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

CALIFORNIA ENERGY COMMISSION
CONSULTANT REPORT

APPENDICES

JULY 1978

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

FINAL REPORT
VOLUME II: APPENDICES
FOR PERIOD MAY 23, 1977 - JULY 31, 1978

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Prepared For
The Department of Energy
Geothermal Energy Division
and the
California Energy Commission
DOE Contract EG-77-0-03-1329 and CEC Contract 500-014

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APPENDIX 3

COMMUNITY NEEDS ASSESSMENT

Regional Perspective

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

The full time resident population of the northern Coachella Valley increased from 48,600 in 1970 to approximately 69,100 at the beginning of 1977, a 42.2 percent increase.² The bulk of the population increase occurred in and around the City of Palm Springs. The population increase in and around Desert Hot Springs was percentagewise approximately equal to that for the northern Coachella Valley as a whole. The City of Desert Hot Springs itself, however, grew at a slightly lesser rate of 39.0 percent over the same period. The southern Coachella Valley increased in population only about 7.2 percent, rising from 38,400 in 1970 to about 41,200 by 1977. One of the characteristics of the recreation and retirement orientation of the northern Coachella Valley is that in the winter time when temperatures are moderate, the visitor population can swell the total population to two and sometimes three times the full-time resident population of the valley. Thus, during the high season, the winter months, the population in the northern Coachella Valley as a whole can exceed 200,000 persons on a peak weekend.

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

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

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

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

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

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

2.0 Community Perspective

2.1 Introduction

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

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

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

2.2 Economic Base

The historic economic base of the City of Desert Hot Springs has been the recreation and tourist industry attracted to the city by the climate of the Coachella Valley and the mineral spas derived from the underlying geothermal resource. As of April 1977, within the city there were approximately 115 hotels, motels and spas with 1,128 rooms available.³ Within the incorporated city there were three mobile home parks with approximately 250 available spaces, some of which were used for mobile homes and the remainder being used for recreational vehicles on a short-term basis. Considering the community area beyond the incorporated boundaries, there were an additional 22 mobile home parks with an occupancy of approximately 2,000 spaces.⁴ Many of these are long-term residents in the community whose spaces cannot be considered to be available to transients. It has been estimated that the population of Desert Hot Springs increases to approximately 12,000 during the winter season from November through May each year, a tripling of the resident population of approximately 4,300.⁴ This tourist and recreation trade accounts for a significant portion of the 6.5 million dollars of taxable sales in the City each year.³

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

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

There has been a shift in the occupation of City residents during the period 1970-1976. Professional, technical and managerial categories increased significantly while white collar sales and clerical workers fell in relative proportions in the work force. Craftsmen doubled while operatives were halved. Laborers and service workers both declined. The skills mix of the population has shifted towards professional, managerial and blue collar skilled trades. The 1976 Special Census reported 1,506 as the total number of employed persons in the City.⁵ Given that the skills mix has shifted in recent years and that the employment opportunities in the major industry of tourist and recreation is of a semi-skilled nature, the bulk of the employment opportunities are considered to lie outside the City of Desert Hot Springs at present. It is suspected that these job opportunities lie in the Palm Springs, Rancho Mirage, Palm Desert, and Indio areas of the Coachella Valley. The development of commercial activities based on the utilization of geothermal resource will require skilled and semi-skilled labor. Commercial utilization of the geothermal resources would, therefore, be expected to attract additional blue collar persons to the community, accelerating and accentuating the evident shift in the skills mix of the population.

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

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

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

2.3 Public Attitude Survey

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

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

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

partly on weekends would probably have resulted in a larger sample. However, the time and resources were not available to perform such a survey. Similarly, it was unfeasible to conduct a mail survey. Considering the constraints associated with the actual survey undertaken, the response rate was probably not as disappointing as it appears.

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

The major results of the survey are as follows:

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

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

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

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

2.4

Environmental Response Inventory

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

The Environmental Response Inventory (ERI)⁶ was devised by George E. McKechnie, from the University of California, Berkeley, as an assessment instrument to measure the various ways people think and feel about the physical environment in which they live. "...a principal goal in the ERI has been to produce an assessment instrument having value for interdisciplinary studies of man and the environment; these include research in the field of architecture and urban design,

city and regional planning, and any other discipline concerned with the patterns and styles of response which individuals manifest with respect to their environment."⁶ Commercialization of the geothermal resource at Desert Hot Springs brings into play individual attitudes towards the environment as people perceive the impact of expanded use of the resource.

Norms for the ERI are based upon two unselected adult populations determined to be representative of the sample areas. The sample appears "slightly biased in terms of middle and upper income individual... and are not offered as a true random sampling of the population of the United States..."⁶

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

2.4.1

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

level and place of residence within the city are equally distributed, and therefore correlate, between the sample and the actual population of the City determines the validity of the sample assessed at Desert Hot Springs. If a high correlation exists a hypothesis can be confirmed regarding those issues.

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

2.4.2 Initial Results of the ERI

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

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

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

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

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

Table 1

Environmental Response Inventory Scale

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

2.4.3 Summary

The results of the ERI, although statistically insignificant because of the small sample, indicate a general confirmation of endorsements of specific issues in the Public Attitude Survey. In particular, increased utilization of technological processes was generally of greater value than the preservation of the natural environment.

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

3.0 Agriculture and Aquaculture Labor Force

One of the early hypotheses was that the potential development of agriculture and aquaculture based on the geothermal resource underlying the City of Desert Hot Springs would provide part-time, flexible hour employment opportunities for senior citizens, many of whom are on fixed incomes. European cucumbers, tomatoes, and cut flowers, were among the most viable agricultural products for agribusiness based on the geothermal resource. Data obtained from existing European cucumber growers indicated that a work force of thirteen to twenty persons is required to service approximately 140,000 square feet of greenhouse, all of whom are assumed to be capable of carrying out any job within the greenhouse. Included in this number is a complex manager and two task supervisors. The work force employed tends to be relatively permanent. Part-time laborers are usually employed during the harvesting and packaging stages of operations.⁷ Thus, even though significant area may be devoted to the production of European cucumbers, the availability of part-time work is quite small in terms of the total number of persons who might be available in the work force within the City. That is, the number of part-time employment opportunities which might be available in greenhouse operations is quite small. Compared to the total number of employed persons in the City, 1506 in 1976, the number of jobs potentially available would constitute a small percentage. The number of permanent full-time positions would be even fewer. Therefore, if agriculture, in particular greenhouses growing European cucumbers, tomatoes or cut flowers are developed, these facilities would tend to attract younger skilled and semi-skilled laborers on a full-time basis. The number of job opportunities on a part-time flexible hour basis for senior citizens, therefore, appears limited in the greenhouse operations.

The labor force required for the production of fish and prawn in aquacultural raceways is similar to that described above for European cucumbers. The commercial aquaculture operation would require a number of trained semi-skilled and skilled laborers who would be responsible for the day-to-day operation of the facility. Here too

the job opportunities appear to be aimed at younger full-time employees rather than senior citizens. Once the aquaculture facility is in operation, the harvesting of the fish crop would occur on a fairly continuous basis. Therefore, it appears the labor force requirements would be fairly constant over time. In this operation as well, there do not appear to be significant opportunities for senior citizen employment.

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

4.0

Summary

One of the original purposes for the City of Desert Hot Springs undertaking this study was to "...exploit its geothermal resource to benefit its citizenry." ⁸ The community needs assessment has attempted to identify the "benefits" which would accrue to the residents of the City from increased utilization of the resource in terms of the desires of the citizens.

In general the residents of the City favor exploitation of the resource as long as the existing spa uses are protected. Community leaders, both business and government, have been the most vocal in encouraging exploitation. However, they have also been the most vocal in insuring that the existing tourism economy is not affected. Over the long term increased utilization of the geothermal resources will have a significant impact on the community: the economic base will be increased and new residents will be attracted to the City.

