Springs are already sited in locations relatively distant from the hotter isotherms, and their requirements do not effectively utilize the resource, it appears that no workable heating system is economically viable with the current cost of conventional fuels.

From the outset of the Desert Hot Springs study, certain facts were obvious in connection with a space conditioning project. Since the city is located in a desert locale, the space cooling load is considerably higher than the space heating load. Thus, any space conditioning project which does not include space cooling is immediately at a distinct economic disadvantage due to the poor annual resource utilization factor. Also, for retrofit situations, a further economic disadvantage exists for the geothermal system since there is no initial capital cost associated with the existing system.

With this background, it comes as no surprise to find that the individual schemes and the municipal geothermal heating network for the city are not feasible based on straight economic considerations and full financing by the City of Desert Hot Springs.

However, there are a couple of positive notes to be pointed out with respect to the proposed municipal heating system. In addition to displacing almost 145,000 equivalent kWh (natural gas and electric) per year of fossil fuel, the geothermal system would provide a certain degree of energy independence, particularly with regard to natural gas. The future prospect of gas curtailment and/or deregulation could drastically alter the economic analysis previously presented, in favor of the geothermal system.

If some source of funding, such as an EDA Public Works Grant or a DOE Program Opportunity Notice (PON) for a field experiment, could be secured for the remainder of the required capital investment, the proposed system could be feasible. A PON for a field experiment could also be very helpful in locating a hotter isotherm closer to the proposed heating network.

E. AGRICULTURAL OPERATIONS

1. Agriculture Potential

After meeting with various consultants and experts in the agriculture field, the wide variety of possible choices suitable for a geothermal greenhouse environment was quickly narrowed to only those with the best market potential. This greatly facilitated the research and screening operation. The consensus choice was the European cucumber, with a possible second choice of the tomato.

One of the strengths of the European cucumber is that it is a distinctly different product than the conventional field cucumbers, and as such, can have its own tailor-made marketing campaign. The greenhouse tomato, on the other hand, is merely a better quality product than the field tomato during certain portions of the year. Some of the key selling features of the European cucumber are the longer shelf life (estimated up to 2 1/2 weeks),² uniform high quality and attractiveness, burpless, seedless, and no peeling needed. The high quality is evident not only by the outside appearance, but especially by the firm inside with minimum seed content and superior taste. Because of the higher price in the market of the European cucumber, people may initially view it as a luxury item as they do many new products introduced. However, once they become familiar with it and realize the advantages it offers, the demand will continue to grow, resulting in even better price stability and profitability.

One of the chief requirements for effective penetration into the agriculture market is to produce a quality product in sufficient quantities to support a steady demand over an extended period of time. Here again the European cucumber offers an advantage over the greenhouse tomato. The cucumber is a year round crop which can be harvested virtually daily. The greenhouse tomato has a limited market between December and May during which a crop can successfully compete with the field crop imported from Mexico. Thus, in order to exploit only the profitable seasonal demand for greenhouse tomatoes, it would be necessary to find a wholesale distributor willing to deal with the product during a limited production season, in addition to changing over the greenhouse production to cucumbers during the remainder of the year.

The European cucumber has been researched and marketed for many years in Holland and other European countries, but has been introduced into the U.S. market only in recent years. Initially, the demand was low (as expected) and the wholesale price fluctuated between breakeven and reasonable profit levels as shown in Figure 3.³ Since then, both demand and wholesale price have grown steadily to the point where profit margins can be achieved year round. This can be seen clearly (Table 3) by the recent price from the Los Angeles wholesale market for two of the slowest market months, June and July.⁴

FIGURE 3 EUROPEAN CUCUMBER WHOLESALE PRICES - 1974

TABLE 3

Los Angeles Wholesale Prices*--European Cucumbers

June-July 1977

<u>Date</u>	<u>Volume (Cartons)</u>	<u>Price Range (\$/Carton)</u>	
		<u>Size 10-12</u>	<u>Size 14-20</u>
June 1	1575	4.00	6.00 - 7.00
June 8	1550	4.50 - 5.00	5.50 - 6.50
June 15	1175	5.50 - 6.00	6.50 - 7.00
June 22	700	6.00	7.00 - 7.50
June 29	1150	6.00 - 6.50	7.50
July 6	550	6.00 - 7.00	7.50 - 8.50
July 13	1000	7.00 - 7.50	8.00 - 8.50
July 20	100	6.00 - 6.50	7.50 - 9.00
July 27	825	No Quote	7.50 - 9.00

*Los Angeles Wholesale Market Report, Fruit and Vegetable Market News,
Federal-State Market New Service, Los Angeles, California

The market for the European cucumber is nowhere near saturation, with the exception of occasional local short term problems during peak harvest periods.³ The Los Angeles and San Francisco markets currently utilize only approximately 15% of the total southern California production, with the remainder going to direct shipments mostly to western or midwestern cities. Because of the high energy costs in the eastern United States, very few European cucumbers are grown there and the market is almost untapped.

In view of the current prospects for future energy costs, European cucumbers grown in geothermal greenhouses appear to be even more attractive. Since the cucumbers require warmer overnight lower temperatures than other produce, they are more energy intensive, with approximately 25% of the direct production expenses going to greenhouse energy.² Recent energy costs in the East and Midwest have already resulted in drastic shrinkage of greenhouse acreage. Because of this energy picture and the fact that they can be grown only in greenhouses (cross pollination by either bees or wind causes distorted fruit⁵), they appear to be an excellent candidate for geothermal energy use.

2. Horticulture Potential

The horticulture industry presents a sizable market in California as the ninth largest industry in the state. Major commercial areas covered by the horticulture label are the cut flower market, all ornamental plants, nursery stock, ground covers, and the entire cactus family.

The members of the succulent family, including cactus, would be very well suited to the desert environment at DHS and are very popular both in the United States and abroad; however, recent international laws have prohibited exportation of all varieties since they were placed on the endangered species list.⁶ The U.S. is currently considering even prohibiting interstate shipments except in very specific cases. In view of these prospects, the succulent family was eliminated from further consideration.

The ornamental plant market is not as strong as it was a couple of years ago when it appeared to have reached peak levels. As a result of this, saturation in this area might pose something of a problem. A second problem affecting the ornamentals as well as the general nursery stock and ground covers is the soil at DHS. All of the above require a good supply of rich solid for shipping purposes. The actual growing media is not much of a problem since it is built up to the desired quality anyway, but shipping soil is a problem. The soil at DHS may have a high salinity level that will require leeching, in addition to the normal buildup required for nitrates and other necessary constituents for a rich growing media.

The cut flow segment avoids this soil turnover problem and may in the long run provide the best potential for a greenhouse application in DHS. In the last few years the demand for quality cut flowers has continued to grow while local greenhouse acreage devoted to cut flowers has been shrinking or at best remaining constant. Several factors have contributed to this lack of growth: smog, energy costs, high taxes, and high land costs. Many growers have been forced out of business because it was more profitable to sell the land; others have elected to relocate operations out of Los Angeles and Orange counties to avoid the smog and high costs.⁷ To counter these negative factors, the area around DHS offers almost unlimited sunshine, relatively clean air, cheaper land, lower taxes, and a potential economical energy source. However, while the warm nights are an asset, the high temperatures during the days will definitely dictate a substantial cooling load.

Because of the many advantages offered by a greenhouse atmosphere (control of temperature, air quality, pests, disease, relative humidity, etc.), growers have been steadily converting more and more of their operation over to greenhouses. Poinsettias used to be grown outdoors and are now grown entirely inside. Ninety percent of all nursery stock and cut flowers are started in greenhouses.⁸ Because of this emphasis on greenhouses, the industry is very energy sensitive and a good candidate for geothermal development.