APPENDIX 3A

DESERT HOT SPRINGS
PUBLIC ATTITUDE SURVEY

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

FIGURE 1
PUBLIC ATTITUDE QUESTIONNAIRE

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

Age _____ Sex _____ Address: _____

- 1) Which income bracket indicates your family's total household annual income in 1976?
 - a. under \$4,000 _____
 - b. \$4,000-\$7,499 _____
 - c. \$7,500-\$9,999 _____
 - d. \$10,000-\$14,999 _____
 - e. \$15,000-\$29,999 _____
 - f. \$29,999 or over _____

- 2) Do you work:
 - a. full time _____
 - b. part time _____
 - c. retired _____
 - d. unemployed _____
 - e. retired with supplemental part time income _____

- 3) If an employment opportunity acceptable to you became available within Desert Hot Springs, would you:
 - a. consider changing jobs if you are already employed in Desert Hot Springs? _____
 - b. consider changing jobs if you are employed outside Desert Hot Springs? _____
 - c. consider accepting employment if you are not presently employed? _____
 - d. be uninterested in new employment opportunities? _____

- 4) Would you be interested in a part-time employment opportunity acceptable to you in Desert Hot Springs?
 - a. yes _____
 - b. no _____

- 5) Do you live in Desert Hot Springs:
 - a. all year _____
 - b. October-March _____
 - c. April-September _____

- 6) Is your residence a:
 - a. house _____
 - b. mobile home _____
 - c. apartment _____
 - d. other _____

- 7) Regarding your Desert Hot Springs residence, do you:
 - a. own _____
 - b. own and lease out when you are not living there _____
 - c. rent, do not own _____

- 8) How much were your utility bills last month?
	<u>Electricity</u>	<u>Heating/Cooling</u>
a. \$0-\$30	_____	_____
b. \$31-\$45	_____	_____
c. \$46-\$60	_____	_____
d. \$61-\$75	_____	_____
e. \$76-\$90	_____	_____
f. \$91-\$105	_____	_____
g. over-\$105	_____	_____

- 9) In which month of the year are your utility bills the highest?

<u>Electricity</u>	<u>Heating/Cooling</u>
Month _____	Month _____
Amount _____	Amount _____

- 10) In which month of the year is your utility bill the lowest?

<u>Electricity</u>	<u>Heating/Cooling</u>
Month _____	Month _____
Amount _____	Amount _____

- 11) Are you aware of the City's interest in developing their geothermal resources, (the use of hot water found underground), for commercial and residential heating and cooling?)

- a. yes _____
- b. no _____
- c. unaware that Desert Hot Springs has geothermal resources _____

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

- a. city ownership and operation _____
- b. private ownership and operation _____
- c. city ownership and private operation _____
- d. users coop ownership and operation _____
- e. users coop ownership and private operation _____
- f. city controlled non-profit corporation _____
- g. have no opinion _____

- 13) There are several possible ways to finance the development of geothermal energy system for the City. Which of the following methods of financing would you:

	<u>Consider Appropriate</u>	<u>Personally Use</u>
a. Federal government subsidy to the City	_____	_____
b. Federal government guaranteed bank loans	_____	_____
c. municipal financing through bond issues	_____	_____
d. private industry	_____	_____
e. have no opinion	_____	_____

- 14) There are several possible ways to finance the installation of geothermal heating and cooling systems in your residence. Which of the following methods of financing would you:

	<u>Consider Appropriate</u>	<u>Personally Use</u>
a. personal savings	_____	_____
b. conventional bank/finance company	_____	_____
c. government guaranteed loans	_____	_____
d. municipal financing through bond issues	_____	_____
e. use of other capital sources which would result in higher monthly costs	_____	_____

(Please rank in order of preference using 1 to 5, with 1 being the most preferred and 5 being the least preferred).

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

TABLE 1

SURVEY RESULTS BY RESPONDING GROUP*

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

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

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

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

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

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

*A total of 96 usable questionnaire responses were received during the survey. For a discussion of the response rate see Section .

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

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

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

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

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

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

TABLE 2

SURVEY RESULTS BY ENERGY COSTS

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

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

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

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

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

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

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

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

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

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

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

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

TABLE 3

SURVEY RESULTS BY LOCATION OF RESIDENCE

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX 4

GEOHERMAL RESOURCE CHARACTERIZATION

For the purposes of this study, the project site is confined to that area that is nearby or within the city limits of Desert Hot Springs. This area is heavily faulted with the Mission Creek Fault dominating the region (Figure 1). Other faults in the vicinity include the Miracle Hill, Long Valley, and Blind Canyon Faults.

The City is located on alluvial material that has washed down the slopes of the Little San Bernardino Mountains. The topographic drainage basin affecting Desert Hot Springs is called the Desert Hot Springs sub-basin, of which the Miracle Hill subarea includes all of the City and Dillon Road area. This subarea entails an expanse of ~70 square miles.

In order to assess the nature and extent of the 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.

The following discussion synthesizes the results of work in characterizing the resource capable of sustaining nonelectric operations. Resource characterization has been conducted in isotherm increments corresponding to representative agribusiness and space conditioning source temperature thresholds.

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

2.1 Literature Review

Little in-depth research has been conducted in the Desert Hot Springs region of the Coachella Valley. Early work by Proctor^{9,10} dealt primarily with the geology of the area and developed little theory dealing with the geothermal resource. The Department of Water Resources has issued a publication¹¹ that summarizes the general environment of the Coachella Valley that includes an analysis of the hydrological characteristics of the valley. Although this work emphasized the western half of the valley, it has proven useful in providing geologic information such as cross sections.

FIGURE 1 FAULT LOCATIONS IN THE DESERT HOT SPRINGS AREA

Another publication of value is a USGS open file report¹² that describes a computer analog developed for the groundwater basins in the Coachella Valley. The data presented appear to have interspersed information dealing with fresh potable water and the geothermal waters in the Desert Hot Springs area. The document, however, has been useful with close scrutiny of each component of work reported therein.

2.2 Field Work

A comprehensive map of the project region was obtained from the Coachella Valley Water District Office in Coachella. Specific wells were located and well logs obtained for as many wells as were available. Geologic cross sections were constructed from the well logs in seven different areas (Figure 2). These cross sections were then used to identify the probable aquifer material.

The field work also involved pump tests* conducted over the entire region of wells that were accessible and operating. These pump tests yield two important hydrologic inputs; the coefficients of transmissibility and storage. Further information obtained included static water level and specific capacity. The test data were then compared to previous data to delineate any changes that may have occurred.

Geochemical properties of a typical aquifer are given in Table 1. The results indicate water typical of a geothermal aquifer with the exception of fluoride whose content is higher than normally found and ~ 7 times higher than the allowable limit in drinking water.

2.3 Areal Extent of Geothermal Aquifer System

A temperature isotherm map for the DHS project site was constructed utilizing temperature graduations representative of agribusiness and space conditioning temperature thresholds (Figure 3). Because the results of early analysis indicate a promising potential for agribusiness applications, initial work was dedicated to characterizing the resource with the corresponding isotherm (i.e., 90°F).

The surface extent determined by the 90°F isotherm is 5.45 square miles. It should be noted that the temperature isotherms are based on physical temperature measurements made during the field work and recorded for well logs upon well completion. Depth has not been considered in the measurements.

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. This hypothesis is further supported by the DWR study that indicates an inferred barrier to groundwater movement between these two areas.

2.4 Safe Yield for the Hydrothermal Resource

Before a safe yield can be calculated, it is necessary to characterize the various hydrologic parameters. The results of the 14 pump tests conducted throughout the Desert Hot Springs and Dillon Road areas were utilized to determine

* Under separate funding to Brent Russell, California State University-Fullerton from the California Energy Commission and as part of the city's cost sharing commitment.

FIGURE 2 LOCATIONS OF GEOLOGIC CROSS SECTIONS

TABLE 1
GEOCHEMICAL PROPERTIES OF REPRESENTATIVE
GEOTHERMAL AQUIFER

<u>Dissolved Gases</u>	<u>mg/l</u>
Hydrogen Sulfide	not detectable < 0.005
Ammonia	not detectable < 0.03
Carbon Dioxide	4.8
Radon	2.0 ± 0.2 picocuries/l

Mineral Content

Calcium	31.6
Magnesium	0.2
Sodium	292
Potassium	0.17
Carbonate	3.0
Bicarbonate	36.6
Sulfate	493
Chloride	103
Nitrate	0.7
Fluoride	8.8
Boron	1.8
Silica	57.1

Heavy Metal Content

Cadmium	< 0.004
Arsenic	0.004
Mercury	< 0.001

FIGURE 3. TEMPERATURE ISOTHERMS IN THE DESERT HOT SPRINGS AREA

the average coefficients of transmissibility and storage. The values of these hydrologic parameters were 20,000 gpd/ft and 1.4×10^{-4} , respectively. (Data used to generate these numbers are presented in Reference 13.) The coefficient of transmissibility indicates an aquifer of sufficient capability to support an industrial, municipal, or irrigation project, whereas the storage coefficient indicates the system is an artesian aquifer (i.e., one under a pressure head from the overlain material).

The thickness of the aquifer system estimated from a geologic cross section that bisects the Desert Hot Springs region is 1000 feet. There are no well logs available in the area that indicate the depth of bedrock (non-aquifer material). 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.

The results of the computations for the hydrologic budget are presented in Table 2. This table presents the items of supply and disposal along with estimates of the safe and safest yield of 3400 acre-ft/yr and 2100 acre-ft/yr, respectively.

An examination of the hydrological equation indicates that water is entering the system from outside the topographic drainage basin. This would account for the difference between infiltration and subsurface outflow. A change in storage may have occurred, although current and past measurements have been nearly identical.

There is no question, however, that 2100 acre feet can be considered the safest safe yield as this number is within the boundaries of the infiltration rate calculated in the items of supply. Corresponding yields of all temperature isotherms considered are presented in Table 3.

2.5 Potential Areas of Recharge and Reinjection

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.

A strong relationship exists for the correlation between the fault zones and the high water temperature. That is to say, as one moves further away from the area of Desert Hot Springs that displays massive faulting, the temperature of the groundwater decreases. To meet requirement (a) the potential site should be away from the major fault activity areas.

High permeabilities occur over the entire upper Coachella Valley.

A number of chemical reactions can occur during the recharge or reinjection process, which obscure water quality parameters. These reactions could possibly degrade the water quality in the area.

TABLE 2. ESTIMATE OF SAFE YIELD FOR DESERT HOT SPRINGS

GEOTHERMAL SUPPLY		Acre Feet	
Precipitation ¹⁵ (over aquifer)	2,200 ±	220	
Surface Inflow ¹⁵	2,300 ±	230	
Subsurface Inflow (Infiltration)*	3,500 ±	350	
Imported Supply	0		
TOTAL		8,000 ±	800

EFFLUENT DISPOSAL		Acre Feet	
Surface Outflow [◇]	1,500 ±	150	
Exported Water and Sewage	0		
Evapotranspiration (over aquifer)	1,750 ±	175	
Well Water Removal ¹²	1,400 ±	140	
Change in Groundwater Storage	0		
TOTAL		4,600 ±	460

SAFE YIELD = SUPPLY - DISPOSAL

Safe Yield = 3,400 ± 1,260 Acre Feet Per Year

Safest Safe Yield = 2,140 Acre Feet Per Year

* Infiltration = Precipitation - Surface Runoff - Evapotranspiration
[◇] Based on calculation of actual groundwater basin, 13% infiltration, calculation of precipitation, surface runoff, and evapotranspiration

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

However, the resource located to the northeast of the Mission Creek Fault is not a potable resource, and siting the recharge or reinjection sites to the northeast would be optional.

The final consideration is that of groundwater movement. Figure 4 is a contour map showing groundwater isopotential lines in relation to sea level. Streamflow or groundwater movement occurs at right angles to these isopotential lines moving toward the fault in the Desert Hot Springs and Dillon Road areas. Just to the southeast of Desert Hot Springs, some groundwater movement appears to parallel the fault. The map indicates that an area of recharge should be sited to the northeast of the Mission Creek Fault in order for the water to move back into the system.

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. It would be better to not increase the pressure on the fault system with a reinjection well; instead a recharge basin would allow the water to percolate at atmospheric pressure. 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 and much of the work that has been accomplished has been widely accepted and rarely challenged.

This project has succeeded in identifying the areal extent, the hydraulic characteristics of the system, safe yield, and potential sites for reinjection. Assumptions have been made to complete the project; assumptions that are valid at this time. The study has accumulated the most up-to-date summary of the geothermal resources in the Desert Hot Springs area.

The resource demonstrates the ability to support greater development and utilization; nearly one-and-one-half times the present rate of use. Accordingly, the resource is one that could be used to exploit agribusiness applications and development should be able to proceed, provided the guidelines presented in this report are followed.

There is also a need 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, this would enable the consideration of space conditioning applications for residential and industrial installations. Notwithstanding, additional tests are needed to better define the geologic, hydrologic, and geochemical characteristics of the DHS hydrothermal resource so that it may be managed as a nondepletable, nonpolluting alternate energy source.

FIGURE 4 GROUNDWATER LEVEL CONTOURS

APPENDIX 5

DETAILED DISCUSSION OF THE GEOTHERMAL APPLICATIONS CONSIDERED FOR DHS

1.0 Potential for Geothermal Space Conditioning in Desert Hot Springs

In order to assess the local market potential for geothermal space conditioning in Desert Hot Springs, the average monthly residential energy costs for space conditioning were calculated. Calculations were performed previously by Southern California Edison to estimate heating and air conditioning energy requirements for an average Coachella Valley home, based on analytical models, and reported in Appendix C of DHS Proposal No. 76-29.⁸ However, these results were tied to a November 4, 1974, SCE Rate Schedule. In order to update these numbers, the old rate schedule was used to convert the monthly costs back into energy usage so the current Rate Schedule could be applied. Table 1 presents the results of these calculations and compares the 1974 costs to current costs. Both Rate Schedules included the applicable fuel cost adjustment factor. The increase in the total annual space conditioning costs for the 2-3/4 year period was only 12.8% (4.5% per annum); however, the brunt of the 1974 oil crisis was already reflected in the 1974 Rate Schedule.

The new cost figures in the table are for an average sized home. Larger homes could conceivably exceed these figures by 50-100%. The data in Table 1 show that the cooling costs were twice as high as the heating costs, the average monthly cost for space conditioning was \$70, and the maximum cost occurred in July with over \$117 for space cooling. These figures are significant for several reasons. First, while the cooling load is twice as high as the heating load, it is significant that one-third of the space conditioning cost in this desert community is spent for heating. Secondly, annual space conditioning costs of \$840 for the average homeowner (and considerably higher for extreme cases) provides more than ample incentive to pursue alternate energy sources. Finally, the daily newspapers provide a wide variety of stories pertaining to gloomy forecasts on the energy picture - skyrocketing costs, curtailments, and the necessity for alternate energy forms. This continual barrage from the press has resulted in an acute public interest at DHS of how the geothermal resource there could be exploited to displace current energy needs.

2.0 Options considered for DHS

Figure 1 shows the space conditioning and miscellaneous options considered for the geothermal resource at DHS. The category of General Heating covers all forms of heating with the exception of comfort heating for humans, which is listed under the second category, Comfort Heating and Cooling. General Heating is split into two subdivisions: direct contact heating in which the user or end product comes in direct contact with the geothermal fluid, and indirect contact heating in which the heat is extracted from the geothermal fluid by some heat exchange process.

The direct contact applications listed were found to be economically and technically feasible, with the possible exception of irrigation. The major obstacle to the irrigation use is the lack of control over the geothermal fluid when used for free watering of the crops. The laws covering

TABLE 1

Heating* and Air Conditioning Costs - Coachella Valley**

Month	November 1974 Rate Schedule			kwhr	Current Rate Schedule
	Heating	Cooling	Total Cost		Total Cost
JAN	\$60.07	\$---	\$60.07	1891	\$67.45
FEB	43.89	---	43.89	1285	46.82
MAR	32.99	16.32	49.31	1488	53.73
APR	24.83	26.89	51.72	1578	56.81
MAY	8.98	46.92	55.90	1735	62.14
JUN	4.38	62.95	67.33	2162	76.71
JUL	---	99.34	99.34	3360	117.53
AUG	---	96.22	96.22	3244	113.55
SEP	---	69.62	69.62	2248	79.63
OCT	5.58	45.01	50.59	1536	55.37
NOV	25.14	16.26	41.40	1192	43.65
DEC	59.87	---	59.87	1883	67.20
TOTAL	265.73	479.53	745.26	26602	840.59
AVE			62.11	1967	70.05

*Assumes all-electric home.

**1500 ft² house, no insulation in walls, 3 1/2-inch insulation in ceiling.

FIGURE 1
GEOTHERMAL APPLICATIONS FOR DHS

the handling of geothermal water require that no contamination of a potable water supply or no increase in constituents in the geothermal water be allowed on return to the aquifer. Neither one of these conditions can be met when the geothermal waters are percolated into the ground.