The largest selling varieties in the cut flower market are roses, chrysanthemums, carnations, and daisies. Another flower looked at was the orchid, but it was eliminated due to its delicate and perishable nature which would not adapt well to the DHS locale. The daisy was eliminated because it is still grown primarily outside and likes a milder climate. Further study needs to be done in order to select the best candidate of the remaining three. The carnation is the most labor intensive of the three, which is a disadvantage, and may not be able to compete effectively against imports from Columbia and large scale operations in the State of Colorado;⁹ while the rose is the most sensitive to rough handling and various diseases.

The location of DHS with respect to the cut flower market is advantageous for several reasons. It is well situated between two very strong regional markets--San Diego and Los Angeles, in addition to a good local market in Palm Springs. DHS is also located just off the main truck route east from Los Angeles. This could work to a double advantage in that empty refrigerated trucks returning to Los Angeles could pick up loads for delivery there.

3. Final Selection

On the basis of market, market penetration capability, income, and year-round operational characteristics, the European cucumber was selected as the target candidate agricultural operation. However, a greenhouse is not limited to agriculture and horticulture can also be considered. This notion is further reinforced by a geothermally heated rose growing greenhouse industry just being developed at Indio which is close to the City of Desert Hot Springs.

4. Agriculture Complex Design

4.1 Greenhouse Design Criteria

The basic concept of a greenhouse is to collect the heat from the sun to provide an environment at a higher temperature than that normally found locally. However, in Desert Hot Springs where high temperatures are experienced during the summer months, there will be a requirement to cool the greenhouse to provide the optimum growing environment for the European cucumbers.

The optimum parameters to be considered for growing European cucumbers are as follows:

Temperature range of 75°F to 90°F; optimum 80°F

Humidity 85%

Minimum night-time and winter temperatures 65°F

The outdoor temperature is 110°F average in the summer months in Desert Hot Springs, and the summer humidity is around 15 to 20% ambient. Therefore, the greenhouse will require cooling. If night-time and winter minimum temperatures should fall below 65°F inside the greenhouse, the crop will experience a slowdown in growth rate.

4.2 Greenhouse Construction

The assessment of greenhouse options resulted in the selection of metal frame construction with fiberglass panels as the most economic type for DHS. The height of the greenhouse side walls is 8 feet. This allows the plants to grow to a height which is workable for fruit collection without the use of ladders or platforms.

4.3 Basic Systems for Cooling and Heating

Cooling is accomplished by means of evaporative cooling (Figure 4) which also adds humidity. The evaporative unit consists of a screen at one end of the building over which water is sprayed. At the other end of the building is placed an extraction fan which draws air across the screen and along the full length of the building interior and exhausts to the outside. Experience indicates that maximum building length be held to 100 to 125 feet for effective cooling using this method. At least one air change per minute is required in the greenhouse to obtain correct cooling by this method.

Calculations made for the Desert Hot Springs area indicate that the temperature inside the greenhouse is likely to be 90°F with 85% relative humidity, using 2 changes per minute, when a coat of whitewash is applied to the greenhouse. The whitewash coat is applied to the outside of the greenhouse in the summer to reduce the heat gain from the sun to the greenhouse interior by reflecting a major portion of the sun's rays. This 90°F temperature condition is likely to occur for about 3 to 4 hours per day during the summer months.

FIGURE 4 EVAPORATIVE COOLING

Heating a greenhouse complex is not as difficult a problem as cooling. The main design consideration is to ensure the introduction of the hot air at a low level between the rows of plants to allow the air to rise slowly. This method will reduce condensation buildup around the base of the plant stems which can cause stem rot.

The one-pass heating system selected, shown in Figure 5, utilizes a heating coil in the first stage of the inlet air duct followed by a second stage consisting of a spray chamber for humidification and a third stage having a reheat coil. The heating bills for this type of building are extremely high because of the tremendous exposed surface which has virtually no insulation value, and the high volume of air passing through to provide the minimum of one air change per minute. This is an ideal application of a resource like geothermal hot water, since the heating costs will be considerably lower than those experienced with oil or gas.

5. Greenhouse Complex Arrangement

Figure 6 shows a greenhouse of approximately 2 acres which is a commercial production size installation capable of making a profit in production of European cucumbers.

A typical installation for a 2 acre production would probably consist of a series of greenhouses with 20' to 30' bays, 120' long, side-by-side, on a one-acre lot contiguous to a similar arrangement on an adjoining acre. The two installations would have a conveyor system located between them to deliver harvested cucumbers into a packing plant located in a warehouse adjoining the greenhouse complex. A small office for dispatching and receiving would be located in the warehouse. Since the cucumbers would sometimes have to be stored awaiting transportation, the warehouse would include a cold storage room cooled to 55 to 55°F.

5.1 Planting Systems

The choice of planting systems can be natural or hydroponic. The natural system consists of placing plants in a bed of sand and soil mixture with drip irrigation and was determined to be the most economical system for the Desert Hot Springs application. The plants can be laid out on rows of two abreast, 24 inches apart, on 18 inches spacing with 4.5' aisles between the rows.

5.2 Production Rate

Plant density is such that typical annual yields are 15 lb per plant per crop, or 240,000 lb per acre. Three crops-plus per year are possible and are being currently achieved in the USA, which translates to annual production of approximately 240 tons from a 2 acre complex. At the present time, about 70 acres of greenhouse production is devoted to cucumbers in the United States.

FIGURE 54 HEATER ON ONE PASS BASIS WITH HUMIDIFICATION

FIGURE 6 PROPOSED GREENHOUSE & WAREHOUSE DEVELOPMENT -
DESERT HOT SPRINGS GEOTHERMAL PROJECT

The greenhouse complex under study can grow a maximum of 825 plants per module. A module equals 30' by 120' of enclosed greenhouse area. Each module would be harvested for 12 weeks, then plants would be chopped down, the beds resowed and a new harvest started. Figure 7 shows the planting, harvest, and resowing schedule.

Based on this schedule the annual production was calculated and found to be approximately 1 million lb/year. Allowing for a 10% loss due to damage or insufficient quality, the total yearly production is approximately 900,000 lb for the 2 acres.

From data gathered by growers in other areas, it has been determined that a good yield for this type of crop is 10,000 lb/1,000 sq ft/year. The complex in this study will produce 11,500 lb/1,000 sq ft/year.

6. Economics Assessment

The 2 acre greenhouse complex utilizing geothermal hot water for heating is economically viable in the Desert Hot Springs area when operated over a 12 month period for production of European cucumbers. In view of the fact that the 2 acre complex is economically viable for a year-round growing season, it is obvious that a larger facility would also be economically viable. The reasons for this are that the labor force, heating and cooling costs, and production rate are all directly proportional to complex size. Therefore, it follows that if a 2 acre complex is economic then will four, ten or any size complex. The limiting factor would ultimately be market saturation.

The totalized costs for the operation of a 2 acre greenhouse complex over a full 12 month operating cycle are shown in Table 4. The net profit is dependent on the cost of capital and has been shown at a 10% and 12% interest rate. The net profit would be \$180,281 at 10% and \$167,504 at 12%.

The reduced growing season study revealed that the abbreviated season operation would not be considered economically feasible for the 2 acre complex.