The most promising indirect contact application was greenhouse space heating. Greenhouse soil heating is not required at Desert Hot Springs because of the high ambient temperatures. Process water heating was not feasible for the projects under consideration because utilization factors were so low and temperatures were required higher than can be provided by the Desert Hot Springs aquifer.

The second category, Comfort Heating and Cooling, is also split into two subdivisions, centralized and decentralized space conditioning systems. Two different types of centralized systems were evaluated for DHS: the "split cycle" variation of the ammonia-water type absorption cooler, and a standard hot/chilled water system where the hot water is the geothermal fluid and the cold water is chilled by means of either a geothermal-powered absorption cooler or a vapor compression cooler coupled with a geothermal-powered organic Rankine unit. The "split cycle" system basically separates the components of the standard ammonia-water absorption cooler. The geothermal heat is applied to the water-ammonia mixture to produce ammonia and water which can be transported as liquids in pipelines at near ambient temperatures. At the use site, cooling is achieved through evaporation of the ammonia, while heating is attainable by the absorption of ammonia vapor by the water. The ammonia-water mixture is then piped back to the central site, completing the cycle. Further technical consideration and details of geothermal space cooling will be discussed in the next section.

While both systems are technically feasible, it does not appear that either system is economically feasible at today's energy costs with the low (known) resource temperature. In addition there are serious social and legal issues raised by the piping of ammonia under city streets. Also, while the temperature of the aquifer at DHS is adequate to meet most heating requirements, it is too low for an efficient application to cooling requirements. Finally, the estimated safe yield of the aquifer is somewhat limited for a centralized cooling system. Specifically, a study investigating a ring main around the City of Desert Hot Springs to convey chilled water to each home, indicated that the requirements of the system exceeded the safe yield of the aquifer.

The same study estimated the costs of such a system to be approximately \$26,000,000. This capital expenditure is extremely large for a city the size of Desert Hot Springs (population 4,600) and would impose severe financial stresses on the community if applied directly to the populace. However, if the system were found to be technically feasible, due to the discovery of a hotter resource at greater depths or increased yield in the aquifer, the economics should be restudied. The existing data on the geothermal aquifer at DHS is based on shallow wells (800 ft.), so it is quite possible that a slim hole drilling experiment might discover a hotter aquifer at greater depths.

A decentralized cooling system suffers with the same big problem associated with the centralized system, that is, inadequate resource temperature to provide efficient cooling. Hence the decision was made to eliminate geothermal powered space cooling from further consideration at this time, with the possible exception of an energy cascaded system (covered in Appendix 9). The various demonstration projects considered for geothermal space and hot water heating are discussed in Appendix 6.

The final category of heating and cooling options considered for DHS included a couple of miscellaneous applications - an energy cascading mobile home park (discussed in Appendix A) and various refrigeration (cucumber storage) and freezing (frozen shrimp) options. Refrigeration could be provided by an absorption-type cooler, either an ammonia-water system or a lithium bromide-water system. Both of these will be discussed in detail in the following section. Freezing is limited to an organic Rankine/vapor compression unit because of the low resource temperatures available.

3.0 Equipment Options

An attempt was made at the outset of the program to single out the high technology items that might pace and control the ultimate feasibility of a proposed geothermal development project at DHS. As soon as the results of the water sample from the well flow test were known, it was obvious that the major difficulties would arise from the effective utilization of the low temperature of the resource rather than the water quality (the water sample analysis is given in Appendix 4). Thus, pumps, piping, conventional heating components and other items that might have been major problems for the case of a highly corrosive or high temperature brine, took a back seat to the problem of finding a cooling system to operate effectively with the low temperature resource.

The most common cooler system used with low temperature heat sources (flat plate solar collectors, waste heat or geothermal) is the absorption-type cooler. Figure 2 shows a simplified schematic for such a system. Starting at the generator, the hot geothermal fluid is used to heat a mixture of the refrigerant and absorbent (under pressure) until the refrigerant (with a lower boiling point) is driven off in vapor form. The vapor is then condensed back to a liquid at constant pressure, with the use of cooling water. Next, the liquid passes through a pressure reducing valve into the evaporator, where it vaporizes and causes the cooling effect. The low pressure vapor is then returned to the absorber where it is absorbed by the concentrated absorbent solution. Finally, the mixture of refrigerant and absorbent is pumped back to the generator, under pressure, to complete the cycle.

Absorption-type coolers are not a new invention by any means. Natural gas fired units were used in Servel refrigerators over 40 years ago. What is new is the low temperature application that has blossomed in the 1970's with the emphasis on solar research. Geothermal applications of the absorption cooler have also been around for years. One notable example was the installation of a 130-ton lithium bromide absorption unit in the 100-room Tourist Hotel in Rotorua, New Zealand in 1969.¹⁶ However, the geothermal inlet water temperature for this case was 250°F, over 40°F warmer than the hottest well at DHS.

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

FIGURE 2
ABSORPTION COOLING SYSTEM SCHEMATIC

are too close together), cheaper and easier to maintain. Also, lithium bromide is as harmless as table salt in contrast to the toxic nature of ammonia.

Figure 3 demonstrates how the performance of a lithium bromide unit varies with decreasing inlet water temperature. Note that while the unit performs at its rated capacity at 240°F, it drops to only 50% of its rated capacity at 200°F and 17% at 170°F (the lower operating limit). Hence, if an installation required a cooling capacity of 50 tons, a 100-ton unit would be required if the available inlet water temperature was 200°F. Figure 4 shows the effect of economies of scale as a function of increasing machine size. As would be expected, the cost per ton decreases dramatically as the units increase in size.

For applications that require freezing temperatures, only the ammonia-water unit could be used, since water is the refrigerant in the lithium bromide-water system. However, the low resource temperatures at DHS are insufficient to yield freezing temperatures with an ammonia-water unit. Thus the only technically feasible means of supporting a geothermal-powered freezer operation at DHS would be to utilize the organic Rankine engine, as discussed below.

The other type of cooling system considered was an organic Rankine engine (ORE) coupled with a conventional vapor compression unit. The ORE would convert the geothermal heat into shaft power, thereby replacing the motor that drives the compressor in the normal vapor compression unit. Figure 5 depicts a simplified schematic of an ORE. The geothermal fluid enters the boiler and vaporizes the organic working fluid. The pressurized vapor then expands through a turbine arrangement (expander) and produces usable shaft power. Next, the low pressure vapor is condensed with the aid of cooling water. Finally, the liquid is pumped back to the boiler, under pressure, to complete the cycle.

As in the case of the absorption coolers, the real question with ORE units today in low temperature applications is not the technical feasibility but the economic feasibility. While recent years have seen a heightened interest in ORE production and research, the units have still not reached a true production status level to cause a major breakthrough in the production cost. However, a recent article in a trade journal indicated that Kinetics Corporation of Sarasota, Florida was ready to begin mass production of a 10kW Freon Rankine Cycle power generating unit.¹⁷ The cost for the complete unit, skid-mounted and ready for hot inlet and cooling water hookup, is \$12,500 or \$1250 per kW.

4.0 Summary

In summary, Table 2 presents a subjective comparison of the advantages and disadvantages of each of the three systems. The lithium bromide system appears to be the best choice for space cooling applications, where adequate inlet water temperatures are available (at least equal to 200°F and preferably greater). Unless a higher temperature isotherm can be located in the future, geothermal-powered space cooling and refrigeration do not appear to be economically feasible for DHS.

FIGURE 3

AVERAGE ABSORPTION CHILLER PERFORMANCE

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

FIGURE 4

AVERAGE ABSORPTION CHILLER COSTS

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

FIGURE 5

ORGANIC RANKINE SYSTEM SCHEMATIC

TABLE 2

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

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

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

APPENDIX 6

SPACE/WATER HEATING ANALYSIS

APPENDIX 6A

DETAILED ANALYSIS OF THE
ANGEL VIEW CHILDREN'S HOSPITAL

LOGS

ANGEL VIEW CHILDREN'S CLINIC

The Angel View Clinic is situated close to the higher temperature geothermal source of around 150°F. The building is currently heated by means of oilfired heaters. The study considered replacing these heaters with geothermal water heaters located at three points in the building. Figure 1 shows the proposed arrangement of a geothermal space and hot water heating system.