FIGURE 7 GREENHOUSE PRODUCTION PATTERN FOR
UNIFORM ANNUAL CROP DISTRIBUTION

TABLE 4

TOTALIZED COSTS FOR 2 ACRE GREENHOUSE COMPLEX

ALL YEAR PRODUCTION OF CUCUMBERS

<u>Item</u>	<u>Cost (\$)</u>	
Initial Capital Investment	932,657	Note 1
Annual Labor Charges	114,084	Note 2
Fuel Costs - Heating	27,842	Note 3
- Cooling	29,778	Note 4
Fixed Annual Costs	69,510	Note 5
Interest Payment on Initial @ 10% for 7 Years	191,345	Note 6
Borrowed Capital @ 12% for 7 Years	204,345	Note 7
Annual Income	615,433	Note 8
Net Profit @ 10% Interest Rate On Capital	180,281	
@ 12% Interest Rate on Capital	167,504	

Note 1 - See Cost Estimate Data (Appendix 7D)

Note 2 - See Table 3 Appendix 7

Note 3 - See Table 5 Appendix 7

Note 4 - See Table 6 Appendix 7

Note 5 - See Table 7 Appendix 7

Note 6 - See Economic Calcs Appendix 7B

Note 7 - See Economic Calcs Appendix 7B

Note 8 - See Economic Calcs Appendix 7B

Table 5 shows the totalized costs for the reduced growing season. As can be seen, the rate of return on the invested capital is critical to the operation profitability and in the case under study would not be considered profitable.

7. Conclusion

The economic study revealed that the 2 acre greenhouse complex would be economically feasible utilizing geothermal energy for winter heating and evaporative cooling in the summer.

Currently, however, the same system could be installed profitably utilizing fuel oil as the heating medium.

Two things could occur to change this situation, one would be a rapid rise in fuel oil costs and the other would be the discovery of a higher temperature geothermal resource capable of supporting both heating and space cooling equipment.

The energy independence obtained by utilizing the geothermal resource is a factor which should be heavily weighed in favor of the geothermal system because the heating system operating costs would be relatively stable in a very energy conscience industry and, therefore, could provide the economic edge over competitors.

TABLE 5

TOTALIZED COSTS FOR 2 ACRE GREENHOUSE COMPLEX
NINE MONTH PRODUCTION OF CUCUMBERS

<u>Item</u>	<u>Cost (\$)</u>	
Initial Capital Investment	932,657	Note 1
Annual Labor Charges	114,084	Note 2
Fuel Costs - Heating	30,212	Note 3
- Cooling	16,243	Note 4
Fixed Annual Costs	67,779	Note 5
Interest Payment on Initial @10% for 7 Years	191,568	Note 6
Borrowed Capital @12% for 7 Years	204,345	Note 7
Annual Income	442,237	Note 8
Net Profit @10% Interest Rate On Capital	47,837	
@12% Interest Rate On Capital	5,059	

Note 1 - See Cost Estimate Data (Appendix 7D)

Note 2 - See Table 3 Appendix 7

Note 3 - See Table 5 Appendix 7

Note 4 - See Table 6 Appendix 7

Note 5 - See Table 7 Appendix 7

Note 6 - See Economic Calculation (Appendix 7C)

Note 7 - See Economic Calculation (Appendix 7C)

Note 8 - See Economic Calculation (Appendix 7C)

F. Geothermal Aquaculture Operation Study

1.0 Potential Aquaculture Candidates for DHS

Aquaculture has generated considerable interest and research in recent years, motivated by increased per capita consumption of sea food, increased difficulty by fishermen in expanding catches, and the need for a dependable high-protein food source for future generations. With this background, Desert Hot Springs appeared to be an interesting choice for an aquaculture operation (requiring higher than normal growing temperatures) because of the desert climate coupled with the geothermal resource.

The most promising species considered suitable for culture in geothermal water of low salinity such as found at DHS include trout, catfish, Tilapia, striped bass, and freshwater shrimp (or prawn) as commercial food products, and also tropical fish for the hobbyist market. The two most promising species were the striped bass and the freshwater prawn, Macrobrachium rosenbergii. Although the production of striped bass appeared to be economically feasible, it was eliminated as the final selected candidate because of the potential legal entanglements discussed in Appendix 8. As a result, the freshwater prawn was selected as the target candidate for an aquaculture operation design at DHS.

In summary, this particular species of freshwater prawn appears well-suited to culturing for numerous reasons: it grows rapidly at elevated temperatures, has an omnivorous diet, reproduces easily in captivity, produces large numbers of larvae per female, has relatively short larval phases, is hardy and disease resistant, has good food conversion ratios, good taste, and a relatively high market value. The general market for shrimp and prawn in the United States in recent years has been very strong with per capita consumption increasing steadily.

One of the biggest problems with prawn culturing in the continental United States to date has been locating sites suitable for year-round growing. The approach has generally been to site near power plants to utilize the waste heat for maintaining optimum culturing temperatures (approximately 85°F) regardless of ambient temperature variations. However, land there is often limited and expensive. Desert Hot Springs provides a possible solution to this problem since land is relatively inexpensive, the climate is warm during a good portion of the year, and the geothermal resource can provide an inexpensive heat source during the remainder of the year. In addition, the water quality of the geothermal fluid at DHS appears to offer no problems for direct aquacultural applications. Thus, M. rosenbergii seems well suited for an aquaculture project at Desert Hot Springs.

2.0 Marketing Assessment for Freshwater Prawn

Obviously, one of the key factors to the success of an aquaculture venture is the marketability of the final product. Therefore, discussions were held with fisheries distributors, wholesalers, processors, and retailers to assess the existing market for freshwater prawn. Little or no quantitative data were uncovered. Based on the comments received, Macrobrachium is a specialty item at present and is not yet differentiated in statistics gathered by the U.S. Department of Commerce, National Marine Fisheries Service. The existing market is, therefore, assumed to be quite small.

If Macrobrachium were produced in DHS, it is assumed the shrimp would initially enter specialty retail markets in Southern California. Because of its size, it is not clear whether the Macrobrachium would compete with saltwater shrimp or lobster for a place in the shellfish market. For this reason, data on the extent and structure of existing markets for both shrimp and lobster were researched.

Data were gathered and plotted (Figures 1-17, Appendix 8) from various documents published by the National Marine Fisheries Service. These sources covered the monthly and annual statistics, from 1968 to 1976, for the ex-vessel (price paid to the fishermen for the catch), wholesale and retail prices, as well as per capita and total consumption, for both lobster and saltwater shrimp.

Shrimp prices have exhibited a relatively strong upward trend from year to year (Figure 1, Appendix 8), with compound annual increases of 11.5% for wholesale and retail prices, and 13% for ex-vessel prices. The ex-vessel and wholesale prices dipped in two years (1970 and 1974), while retail prices dipped only in 1970. These dips can be attributed to poor general economic conditions. The month-to-month variations (Figures 2-8, Appendix 8) were very scattered and exhibited no real seasonal trends.

Lobster prices also exhibited a very strong upward year-to-year trend, with compound annual increases of 10.5% for ex-vessel prices (Figure 9, Appendix 8) and 12% for wholesale prices (Figure 10, Appendix 8). Retail statistics were not available. Lobster prices have risen each year since 1968 without exception and are less sensitive to general economic conditions than shrimp. The month-to-month variations showed some definite seasonal trends, with marked differences between the ex-vessel and wholesale price patterns. Ex-vessel prices had a consistent yearly high peak in March or April followed by a steady decline to a low point in September (see Figure 11, Appendix 8). This appears to be a direct function of the lobster fishing season. The typical March peak is 90% above the previous September low price. The wholesale price curves (see Figure 12, Appendix 8) exhibit a similar March peak, but decline sharply to a May low point for the year followed by a second peak in August. In three of seven years plotted, the August peak exceeded the March peak. The higher of the two peaks represented a 52% increase over the May low price.

Statistics on shrimp and lobster consumption (both on an aggregate and per capita basis) were also studied. The U.S. aggregate consumption of shrimp increased fairly steadily over the period of 1947 to 1974, rising from 100 million pounds to 347 million pounds (Figure 14, Appendix 8). The per capita consumption over the same period increased from 0.69 pounds per person to over 1.5 pounds per person (Figure 15, Appendix 8). The only data gathered on lobster consumption were on lobster tails over the years of 1960 to 1974. Aggregate consumption rose from 27.3 million pounds to 32.4 million pounds, with a high of 39.0 million pounds in 1970 (Figure 16, Appendix 8). Per capita consumption rose from 0.152 pounds per person in 1960 to 0.187 pounds per person in 1970; however, steep declines tied to prevailing economic conditions resulted in a 1974 level of only 0.154 pounds per person (Figure 17, Appendix 8).

Other factors considered and discussed in some detail in Appendix 8 pertaining to establishing a market for freshwater shrimp were product identification, education of the public and restaurant community on the product (different taste, etc.), market approach (sales campaign aimed at "gourmet" versus "family-oriented" restaurants), and the market pricing strategy. Considering all factors and information gathered, the creation of a market for freshwater prawn in Southern California appears to be primarily a function of two factors: first, the introduction of 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. The lower the price of the Macrobrachium relative to shrimp and lobster, the greater portion of the market which will be captured. Arguments advanced relative to the requirements of product differentiation, alternative names, competitors in the field, and such factors 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 any new product introduction. The answer to a question of the existence of a market must be articulated in terms of prices, quantities, and timing. This analysis is by no means complete, but it does indicate a reasonable course to be followed in Desert Hot Springs for market creation activities.

3. Preliminary Aquaculture Design Studies

Some of the key areas to be looked at in detail when considering an aquaculture undertaking are the following: nutrition and disease control, water quality management and treatment, temperature control, and harvesting. Each of these items were addressed in detail, as reported in Appendix 8, and the results are summarized below.

3.1 Nutrition and Disease Control

Considerable progress has been made in recent years in the area of prawn nutrition, particularly in Japan and Hawaii. While the physical nutritional requirements of prawn are still not well understood, fortunately an adequate and fairly economical diet has been worked out for the prawn once they have reached the post-larvae stage. The larvae are still fed an expensive live fish diet such as *Artemia nauplii*, while the post-larvae diet consists of a commercially available Purina Shrimp chow at around \$0.25 per pound.

Once a proper diet has been worked out, it must be fed to the prawn in a controlled manner. If the prawn are not fed enough their growth suffers and they also become more cannibalistic. If they are overfed, food is

wasted and water quality suffers from the decaying food matter. For this reason, an automated feeding scheme is recommended to maximize control.

An important reason for a better understanding of aquaculture nutrition requirements is that a definite relationship has been established between nutritional stress and disease. A second factor affecting disease problems is crowding. As population density increases with intensive culture practices, more disease problems are observed.

Research is currently being conducted on normal and diseased shrimp to aid in recognizing diseases. Methods of preventing and treating diseases are also being tested. The implementation of suitable techniques for preventing and controlling diseases could have an important impact on the success of an aquaculture venture. Fortunately, with good water quality control, proper feeding and adequate culturing densities, disease control does not appear to be a major problem, since the prawn themselves are quite disease resistant.

3.2 Water Quality Management and Treatment

In order to design a geothermal aquaculture system, it is necessary to determine the flowrate required from both a biological and a thermal standpoint. The biological findings will be covered here, while the thermal discussion will be covered in the next section.

At the time this study was being performed, the EPA document pertaining to the effluent from a Macrobrachium culturing facility was under revision, and no definite effluent limits could be established. However, the following limits applied to native fishes and were selected as being representative for preliminary studies:

2.2 kg suspended solids/100 kg fish/day
0.0 kg settleable solids/100 kg fish/day
0.09 kg ammonia/100 kg fish/day

An analysis was performed to determine if the ammonia buildup for prawn would pose a problem. The actual ammonia production rate for prawn is 0.036 mg per gm of dried prawn per hour. This converts into an ammonia production rate of 0.022 kg/100 kg/day, or less than one-fourth of the above specification limit.

Another calculation was made to determine what water flowrate would be required in a high density raceway to maintain ammonia levels at an acceptable limit for the health of the prawn. While the ammonia tolerance level for prawn is not known exactly, it is believed to be no less than that for lobster larvae, or 0.14 mg/l. Assuming the worst case assumption on prawn density would still require an inflow water flowrate of only 87.4 gpm to maintain an equilibrium level of 0.14 mg/l. This is not unreasonable and on the order of the flowrates necessary to maintain heat balances. Also, the above analysis does not consider filtering of any kind, which could be accomplished without difficulty and would help considerably.

3.3 Temperature Control

In order to evaluate the temperature control problems for a pond or raceway at Desert Hot Springs, the first step was to analyze the local weather data to determine realistic design conditions. The closest major city with a comprehensive weather data summary available was Palm Springs, which is quite representative of the weather conditions at Desert Hot Springs. Therefore, based on these data, worst-case cold and hot day conditions were selected. In order to calculate the net heat loss (or gain) from a pond or raceway, these conditions were used in conjunction with a set of heat transfer equations derived for the heat loss or addition to swimming pools. The equations considered the total heat flow from radiation, convection, and evaporation.

Table 1 Appendix 8, shows the heat loss (or gain) from a one-acre pond for the two design cases as well as for special perturbations of each input variable. These perturbation cases provide some visibility as to the sensitivity of each of the variables. Table 2 Appendix 8, shows the same data for the outdoor raceway system.

In comparing the two tables, it can be seen that the heat loss from the raceway is only 5% of the loss from the pond. This is a direct result of the reduced surface area of the raceway, which is a linear term in each of the heat transfer terms. Thus, the raceway is clearly much more energy efficient than the pond system. The enclosed raceway system is similar except the temperature conditions will be less severe in the winter and more severe in the summer. Also, relative humidities will be higher which reduces evaporation losses, and wind velocities will be limited to the air change rate in the greenhouse.

Once the worst-case heat losses were determined, they were converted into flow-rate requirements, both for the geothermal well and for the pond (or raceway) circulation pump. The circulation pump is used to reduce the temperature of the incoming geothermal well water by premixing it with pond (or raceway) water. Thus, the higher the temperature of the well water, the lower the required flowrate of the geothermal water, but the higher the flowrate of the circulation pump.

The actual analysis showed that very high combined flowrates would be required to maintain an outdoor pond during the worst-case cold day. However, if a raceway is used instead of a pond, the combined flowrates decrease drastically to reach an acceptable level. Thus, the raceway system greatly reduces the waste treatment and disposal problems in addition to reducing the energy requirements (pumping costs).

3.4 Harvesting Technique

Harvesting does not appear to pose a serious problem for the final aquaculture design, although it is accomplished more easily for a pond than for a raceway system. The most common method for pond harvesting is to seine the pond slowly

with a net properly sized to allow the undersized prawn to pass through for later harvesting. A second variation is to use horizontal grading bars, in which the spacing between the bars can be adjusted to control the harvest size. Then, the bars are drawn slowly across the pond in the same manner as the seine.