The capital cost of converting the Angel View Clinic to utilize the geothermal resource would be \$62,000, while the operating cost of the system would be \$530 per year. Considering the value of the initial investment at a 10% rate of interest, the annual cost would be \$9,768. When these figures are compared with the currently installed oil-fired heaters the conclusion is apparent. The annual cost for the current system is only \$3,850 per year. Hence, the project is not economically viable due mainly to the high cost associated with the required mechanical conversion. The comparison would be more equitable for a new installation where some initial capital expense would be included with the oil-fired system. The economic calculations are attached to this Appendix.

FIGURE 1 SCHEMATIC OF SPACE AND WATER HEATING FOR
ANGEL VIEW CHILDREN'S HOSPITAL

Rogers

SUBJECT DESERT HOT SPRINGS
ANGEL VIEW CHILDRENS HOSPITAL

SHEET NO. 1 OF
 JOB NO. 576023
 BY RI DATE 1/20/18
 CHKD. BY JAB DATE 1/22/18

PAYBACK PERIOD CALCS.

$$\text{SAVINGS} = \$3847 - (844 + \text{Pumping Costs})$$

I = Heat Exchangers + Piping Costs

$$PV = 0 = I - \left\{ S \times (P/A, 10\%) + \frac{I}{n} \times 0.4 \right\}$$

$$= 0 = I - \left\{ 1 - \frac{0.48}{n} - S \times (P/A, 10\%, n) \right\}$$

$$(P/A, 10\%, n) = \frac{I \left\{ 1 - \frac{0.48}{n} \right\}}{S}$$

Assume linear Depreciation and 20 years life of equipment.

$$(P/A, 10\%, n) = \frac{I \left(1 - \frac{0.48}{20} \right)}{S}$$

COST OF EQUIPMENT

Total Heat Exchangers	=	\$19,600
Total piping	=	\$42,200
		\$61,800
say		\$62,000

Rogers

SUBJECT DESERT HOT SPRINGS

ANGEL VIEW CHILDREN'S HOSPITAL

SHEET NO. 2 OF

JOB NO. 576023

BY RT DATE 1/20/78

CHKD. BY JAB DATE 1/22/78

$$\begin{aligned} \text{Total Energy Cost : wells} &= \$140/\text{yr} \\ \text{pumping} &= \$385/\text{yr} \\ &= \underline{\$525/\text{yr}} \end{aligned}$$

$$\text{Current Energy Cost} = \$3847/\text{yr}$$

$$S = \text{SAVINGS}/\text{yr} = 3847 - 525 = \$3322$$

Taking a 20 year life check if a payback period exists

$$S_1 = 62,000 \left(n=20 \text{ } i=10\% \right)^{6.727} = 417,074$$

$$S_2 = 3322 \left(n=20 \text{ } i=10\% \right)^{57.275} = 190,267$$

No payback period possible within life of the plant.

APPENDIX 6B

DETAILED ANALYSIS OF THE
PROPOSED MULTI-USE CENTER

PROPOSED MULTI-USE CENTER

The City of Desert Hot Springs has proposed the construction of a new community center. The present location suggested 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 100' by 120' in size. Because the City Hall complex is located close to the 90°F isotherm, approximately one mile of piping would be needed to reach the higher 150°F isotherm. Only a cursory look was necessary to determine that this would not be an economic proposition because of the large capital expense required for the pipeline coupled with the low utilization factor for the center. Thus, since the center site was not definitely fixed, the decision was made to assume a new site over the 150°F isotherm. For comparison purposes, the alternative system was assumed to be a gas-fired system.

Table 1 summarizes the results of this study. Note that the geothermal system total annual cost is considerably higher than the gas-fired system. In addition, it should again be stressed that this assumes the multi-use center can be sited over the 150°F isotherm rather than the current site. Hence, the geothermal system is not economical when considering natural gas at current prices. The economic calculations are attached to this Appendix.

Table 1. 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

Subject - Desert Hot Springs
New Multi-Use Center

Sheet No. 1 of 3
Date 4/25/78

Geothermal System

Hot Water Usage: total kitchen & bathroom,

$$5 \text{ gal/day/person} \times 150 \text{ persons} = 750 \text{ gal/day} \\ = 0.5 \text{ gpm}$$

$$Q = 0.5 \text{ gpm} \times 60 \text{ min/hr} \times 8.34 \text{ lb/gal} (135-45) \\ = 22,518 \text{ Btu/hr}$$

$$C_{min} = 250 \text{ Btu/hr/}^{\circ}\text{F}$$

$$\text{Area Heat Exchanger} = 3.7 \text{ ft}^2$$

Forced Air Heating: $12,000 \text{ ft}^2$ (2 Tons/1000)

$\therefore$ 24 Tons required

or 20 gpm required

$$\text{Pumping power required: } \frac{20 \times 20.5}{1.714} = 0.239 \text{ kW}$$

$$\text{Assume sharing of wells: } \frac{20.5}{500} = 0.04 \text{ (4\%)}$$

$$\therefore \text{Well cost} = \$8000 \times 2 \times 0.04 = \$640$$

$$\text{for 5\%, } = 8000 \times 2 \times 0.05 = \$800$$

$$\text{Well Cost/yr} = \$800 \text{ CRF}_{10}^{20} = \$191/\text{yr}$$

$$\text{Pumping cost} = 0.25 \text{ kW} \times 90 \times 6 \times \$0.028 \\ = 3.78 \approx \$4$$

$$\therefore \text{Total annual "energy" cost} = 191 + 4 = \$195$$

Subject - Desert Hot Springs
New Multi-Use Center

Sheet No 2 of 3
Date 4/25/78

Capital Cost:

Geothermal -

Piping costs	760
Air Heat Exchanger	3400
Water Heating	500
Pumps Misc	500
	<u>\$5160</u>

$$\text{Annual Cost} = \$5160 \text{ CRF}_{.10}^{20} = \$1230$$

Gas-Fired System

Gas Heaters	2 x 335 =	670
Labor	2 x 4 x \$20 =	160
Water Heater		= 250
Labor	2 x \$20 =	40
		<u>\$1120</u>

$$\text{Annual Cost} = \$1120 \text{ CRF}_{.10}^{20} = \$267$$

$$24 \text{ Tons} \times 12,000 \text{ Btu/hr} = 288,000 \text{ Btu/hr}$$

$$\text{Use } 300,000 \text{ Btu/hr}$$

$$\begin{aligned} \text{Energy cost} &= \frac{\$2.00}{10^6 \text{ Btu}} \times 300,000 \times 90 \times 6 \text{ hr/da} \\ &= \$324 / \text{yr} \end{aligned}$$

Summary Sheet

Capital Cost:

Geothermal System:

Total Cost - \$5160

Cost / yr - \$1230

Gas Fired System:

Total Cost - \$1120

Cost / yr - \$267

Energy Cost:

Geothermal System:

Well + Pumping = $191 + 4 = \$195$

Gas Fired System:

Cost / yr = \$324

Annual Cost w/ dep.

Geothermal: $\$5160 (0.16275) (1 - \frac{0.48}{10}) + 195$
 $= 800 + 195 = \$995 / \text{yr}$

Gas System: $= 267 + 324$
 $= \$591 / \text{yr}$

APPENDIX 6C

DETAILED ANALYSIS OF THE
HEATING SYSTEM FOR MUNICIPAL BUILDINGS

HEATING SYSTEM FOR MUNICIPAL BUILDINGS IN DESERT HOT SPRINGS

1.1 Introduction

City Hall is located near that portion of the geothermal aquifer which contains 90°F 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 approximately 1-1/2 miles of source pipeline.

A heating system for City Hall would require a minimum of two wells, one for production and the other for injection, plus installation of approximately three miles of pipeline and appropriate conversion equipment in City Hall. In view of the limited heating season and the low heating requirements of City Hall, the high capital cost and low annual utilization of the resource make the geothermal heating system for City Hall alone an uneconomic project.

1.2 Expanded Heating System

Based on the above, the decision was made to consider 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

Table 2 shows the heating load requirements for the proposed system.

The maximum heating load occurs during winter period which creates an imbalance in annual resource utilization. This condition 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 the uniform annual load required for economic geothermal utilization.