Raceway harvesting is complicated by the presence of the substrate layers used as the high density culturing media. Raceway systems are commonly drained to facilitate harvesting, but this compounds the waste treatment problems and also requires a total harvest of the population. The other technique is to remove the substrate, which is time consuming, and harvest with a seine or grading bars as in the case of the pond.

4.0 Final Aquaculture Design Selection

In selecting a final aquaculture design, three separate systems trade-off studies were performed: facility configuration selection, harvest cycle optimization and facility size optimization. Each of these studies is discussed in detail in Appendix 8, while the results and conclusions are summarized below.

4.1 Facility Configuration Selection

The first system trade-off study involved selecting the best facility configuration consistent with the environmental constraints of DHS and the general region. Three different configurations were considered: outdoor ponds, outdoor raceways, and indoor (greenhouse) raceways. Outdoor ponds are the most common method in use today. Initial construction costs are less expensive than a raceway system, operation, and maintenance are simpler, and feeding and harvesting are less complicated. On the other hand, the raceway system takes up considerably less land space than a pond (due to high density culturing techniques) and is more energy and waste treatment efficient because of the reduced heat loads required by the smaller surface area exposed to cold weather.

The design selected by this study was the indoor raceway. Table 6 shows some of the parameters used in the study, and a somewhat subjective ranking of the candidate configurations against each parameter.

While seven different parameters are shown in the table, the first three were the major drivers in the study. The heat loss from an outdoor water body in cold weather, and hence the requirement for geothermal fluid, is directly proportional to the exposed surface area. Thus, with a ratio of approximately 18:1 for surface areas of the pond versus an equivalent raceway, the requirement for geothermal fluid is substantially reduced for the raceway design. This reduction in fluid flowrate also directly benefits waste treatment requirements and favors the raceway design. Moving the raceway inside a greenhouse offers still a further reduction in fluid requirements by controlling evaporative losses, which are a function of wind and humidity. However, a factor that proved equally important in selecting an indoor raceway was the summer heating problem.

TABLE 6
Facility Configuration Trade-off Study

	<u>Outdoor Pond</u>	<u>Outdoor Raceway</u>	<u>Indoor Raceway</u>
Geothermal Requirements	3	2	1
Waste Treatment Requirements	3	2	1
Capital Costs	1	2	3
Maintenance Requirements	1	2	2
Harvesting Techniques	1	2	2
Feeding Methods	2	1	1
Disease/Pest Control	2	2	1

NOTE: "1" denotes first place

Figure 8 shows an artist's conception of what a one-equivalent-acre indoor aquaculture facility might look like. Note the vertical nets in the cross section view of the raceway. These are the artificial substrate that allow densities of one prawn per square foot of surface area.

The recirculation and mixing circuit shown in Figure 8 is used to reduce the incoming geothermal water temperature to a level acceptable to the prawn. While 85°F is considered the optimum pond temperature, 90°F is acceptable as the inlet water temperature where it enters the pond. The mixing chamber will pump a sufficient supply of water out of the pond (at 75-85°F) and mix it with the hotter water from the geothermal well such that the resultant water entering the pond is $\leq 90^\circ\text{F}$.

4.2 Harvest Cycle Trade-off Study

After selecting the indoor raceway configuration, a system trade-off study was performed to select the optimum harvest cycle (or growout period). The key parameters to be considered were costs for larve, labor, feed and pumping, as well as the prawn growth and survival rates.

Table 7 shows the results of this trade-off study. Harvest cycles from six to nine months in length were selected, since six months produced a minimum marketable size and nine months was felt to be the point where problems began due to increased aggressiveness, cannibalism, and diseases. The cost figures expressed in the table are for a one-equivalent-acre facility and show the net operating income (revenues minus expenses), exclusive of any capital recovery costs. Three different scenarios are presented with different assumptions as to whether the larvae are purchased or grown, or what the final selling price of the prawn will be;

FIGURE 8
RACEWAY CULTURE SYSTEM

however, in each of the three cases the net income increases with the length of the harvest cycle. Thus, the longer the growout period the better the economic viability.

TABLE 7
Harvest Cycle Duration Trade-off Study*

Harvest Cycle (Months)	Net \$ (Buy Larvae, Sell \$3.00/lb)	Net \$ (Grow Larvae, Sell \$3.00/lb)	Net \$ (Grow Larvae, Sell \$3.50/lb)
6	(6567)	(2480)	(1355)
7	(3194)	310	2005
8	65	3131	5504
9	1303	4028	6668

*Figures are for one-equivalent-acre facility and do not include capital recovery costs.

4.3 Facility Size Optimization Study

In order to determine the sensitivity of the economic analysis of the selected aquaculture operation to the size of the operation, three different sizes were studied: one, two and one-half, and five equivalent acres. For this study it was necessary to consider the annual figures (expenses and revenues) as well as capital costs.

The eight-month harvest cycle was selected, rather than nine months, because it used considerably less geothermal fluid with only a modest decrease in net operating income. Also, due to the high cost of purchased larvae compared to those grown in an onsite hatchery, only the latter option was considered. Whole weight wholesale prawn prices of both \$3.00 and \$3.50/pound were considered, to show the sensitivity of profit to selling price.

Table 8 shows the results of the study for a prawn selling price of \$3.00/pound. For this case, all three facility sizes show a substantial deficit, with only a weak relationship noted between the net profit (loss) and the facility size. The financial picture improved markedly for a prawn selling price of \$3.50/pound, as shown in Table 9. In this case there is a strong relationship between the net profit and the facility size, with the five-acre facility actually generating sufficient net operating income to exceed the required capital investment.

TABLE 8
FACILITY SIZE TRADE-OFF STUDY*

	Size (Equivalent Acres)		
	1.0	2.5	5.0
Annual Operating Expense (\$)	11,105	23,375	42,670
Annual Revenues (\$)	14,235	35,585	71,170
Net Operating Income (\$)	3,130	12,210	28,500
Present Worth (\$)	23,805	92,870	216,770
Actual Capital Investment (\$)	116,000	183,200	299,500
Net Gain (Loss) (\$)	(92,195)	(90,330)	(82,730)

*Whole prawn wholesale price \$3.00/pound

TABLE 9

FACILITY SIZE TRADE-OFF STUDY*

	Size (Equivalent Acres)		
	1.0	2.5	5.0
Annual Operating Expenses (\$)	11,105	23,375	42,670
Annual Revenues (\$)	16,610	41,515	83,030
Net Operating Income (\$)	5,505	18,140	40,360
Present Worth (\$)	41,870	137,970	306,980
Actual Capital Investment (\$)	116,000	183,200	299,500
Net Gain (Loss) (\$)	(74,130)	(45,230)	7,480

*Whole prawn wholesale price \$3.50/pound

5.0 Summary

While this first cut analysis is useful for parametric comparisons, and shows a potential for a profitable operation of a five-acre aquaculture facility at DHS, it is by no means a detailed economic analysis. Such an analysis would have to be made before any investment decisions could be made. In lieu of a more detailed analysis, a facility of five acres or more does appear to have profit potential. However, a prawn culture operation of this size (yielding approximately 24,000 pounds of prawn a year) represents a rather ambitious undertaking at this time, considering the state-of-the-art of geothermal aquaculture. High density prawn culturing techniques in raceways have yet to be proven on a large scale and prawn compatibility with the geothermal fluid at DHS has not been demonstrated.