1.3 System Layout and Requirements

1.3.1 Expanded Heating System Layout

Figure 2 shows a map of the Desert Hot Springs area with the indicated locations of the various city buildings and facilities in the network, as well as the estimated isotherm boundaries. Also shown on the map are the proposed locations of the source and injection wells

TABLE 2

Heating Loads, Requirements and Costs
for the Proposed Heating Network

<u>Building</u>	<u>Heat Load Required (Btu/hr)</u>	<u>Geothermal Flow Req't (GPM)</u>	<u>Current Heating Cost/Year (S)</u>
Wardman Hall*	499,500	33.3	840
Recreation Hall*	101,400	6.7	100
Scout Hall*	166,500	11.1	179
Elementary School	250,000	16.6	1,584
City Hall	169,000	11.2	62
Library	136,500	9.1	62
Community Center (Future)	338,500	22.5	126
Swimming Pool*		<u>50.0*</u>	<u>465</u>
Total for Given Year		110.5 (w/o pool)	3,418
Total for Random Year**		127.1 (w/o pool)	3,930

*Summer load only, all other loads are winter.

**Includes a 15 percent contingency factor to extrapolate from data for a selected year to nominal year.

The supply well could be located in the area adjacent to the junction of Pierson Boulevard and Miracle Hill Road, inside the 150°F isotherm. The supply 6" diameter pipeline would be laid underground, buried in sand, and would run from Miracle Hill Road down Pierson Boulevard to the corner of Pierson and Cactus Streets. At this junction the line would divide into two 2-1/2" diameter branches. One of the branches would run along Cactus Street to Eighth Street to provide the space heating for Wardman Park. The other branch would continue along Pierson Boulevard from Cactus Street to West Drive, before distributing to the City Hall, Library, Proposed Community Center, and Elementary School. Figure 3 shows a schematic of the system.

The return pipeline would follow the same route except that it would be connected to an injection well located at a suitable site between Palm Drive and Verbena in the 90°F isotherm. The above layout is proposed on the assumption that access to the locations for the wells and necessary right-of-ways are obtainable.

1.3.2 System Requirements

Based on data obtained from city officials at Desert Hot Springs, calculations were made to establish the average heating loads, equivalent geothermal flow rates, pipe sizes and pressure drops for the

FIGURE 2 LOCATION OF BUILDINGS AND WELLS FOR SPACE HEATING SYSTEM

FIGURE 3. MUNICIPAL HEATING SYSTEM SCHEMATIC

proposed network (Table 2). The geothermal water flow requirement, based on a 150°F source and a 30°F temperature drop through the various heating devices, requires development of one production well and one injection well.

Based on the required geothermal flow rates shown in Table 2 and an assumed duty cycle for the various facilities in the network, an annual energy cost (i.e., pumping cost) could be calculated for the proposed network.

1.4 Construction Cost

A construction cost estimate was made considering all the mechanical equipment, piping, valves, electrical equipment, excavation and back-fill, and total labor costs for the installation of the system. Table 3 shows a summary of these costs. The total estimated construction cost for the complete installed and working system is approximately \$250,000. See cost estimate attached to this Appendix.

1.5 Operating Costs

The normal operating cost for the existing heating systems is \$3,930 per year (Table 2). The geothermal heating system would require an energy input for pumping which is calculated to be approximately 39,430 kWh per year. This results in an annual operating cost of \$1,104, based on average electric power costs of 28 mills per kWh.

As can be seen from the above figures, the annual operating expense for the proposed geothermal system represents a substantial savings over the present system. These figures, however, represent only the annual operating costs and do not include the required capitalization for the geothermal system (versus no capitalization for the current system).

TABLE 3

Capitalization Cost Summary
for Heating of Municipal Buildings

<u>Item</u>	<u>Required Cap. Invest. (\$)</u>
Gathering and Reinjection System	31,112
Pipeline System - Piping	170,427
- Valves	5,846
Mechanical Equipment	8,850
Civil Engineering - Trenching	5,143
- Backfill	27,669
Electrical	<u>2,733</u>
Total	\$251,780

Capitalized Cost Analysis

The capitalized cost analysis can be considered from two different approaches: first, consider what the present worth of the system is, this will immediately identify the economic feasibility of the system; second, should the above premise prove negative, how much capital expense would the annual savings justify in order to investigate the possibility of funding the remaining portion through grants or other sources?

In order to address the first question, the following assumptions were made: a system life of 20 years, financing at 12%, straight-line depreciation and a 48% corporate tax rate. For these assumptions the present worth was found to be -\$227,005 (See Table 4 for details). Obviously the system is uneconomical.

In regard to the second question, the annual energy savings of \$2,826 over the 20 year life of the project would justify an initial capital investment of only \$25,709 (including the tax benefit from the depreciation of the city's portion of the investment). In other words, the city would have to secure a grant for approximately \$277,000. The project therefore remains a very poor economic prospect for the city or the government.

There are several important thoughts that are germane at this time. These deal with a number of tangible as well as intangible issues that have a direct bearing on the above analysis and any conclusions that might be drawn from the results. First, the assumption was made that no capital expense was required on the current heating system over the next 20 years! This is obviously very conservative and penalizes the geothermal system. Every dollar spent in the future for replacement of a portion of the current system has some present worth that can be directly subtracted from the required capital investment for the geothermal system. However, the cost differentials are so large that the calculations were not undertaken as the difference would not alter the conclusion.

A second important observation can be made regarding some very conservative assumptions about the future energy situation. The current heating system at Desert Hot Springs is primarily committed to natural gas (with the exception of electric heating at the elementary school). The previous analysis assumed no energy cost escalations for either natural gas or electric energy over the next 20 years, in spite of much recent talk of gas curtailment, gas deregulation (which could potentially double the cost of natural gas overnight), and the ultimate possibility that natural gas supplies will be exhausted in the foreseeable future. In order to assess the impact that projected fuel escalation rates would have on the economic viability of the project, the analysis was repeated assuming various escalation rates between 0-10 percent per year. The results are shown plotted in Figure 4 as

FIGURE 4
Capital Investment Justified by
Annual Energy Savings

a function of the amount of capital the city could afford to spend versus the various escalation rates. Note that, for an assumed rate of 7 percent per year, the capital investment justified by the city has increased to \$53,800. For the above analysis, both natural gas and electric energy rates were assumed to increase at the same rate, which penalizes the geothermal system.

TABLE 4

Cost Comparisons on Basis of Present Worth

<u>Item</u>	<u>Dollars (\$)</u>
1. Capital Expenditure	= 302,412
2. Present Worth of Existing System Fuel Costs	= 42,735
3. Present Worth of New System Pumping Costs	= 12,005
4. Present Worth of Maintenance Costs	= 9,458
5. Present Worth of Energy Savings	= 30,730
6. Present Worth of Savings from Depreciation	= 54,135
7. Present Worth of Net Savings	
5. + 6. - 1. - 4. = 7	= -227,005

Item 1. through 6. are derived in the calculations attached to this Appendix.

1.7

Conclusion

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

With this background, it comes as no surprise to find that a geothermal heating network for the aforementioned city facilities is not feasible based on straight economic considerations when fully financed by the City of Desert Hot Springs.

However, there are numerous positive facts to be pointed out with respect to the proposed network. In addition to displacing almost 145,000 equivalent kWh (natural gas and electric) of fossil fuel, the geothermal system provides a certain degree of energy independence, particularly with regard to natural gas. As was mentioned earlier, the future prospect of gas curtailment and/or deregulation could drastically alter the economic analysis previously presented in favor of the geothermal system.

As Figure 4 shows, the geothermal system is capable of supporting from \$30,000 to \$70,000 in capital investment, for energy cost escalation rates of 0-10 percent per year, respectively. Thus, 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 \$250,000 capital investment, the proposed system could become financially feasible to the City of Desert Hot Springs.

A PON or other financing program for a field investigation would also be very helpful in locating a hotter isotherm closer to the proposed heating network.

CONSULTING ENGINEERS

DWG. NO.

Municipal Heating System

COST ESTIMATE

REVISÉ.....

SHEET: OF

PREPARED BY JAB CHECKED BY DMB

PRELIM. ☐ % FINAL ☒

[illegible]

GE-001

SUB TOTAL

CONSULTING ENGINEERS

DWG. NO.

COST ESTIMATE

REVISÉ

PREPARED BY RLH CHECKED BY DMB

PRELIM. ☐ % FINAL ☐

ACCOUNT NO.	DESCRIPTION	QUAN.	UNIT	UNIT LABOR	LABOR	UNIT MATERIAL	MATERIAL	OTHER	TOTAL
	Size 3 FVNR Circuit Breaker Type Motor Starter For 40 HP Gathering System Pump In NEMA 4X Enclosure	1	ea.	210.00	210.00	935.00	935.00		1,145.00
	Size 2 FVNR Circuit Breaker Type Motor Starter for 15 HP Reinjection System Pump in NEMP 4X Enclosure	1	ea.	150.00	150.00	590.00	590.00		740.00
	600V Metal Clad Cable with 3-#10 XHHW Insulated Conductors Direct Burial	200	L.F.	1.50	150.00	.96	192.00		342.00
	600V Metal Clad Cable with 3-#6 XHHW Insulated Conductors Direct Burial	200	L.F.	1.50	150.00	1.78	356.00		506.00
GE-001	SUB TOTAL				660.00		2,073.00		2,733.00

CONSULTING ENGINEERS.