A more reasonable and recommended approach at this time would be to conduct a pilot research program, either onsite or at a research lab using geothermal water from DHS, to answer these questions. If the results proved positive with respect to culturing, then a detailed analysis could be performed to verify economic viability of a given operation.

G. Energy Cascading Systems

Preliminary analysis showed that the economic viability of geothermal-powered air conditioning at the DHS resource temperatures was marginal, at best. Thus, attention was quickly directed to energy cascading systems as the best means of utilizing the limited energy available. Basically, energy cascading is a means of extracting the maximum energy possible from the geothermal fluid before discharging the effluent. This is done at a practical level by combining various applications in series and parallel combinations that can each effectively utilize thermal energy at different temperature levels.

Two different energy cascading systems were considered for DHS. The first was a combination industrial complex involving prawn culturing and greenhouse cucumbers. After a cursory look, this project did not appear to be particularly attractive for several reasons and was dropped from the study. Most importantly, the high temperature use (refrigeration and air conditioning) had a very low utilization factor, making it an uneconomical proposition. Without the high temperature application, there was little reason to consider coupling the agriculture and aquaculture complexes together, especially since the agriculture utilization of the fluid involved indirect use only.

The second system considered was an energy cascaded mobile home park. Considerable interest has already been shown in such a venture by private entrepreneurs at DHS. The particular design envisioned would utilize the hottest temperature available for indirect hot water heating year round as well as air conditioning during the warm months. The reduced temperature effluent from the hot water heating would serve for space heating needs. The space heating effluent would feed directly into a Spa application, with possible augmentation necessary from the geothermal source depending upon the final energy balance. A mobile home park was chosen for study because of its high population density and hence minimum network requirements.

The proposed 100-unit energy cascaded mobile home park would provide the following: space cooling, space heating, hot water (potable) heating and Spa use. Figure 9 depicts a simplified schematic of the system. A description of the various elements in the schematic can be found in Appendix 9.

The heart of the system and the key to the economic viability of the project is the space cooling system. Thus, the initial systems analysis effort was concentrated on a parametric study of the cooling system over a range of inlet temperature of 180 to 220°F. While the final overall system design assumed that only 180°F geothermal fluid was available, the parametric analysis was helpful in determining the sensitivity of the economic analysis to inlet temperature in the event that a hotter resource can be located.

The results of the parametric analysis are presented in Table 10. It can be seen from the table that an increase from 180 to 200°F results in a system cost decrease of 29%, while an increase from 180 to 220°F results in a decrease of 42%. Thus, substantial savings are possible if higher geothermal source temperatures can be located.

FIGURE 9

ENERGY CASCADED SYSTEM SCHEMATIC

TABLE 10

PARAMETRIC SPACE COOLING SYSTEM RESULTS

	INLET TEMPERATURE (°F)		
	180	200	220
UNIT SIZE REQUIRED (TONS)	955	465	294
GEO THERMAL WATER (GPM)	470	384	325
COOLING WATER (GPM)	2,200	1,050	800
ABSORPTION UNIT COST (\$)	92,000	62,000	46,000
COOLING TOWER COST (\$)	47,750	23,250	14,700
PUMPS AND PLUMBING COST (\$)	105,350	89,385	81,205
PUMPING COST (PWF \$)	26,690	18,460	15,225
TOTAL PRESENT WORTH (\$)	271,790	193,095	157,130

In order to assess the economics of the entire energy cascaded system, it was necessary to consider the total capital investment involved, the operating and maintenance costs, and the expected revenues. The capital cost analysis was broken down into four areas: cooling network, heating and hot water network, wells and plumbing, and equipment and miscellaneous costs. The cooling network included the supply and return loops in addition to the individual plumbing to each mobile home and retrofitting expenses. The heating network included only a supply loop, utilizing a common cooling network return loop. The hot water network was totally independent since it used potable water.

The preliminary cost analysis, based on an assumed 180°F inlet water source and current energy rates, showed that the net operating income for a 100-unit park (\$480,000) would not justify the required capital investment (\$765,000). However, a 5% inflation factor for both revenues and expenses would result in a break-even situation. In addition, the discovery of a hotter resource temperature would greatly improve the economic picture. Thus, while an energy cascaded mobile home park is not economically viable at today's energy rates for the known DHS resource temperature, it could well become economical if a hotter resource can be located or if energy rates continue to escalate at greater than 5% per year.

H. Regulatory Agency Authority Over Non-Electric Geothermal Development

1.0 Introduction

This section discusses the scope of regulatory agency purview over non-electric geothermal development, and attempts to clarify the regulatory requirements of geothermal development in the City of Desert Hot Springs. It identifies the extent of regulatory agency involvement with the development of geothermal energy, the government levels of the involved agencies and the importance of reviewing regulatory agency requirements during feasibility study phases of geothermal development projects.

2.0 Necessity of Agency Review

Planning a geothermal development project is similar to planning most developments in that estimates are made of the time, money, and resources required for project completion. Timing is often crucial to the efficient completion of a project. This is where regulations and regulatory agencies impact development projects the most. When a number of permits must be obtained (and this is usually the case), it is useful to know early in the process the extent of information required, the time required by the agency to review permit applications, and the time needed to comply with all permit requirements.

Another important aspect of project planning is ensuring that all the necessary agencies have been notified of the project and all necessary permits have been acquired. A serious time delay could occur as the result of the late involvement of a regulatory agency. Another result of late agency participation could be the alteration of the project which could lead the other agencies involved to believe they needed to review the project further.

It is much more desirable to consider regulatory agency requirements at an early stage in development planning, rather than at a late phase. If the project can be designed around regulatory requirements from the very beginning, the chances of having to redesign because of an agency's restrictions are greatly reduced. For example, project applicants unaware of the waste water disposal requirements of their regional WQCB who design their facility assuming use of the city's municipal waste water disposal system, may be required to redesign the facility to include their own waste disposal facility because the municipal system is unable to handle it. This may require expensive time and resources.

The three previous paragraphs discussed the advantages of knowing the full extent of regulatory agency involvement with a project beforehand but the primary reason for dealing with all applicable regulatory agencies is the legal requirement to do so. The best method of dealing with regulations and regulatory agencies is to comply with them early in the planning stages of any project.

3.0 Regulatory Agencies in Different Levels of Government

There are regulatory agencies at every level of government: federal, state, regional, county, and local. A development project must comply with the regulations of agencies in all of these levels. Many local and regional agencies are branches of state and federal agencies. Other local and regional agencies regulating the same issues as federal and state agencies are independent agencies. Often it is possible to comply with agencies in all levels of government which regulate the same issues by complying with the regulations of the local agency. This is because agencies in lower governmental levels usually have stricter regulations than cousin agencies in higher levels of government. For example, in the State of California, state air pollution control agencies have set higher air quality standards than the Environmental Protection Agency in the Federal government. In turn regional air quality management districts may require higher air quality standards than the state agency, but never lower ones.

Not all states have agencies with the authority to implement higher standards than the agencies at the federal level, and in this case the regulations of the federal agencies would be followed. Another case in which the standards of the federal agencies would be followed instead of the standards of state, regional and local agencies, would be when a new federal law had been recently enacted and the state, regional and local agencies had not had time to adopt comparable regulations. If these regulations are not adopted by state, regional and local agencies, they may adopt guidelines implementing the federal statute. Because of these exceptions, the regulations of agencies in all levels of government should be determined for every development project instead of relying on the regulations of local agencies to be the most stringent.