DWG. NO. _____

ITEM TITLE Mechanical Estimate

PRELIM. ☐ % FINAL ☐

GE-001

SUB TOTAL

CONSULTING ENGINEERS

JOB NO. S-76023

FOR Desert Hot Springs

PROJECT

DWG. NO.

COST ESTIMATE

ITEM
TITLE.....Mechanical Estimate.....

DATE.....3/23/78.

... REVISED.

SHEET.....3

... OF

PREPARED BY.....JAB

... CHECKED BY DMB

PRELIM. ☐

... FINAL ☐

[illegible]

GE-001

SUB TOTAL

5,845.00

CONSULTING ENGINEERS

DATE.....3/23/78

.. REVISED

FOR Desert Hot Springs

ITEM TITLE Mechanical Estimate

SHEET.....4

.. OF

PROJECT

PREPARED BY.....JAB

.. CHECKED BY.....**DMB**

DWG. NO.....

PRELIM. ☐

....% FINAL ☐

GE-001

SUB TOTAL

CONSULTING ENGINEERS

DWG. NO.

ITEM TITLE Mechanical Cost Estimate

... REVISED...

... OF

... CHECKED BY DMB

.....% FINAL ☐

GE-001.

SUB TOTAL

CONSULTING ENGINEERS

PRELIM. ☐ % FINAL ☐

GE-001

SUB TOTAL

BACK UP SHEET

Mechanical Estimate

Installation of space heating coils:

Remove existing coils	-	4 hours
Install new coils	-	4 hours
Check system	-	<u>2 hours</u>

10 hours

Rate/hour = \$21.50	\$215.00
---------------------	----------

Installation of water heater:

Remove existing heater	-	1 hour
Install new heater	-	2 hours
Test	-	<u>2 hours</u>

5 hours

Rate/hour = \$21.50	\$107.50
---------------------	----------

Rogers

SUBJECT Desert Hot Springs

SHEET NO. OF

JOB NO. 576023

BY JAB DATE

CHKD. BY DATE 3/27/77

Back Up Sheet for Civil Estimate.

Length of trench = 11,412 ft.

Cost (per Richardson)
2-17 p. 3

Volume of trenching / ft of length with class 3
repose.

$$2 \times 0.1482 + 0.2964 = 0.5928$$

$$\text{Volume} = 0.5928 \times 11412 = 6765 \text{ cu. yds}$$

$$\begin{aligned} \text{Machine output} &= 126.8 \text{ cu yds / hr} \\ \text{Hrs REQD} &= \frac{6765}{126.8} = 53.35 \end{aligned}$$

Rogers

SUBJECT Desert Hot Springs

SHEET NO. _____ OF _____
 JOB NO. 576023
 BY JMS DATE _____
 CHKD. BY JMS DATE 3-27-78

$$53.35 \text{ km} @ \$86.44$$

$$= \$4622$$

$$54 - 53.35 = 0.65$$

$$0.65 \times (86.44 - 28.60)$$

$$= \$37.60$$

$$1 \text{ load} \times 28$$

$$= 28.00$$

Sub. total

$$\$4676.00$$

Profit

$$467$$

Total

$$\$5143$$

$$5154$$

Backfill

$$6765 \text{ cu. yds.}$$

$$6765 \times \frac{1}{4} = 1691 \text{ cu. yds.}$$

$$6765 \times \frac{3}{4} = 5073 \text{ cu. yds.}$$

Confined area
pipe vol.

$$= \frac{\pi \left(\frac{6}{12 \times 3} \right)^2}{4} \times \frac{1}{3} \text{ y yds.}$$

$$= 0.007 \text{ cu. yds. / ft.}$$

$$\text{Total} = 11412 \times 0.007 = 79.8 \text{ cu. yds.}$$

$$\text{Confined } 1691 - 79.8 = 1611$$

Rogers

SUBJECT

Desert Hot Springs

SHEET NO. OF

JOB NO. 576923

BY JAS DATE

CHKD. BY DATE 3/27/77

H.P. for Gathering system & Rejection system

$$HP = \frac{f h s}{3960 \times e}$$

Gathering system well pump

$$HP = \frac{152 \times 383 \times 1}{3960 \times 0.85}$$

$$= 17.2 \text{ say } 20HP$$

for return line also

$$40 HP$$

Reinjection

$$HP = \frac{152 \times 231 \times 1}{3960 \times 0.85} = 15$$

Field Fabricated R piping

(consider 20' length)

4" Supply - 8320 ft.

416 joints

$$\frac{\text{cost}}{\text{ft}} = 3.53$$

$$\frac{\text{cost}}{\text{ft inst}} = 1.07$$

Reinjection - 4080.

$$\text{cost/ft} = \$98.60$$

2 1/2" - 2854 ft

143 joints
7040

$$1.95$$

$$0.95$$

2" - 200

10 joints

$$1.36$$

$$0.83$$

1 1/2" - 238

12 joints

$$1.78$$

$$0.91$$

1" - 200

10 joints

$$1.18$$

$$0.66$$

Rogers

SUBJECT

Desert Hot Spring

SHEET NO.

OF

JOB NO.

576023

BY

JAB

DATE

4/4/78

CHKD. BY

RT

DATE

BACK UP DATA.

FIELD FABRICATED PIPE.

6" C.S. SCH 40 B.W.

COST/FT

COST/FT EST.

6"

8320 ft

416 JTS @ 135⁴⁵

5.93

1.8

6"

4080 ft

204 JTS @ 135⁴⁵

5.93

1.8

6" field fab pipe cost.

$$(8320 + 4080) \times (5.93 + 1.8) + (416 + 204) \times 135⁴⁵$$

95832

+

83979

179,831

6" GATE VALVES.

6" C.S. GATE

\$576 ea.

\$58⁰⁵

6 valves

@

576

@

58⁷⁶

3456

LABOR

TOTAL

353

3809

6" CHECK VALVE

494

58⁷⁶

553

TOTAL

4362

APPENDIX 6 D.

DETAILED ANALYSIS OF THE

AUTOMATED CAR WASH

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.

To obtain information on the nature of the car washing business, the equipment utilized, and the energy usage, a survey of several manufacturers and users was done. Based upon the results of this survey, the following main points were observed (see Table 5):

- (a) Hot water is used mainly in the self-service systems. Only a few of the conveyor-type systems use hot water.
- (b) High-speed air used for drying purposes is not heated.
- (c) The self-service system requires high water pressure but relatively small flow rates.
- (d) The conveyor-type system requires low water pressures but relatively high flow rates.

To obtain more detailed information on the operation of a car wash system, The Bubble Machine, one of the big users in the State of California, was surveyed. This company has 49 installations, 29 of them in the San Francisco Bay Area. According to The Bubble Machine Company most of the installations do not use hot water anymore. The cold water detergents have replaced the need for hot water. Estimated load factors (7:00 A. M. to 10:00 P. M. daily basis) of 40 to 50 percent in a busy day, and 5 to 10 percent in a bad day, were reported for an installation in downtown San Francisco. From the energy usage point of view the energy bill represented in 1975 about 35 percent of the total operating cost including overhead and rent. Since the hot water is being replaced by detergents, the energy bill has dropped to about 20 percent of the total operating cost. The main energy consumption comes from the electric motors of the high-speed air blowers which could not be replaced with geothermal energy.

Since most car washes are now no longer using hot water, consideration of a geothermal car wash is not practical and the study was discontinued.