4.0 Agency Involvement

The involvement of regulatory agencies with development projects can take several forms:

- 1) issuance of permits
- 2) recommendation of performance standards
- 3) review other agency actions

Some agencies have the authority to delay project commencement until they issue construction and operation permits. Issuance of these permits is contingent on their satisfaction that all permit conditions have been met by the applicants.

Agencies with regulatory power and permitting authority are the most active regulators and carry the most legal authority. An agency responsible for permitting a phase of a project usually has permit forms which require the applicant to provide specific information describing the impact his project will have on that agency's area of interest. The agency may require as much information, subject to legal constraint, as it considers necessary to determine whether the permit should or should not be granted. The length of time the agency has to review the application is usually specified by their enabling legislation. Some times the application must be jointly reviewed by several agencies before a determination is made.

Some agencies have regulations in the form of performance standards which must be met by all projects. Although no permit is issued, the agency monitors development to ensure compliance with its regulations and may comment on an Environmental Impact Statement (EIS), or EIR if one is written.

In this analysis the two previously described types of regulatory agencies have been grouped according to project development phases and will be identified with regard to Desert Hot Springs in part 4.2 of this section.

The third type of agency involvement consists of environmental impact review and other forms of review exclusively. Most of these agencies are only involved because some aspect of a project fits under their area of responsibility as defined in their enabling legislation. They may not choose to become involved with all projects which come to their notice and do not have any regulatory authority or permitting powers. An explanation of environmental and historical review requirements is included in Appendix 10 and in the Self Start Manual.

4.1 Review Agencies

In Desert Hot Springs a geothermal development project may be reviewed by:

National Advisory Council of Historic Places - federal
The Department of Energy (DOE) - federal
State Office of Historical Preservation - state
The California Energy Commission (CEC) - state
The Division of Mines and Geology - state
The Desert Hot Springs County Water District - state

Descriptions of these agency's roles as reviewers is included in Appendix 10.

4.2 Agencies with Permitting Authority and Performance Standards

The approach used in gathering information concerning regulatory agency involvement with the development of geothermal energy in the City of Desert Hot Springs was to divide development into several phases. Agencies contacted were asked to specify their involvement with each development phase. These development phases are:

- 1) The acquisition of use rights
- 2) Well development
- 3) Utilization
- 4) Waste water disposal

These phases are used partly because they represent the chronological order in which projects are developed, and partly because each phase represents a distinct body of regulation. Detailed descriptions of the involvement of these agencies with geothermal development in Desert Hot Springs is included in Appendix 10. The agencies in each phase of development are listed below.

Acquisition of Use Rights -	Bureau of Land Management, U. S. Department of the Interior California State Lands Commission Riverside County Planning Department
Well Development -	California Division of Oil and Gas California State Solid Waste Management Board U. S. Environmental Protection Agency Riverside County Solid Waste Management Facilities Agency
Utilization -	U. S. Environmental Protection Agency U. S. Food and Drug Administration California Air Resources Board California Department of Fish and Game California State Department of Health South Coast Air Quality Management District Riverside County Department of Health
Disposal -	California Water Resources Control Board Regional Water Quality Control Board U. S. Environmental Protection Agency

5.0 Conclusions

From a regulatory perspective, there do not appear to be any insurmountable impediments to future geothermal development in the City of Desert Hot Springs. Agencies responsible for regulating and permitting geothermal development have established procedures, and are knowledgeable of the issues to be dealt with in this type of development. By and large, these agencies do not now have regulations specific to geothermal utilization; they have adapted the permit requirements and regulations applicable to other kinds of development within their purview to meet the needs of geothermal users.

A city relying on its geothermal resource for most of its energy will need to ensure that the resource is maintained and not misused. Issues of governmental management of geothermal resources which may be necessary in this situation are discussed elsewhere in this report. Water and air quality agencies may have to view geothermal development holistically in this case instead of incrementally; and the controversy over the classification of the resource, whether it is mineral, water, or heat must be settled in order to define ownership consistently with expanded use. By hypothesizing the future with regard to future geothermal energy use, perhaps regulatory agencies can prepare themselves and their regulations to facilitate development where and when it is needed.

Finally, it should be emphasized that the above discussion of regulation is neither comprehensive nor exhaustive. It is intended to demonstrate the type and scope of regulation which may be applicable to geothermal development.

1. ENVIRONMENTAL IMPACT ASSESSMENT

1.0 INTRODUCTION

The purpose of this analysis was to identify any significant adverse environmental impacts which may result from the implementation of any of the proposed demonstration projects at DHS. (See Table II for the projects under consideration.) The delineation of the expected environmental impacts resulting from the various alternatives make it possible to recommend reasonable mitigating measures so that the unavoidable adverse impacts can be identified. The result of this exercise will provide inputs to be utilized in the selection of a subject of the proposed project, which will then undergo the next step in the evaluation process. The projects selected will hopefully be those which present the smallest potential for unavoidable adverse environmental impacts.

2.0 MAJOR CATEGORIES OF ENVIRONMENTAL IMPACT

The major areas of concern in evaluating the environmental constraints resulting from the development of geothermal resources for nonelectric uses are factors which:

1. Are site specific;
2. Deal with the construction of individual projects;
3. Arise from the use of the geothermal resource.

Site-specific factors are those which are particular to the Desert Hot Springs area which could affect project completion. The second factor relates to project implementation and is highly dependent on whether the proposed use facility currently exists. The last major area of concern is the use and disposal of the geothermal resource itself. These three areas may manifest themselves upon implementation of any selected application through environmental impacts on air and water quality, land use planning, archeological or historical sites, noise, construction, public health, aesthetics, and safety.

2.1 IMPORTANT SITE-SPECIFIC FACTORS

In evaluating site-specific factors it was necessary to identify the nature of the available geothermal resource. Since the minimum temperature required for any application (the aquaculture option) is 90°F, the extent of this isotherm in the DHS area was identified (see Figure 10). This area contains two hot spots with temperatures that range from 150°F to over 180°F. One is in DHS itself in the vicinity of Angel View Children's Hospital, while the other is southeast of the city near Dillon Road. The geothermal aquifer lies north of the Mission Creek Fault which cuts through the center of the city from northwest to southeast. Although natural seismicity is normally associated with the existence of geothermal resources,

TABLE 11
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, COOLING, HOT WATER	---
CAR WASH	HOT WATER	---

*This involves transferring the heat of the geothermal water to other mediums.

Figure 10- Desert Hot Springs Location of Geothermal Aquifer, Major Faults, and Main Thoroughfares

this is probably not so important at DHS since the geothermal aquifer is not very deep. If recharge of the geothermal aquifer takes place after use, the Blind Canyon area on the northeast side of DHS appears to be the optimal area for doing this. This would minimize any potential contamination of the City's potable water aquifer which lies south of the Mission Creek Fault.

The area surrounding the hot anomaly in DHS is primarily zoned residential. However, there are large portions of undeveloped land nearby. The hot area at Dillon Road is very sparsely settled and is not presently zoned.

There are eight potential sites of archeological or historical importance in the DHS area which may impact project implementation. However, only two of these are within the 90°F isotherm. Intrusion upon one of these sites (which is just south of the hot spot in DHS) by a chosen application may necessitate compliance with the California Environmental Quality Act.

2.2 PLACEMENT OF PROPOSED APPLICATIONS

The major factors in placing the individual applications are whether or not the proposed facilities exist, whether they have temperature constraints, factors such as the size of the tract needed by an application, compliance with zoning regulations, and placement with respect to the geothermal resource. It was found here that the industrial complex would require a relatively large land area and might create adverse zoning, historical, air and noise impacts if placed in DHS. The proposed multi-use center and City Hall/library would be located one mile from the hot source in DHS which they require. This could result in the disruption of local streets during construction. Likewise, the utility network could present large areal impacts and could also disrupt local streets. However, proper planning and design of these projects could probably minimize these impacts. The greenhouse and cascaded agribusiness options would also cause large areal impacts but could be placed outside of populated or developed areas so that siting impacts could be minimized. If the car wash was to be placed in DHS, zoning and historical site impacts could result because its temperature constraints would limit its location.

The Angel View Clinic, spa-tel, and mobile home park options should not present any siting constraints, since they already exist and are in close proximity to the hottest geothermal resources. Likewise, although the aquaculture facility does not exist, it has no stringent temperature constraints so that its location could be carefully chosen so as to minimize any potential siting problems.

2.3 ENVIRONMENTAL IMPACTS ARISING FROM THE UTILIZATION OF THE GEOTHERMAL WATER

Indirect utilization of the geothermal resource for space heating or cooling, hot water, and for cold storage could result at some future time in the accidental contamination of potable water supplies. If ammonia-water absorption cooling systems are used, the accidental release of ammonia could also create a potential hazard. In the

direct use options such as for aquaculture or for agriculture, further tests are probably needed to determine the possible adverse effects of the geothermal water on the products of these businesses.

Concerning disposal of the geothermal fluids after use, direct use of the resource could result in the contamination of the geothermal aquifer, if this water re-enters the geothermal aquifer. This occurs as a result of the concentrating of pollutants in the water used. It may be possible to circumvent such a problem by treating the water before it is reintroduced, or by disposing of it in some other manner. However, if evaporation or the local sewer system is used for disposal, it is possible that the geothermal aquifer may be depleted to a point where subsidence could be exacerbated. The only proposed options that would probably create no concern with respect to disposal are indirect uses coupled with reinjection or in-ground heat transfer.

3.0 CONCLUSIONS

The conclusion of this analysis is that some applications appear to present somewhat more obstacles than others. However, there are no major problems currently foreseen for any option which would prohibit implementation from an environmental viewpoint. The best way to mitigate potential problems would be to take utmost care during the planning and design stage. (For a more complete discussion of the environmental impact assessment conducted for DHS, see Appendix 11.)

J. RESOURCE MANAGEMENT PLAN

1.0 Introduction

In charter cities such as the City of Desert Hot Springs, the City Council is the final legislative decision making body responsible for setting policy within the City. When considering the continuum of possible policies relative to utilization of geothermal resource, the City Council could adopt policies ranging from complete utilization of the resource in the present time with little or no consideration for its preservation, or to the other extreme a policy of conservation and slow development reflecting the uncertain knowledge of the exact characteristics of the resource. The policy the City Council adopts will be directly manifested in the type of management scheme which is implemented within the City. Since the City Council has not yet had to make a decision relative to geothermal policy, this report presents management scenarios based on policies which could be adopted and implemented by the City of Desert Hot Springs (See Appendix 12).

A major constraint on any management system for the geothermal resources underlying the City of Desert Hot Springs is that it must reflect the limited financial and personnel resources the City has to devote to managing the resource. To the greatest extent possible, the management scheme should mesh with existing practices and procedures within the City. This constraint will ultimately limit the amount of data which the City can reasonably collect about the geothermal resource and determine the amount of review any individual application may be given. Additionally, the City must recognize the existence of private property rights as they are now structured and if it chooses to exercise control over the geothermal resource, do so within the framework of its police power control of development (See Appendix 13).

The identified geothermal resource transcends the legal boundaries of the City of Desert Hot Springs. Therefore, any resource management system which seeks to control the resource itself must be negotiated and jointly administered by the City and the County of Riverside. The City will have to devote time and resources to the negotiation process to establish a jointly acceptable management system. If the City were able to act independently, the initial costs incurred in implementing a system would be considerably lower. Given the interactive nature of the resource over its extent, it is imperative that the entire resource be managed as a unit. If the management plan is concerned only with surface manifestations of use of the geothermal resource, the City can act independently.

2.0 RESOURCE UTILIZATION SCENARIOS

Of the resource management scenarios evaluated, the most desirable one of the City to adopt is the maximum Resource Conservation scenario. The adoption of this approach will enable the assessment of new project impacts on the overall resource and determine appropriate conservation measures while providing social benefits for all the residents of Desert Hot Springs.

The Maximum Resource Conservation Scenario is the most stringent scenario evaluated and has as its objective maximum conservation of the geothermal resource over time. It would be a significant departure from existing practices relative to utilization of the geothermal resource. The first requirement would be to prepare a geothermal planning element as part of the general plan. The geothermal element would identify areas in the City which overlie the resource, enumerate potential uses and applications, and establish City goals and policies relative to utilization of the resource. The zoning ordinance would be revised to require a conditional use permit (CUP) for all potential users of the resource.

The fundamental element of the management scheme is well output monitoring, both temperature and mass flow rate. Self reporting would be required with random City sampling to ascertain compliance with a significant penalty for noncompliance. The City would also develop a city-wide reservoir data base to be used in making further decisions on utilization of the resource. All existing wells would also be required to monitor and report.

In addition to the generic geothermal EIR, each project would be subject to environmental assessment as part of the conditional use permit (CUP) process.

Since the main objective of this scenario is conservation of the resource, it requires central disposal of spent geothermal brines so that the temperature, volume and pressure within the reservoir can be maintained. It is unclear who would be responsible for the central disposal system, however, each individual user would be required to hook up to the disposal system and pay a proportionate share of the charge for its operation. The City should also require bonds for the removal of drilling muds, sludge, etc.

Implementation of the Maximum Resource Conservation Scenario would be most effective with a designation of responsibility within City government for the issuance of geothermal permits, integration of permit processing into existing procedures, and collection and maintenance of the well monitoring data. It would be highly desirable to have a single individual charged with the responsibility for administering the geothermal permit application process. It is anticipated that the actual decision on the

issuance of the permit would continue to be made by the Planning Commission and the City Council. This scenario maximizes the preservation of the resource by examining each new use sequentially to determine its impact on the overall condition of the reservoir and the reservoirs' continued use. Although this system imposes the largest costs on the City government for the operation of the management system, it does attempt to optimize the social benefit of the resource for all individuals residing within the City. Implementation of and strict adherence to the Maximum Resource Conservation Scenario would be to ensure the continuance of existing uses and nondegradation of the reservoir.

3.0

Conclusion

Before implementing any management plan, the City must resolve a basic policy issue whether they wish to control only surface uses associated with geothermal development, or whether they wish to control the resource itself. This decision dictates the structure of the management plan to be implemented.

If the objective of the regulatory scheme is to control the potential impacts of exploitation on other uses of the land, then it may be argued that the existing structure of the general plan and zoning ordinance is sufficient to provide the necessary regulation. The city could create a geothermal zone which would overlay the boundaries of the resource 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 the City would review individual applications on their own merit. Here, the developer files an application describing his proposed use, the City 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 performance standards for environmental effects. Examples of these conditions are restrictions on the hours of operation, posting of bonds, etc. It should be re-emphasized that the fundamental character of this management plan is that there is little or no concern with management of the resource itself. 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. With any management scheme of this type, each developer faces a rule of capture relative to his ability to find, confirm and develop the resource. In any of these management scenarios reservoir production, well interference, temperature degradation, depletion of the resource, and the like, are the concerns of the developers within the anomaly and not the concern of the City.

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