TABLE

FIRM.	USES HOT WATER.							USES STEAM		USES HOT AIR DRYING				TIME TO MAJOR MAINT.	TYPE OF SYSTEM	APPROX COST EXCD. W. HTR
	YES	NO	FLOW RATE	P.S.I.	°F	TYPE OF HEATER	COST OF HTR	YES	NO	YES	NO	FLOW HP	VEL.			
WEBER INDUSTRIES.	X		3.5	750 800	105	GAS 400,000 BTU/HR	2250		X	X		—	—	6 YRS	SS	20,100 Equip only
GAIL INDUSTRIES	X		25-10	700 -1000	120 -140	—	—		X	X		—	—	—	SS	—
BELANGER INC		X		60	Amb	—	—		X	X		35HP	160mph	—	C	—
HANNA INDUSTRIES		X	75	60	Amb	—	—		X	X		—	160mph	—	C	—
KWICK CAR WASH	X		3	600 -1200	135	GAS 500,000 BTU/HR	3000		X	X		—	—	—	SS	30,000
THE BUBBLE MACHINE	X		35	60	110-130	10 ⁶ BTU/HR	—		X	X		1800 ACFM 5HP	160mph	—	C	—
FIELDWAY INDUST. CO.	X		9	600 -1000	120 -140	—	—		X	X		—	—	5-9 yrs	SS	2-25,000
WEST COAST CAR WASH	X		60	60	130	GAS	—		X	X		—	HIGH	—	C	—
HOLLINGSHEAD INDUSTRIES		X	8	60	Amb	—	—		X	X		—	HIGH	—	C (90 CARS /HR)	48,000 Equip only
ALLEN CAUF CAR WASH SYSTEMS.		X	—	—	—	—	—	X			X	—	—	—	C	—

APPENDIX 7

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),¹⁸ 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 1.¹⁹ 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 1) by the recent price from the Los Angeles wholesale market for two of the slowest market months, June and July.²⁰

FIGURE 1 EUROPEAN CUCUMBER WHOLESALE PRICES - 1974

TABLE 1

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.¹⁹ 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.¹⁸ 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 fruit²¹), 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.²² 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.²³ 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.²² 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;¹⁹ 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.

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 locale of Desert Hot Springs which does not have a totally suitable climate for a greenhouse complex growing European cucumbers is based on other economic factors mentioned in the main text which are the overriding criteria making the siting attractive.

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 temperature 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 nighttime 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 current greenhouse production of European cucumbers is achieved in the following types of greenhouse construction, the Quonset type and Frame type (see Figure 2). The Quonset type is ideal for a single unit "back-yard" type operation. However, the Frame type can be conveniently linked together to form large area production facilities. For the purposes of this report, only the Frame type is considered. Methods used in the construction of Frame greenhouses are:

- Wood frame with polyethylene cover
- Metal frame with polyethylene cover
- Metal frame with glass panels
- Metal frame with fiberglass panels

The latter type is the most common and economic type. The height of the greenhouse side walls should be 8 ft. This will allow the plants to grow to a height which is workable for fruit collection without the use of ladders or platforms.

Current designs of a greenhouse usually include a cooling and humidification system and a heating system. The cooling is usually done by means of evaporative cooling which also adds humidity. The evaporative unit

QUONSET TYPE

FRAME TYPE
MOST ECONOMIC FOR
LARGE FARMS

LESS EFFICIENT IN PLANTING
VOLUME FOR UNITS IN SERIES

MORE VOLUME ON LESS ACREAGE AND
BUILT IN A COMPLETE INTEGRATED UNIT

4 TYPES

- WOOD FRAME POLYETHELENE COVER
- METAL FRAME POLYETHELENE COVER
- METAL FRAME GLASS PANELS
- METAL FRAME FIBERGLASS PANELS

FIGURE 2 ALTERNATE BUILDING TYPES

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 indicated 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.

4.3 Basic Systems for Heating and Cooling

The geothermal reservoir temperatures are in the range of 90°F to 180°F. Though this is an ideal temperature range for heating and hot water usage, it is approximately 100°F too low for efficient (90-100%) mechanical operation of absorption type air conditioning system. To obtain units which are economically efficient, that is, reduce the size of the equipment, the temperature source would have to be in the 300°F range. The main load problem in Desert Hot Springs is cooling, and the greenhouse required an exceptionally large amount of cooling because of the need to allow sunlight in for cucumber growth, but requires the temperature to be controlled below ambient at the same time. The two recommended methods for heating and cooling the greenhouses are shown below.

4.3.1 Heating Systems

In a heating system 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, shown on Figure 3, 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. Calculations have shown that this method of adding heat and humidification will be the most economical method of providing the correct temperature and humidity conditions. 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.

FIGURE 3: HEATER ON ONE PASS BASIS WITH HUMIDIFICATION

4.3.2 Cooling System

An evaporative cooling system based on one air change through the building every two minutes is shown in Figure 4. This system is the best candidate from the economic viewpoint and, as mentioned previously, this type of system is currently and successfully being used for cooling of greenhouses.

Other heating and cooling systems such as Recirculation Heating and Chilled Water Accumulation System were studied but rejected on a cost basis.

5. GREENHOUSE COMPLEX ARRANGEMENT

Figure 5 shows a greenhouse of approximately 2 acres which is a commercial production size installation capable of making a profit introduction 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 from 50°F to 55°F. Figure 6 shows a schematic of the harvesting and packing operation.

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 is considered the basic and most economical system for the Desert Hot Springs application. The plants can be laid out in rows of two abreast, 24 inches apart, on 18 inches spacing with 4.5' aisles between the rows. Figure 7 shows a typical layout of cucumber plants.

A typical hydroponic system consists of gravel beds through which water rich in nutrients is circulated. The pumps are set to circulate the solution on a timed basis. This gives the option of being able to "stress" the plants for maximum production by varying the feed rate.

The soil at Desert Hot Springs should be ideal for growing the cucumbers and therefore a natural planting system with drip irrigation should be sufficient.

5.2 Production Rate

Plant density is such that typical annual yields are 15 lbs. per plant per crop, or 240,000 lbs. per acre. Three crops-plus per year are possible and are being currently achieved in the U. S. A. which translates to

FIGURE 4 EVAPORATIVE COOLING

FIGURE 5 PROPOSED GREENHOUSE & WAREHOUSE DEVELOPMENT -
DESERT HOT SPRINGS GEOTHERMAL PROJECT

FIGURE 6 HARVESTING, PACKING & SHIPPING

FIGURE 7 TYPICAL LAYOUT OF CUCUMBER
PLANTERS

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.

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, and beds resowed and a new harvest started. Figure 8 shows the planting, harvest, and resowing schedule.

Based on this schedule the annual production was calculated and found to be approximately 1 million lbs./year. Allowing for a 10% loss due to damage or insufficient quality, the total yearly production is approximately 900,000 lbs. 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 lbs./1,000 sq. ft./ year²⁴. The complex in this study will produce 11,500 lbs/1,000 sq. ft./year.

6. ECONOMICS ASSESSMENT

The totalized costs for a two-acre greenhouse complex are summarized in Table 1 & 2. Table 1 shows the economics of a 12 month production schedule and Table 2 shows the economics for 9 months' production.

Table 1

The total capital cost is \$932,657. A major portion of this sum, \$304,620 is accounted for by the geothermal wells and gathering and reinjection system for the geothermal heating. The balance of \$628,037 comprises the greenhouse structure, foundations, heating and cooling equipment, dispatch office and warehouse complete with heat sealing machine, conveyor system inside the greenhouse, and the purchase of land for siting of the greenhouse.

Based on information obtained from the University of California Agricultural Extension and field observation of a cucumber facility near San Diego, it was estimated that 11 full-time employees would be required to operate the two-acre greenhouse complex. The total yearly salary including overhead was calculated to be \$114,000, approximately (Table 3).

The heating system for this greenhouse complex design will be a geothermal hot water to air heat exchanger system. The system would use approximately 4,000 gpm of 110°F water. The gathering system for the heating would comprise 11 wells operating at 350 gpm/well.

An electric rate schedule was calculated for the Desert Hot Springs area and is shown in Table 4. The rate was found to be \$0.028/kWh for agricultural use based on the A-1 schedule of the Imperial Irrigation Dis-

FIGURE 8 GREENHOUSE PRODUCTION PATTERN FOR
UNIFORM ANNUAL CROP DISTRIBUTION

TABLE 1

TOTALIZED COSTS FOR 2 ACRE GREENHOUSE COMPLEXALL 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

Note 3 - See Table 5

Note 4 - See Table 6

Note 5 - See Table 7

Note 6 - See Economic Calcs Appendix 7B

Note 7 - See Economic Calcs Appendix 7B

Note 8 - See Economic Calcs Appendix 7B

TABLE 2

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))
 Note 2))
 Note 3))
 Note 4))
 Note 5))

Same as Table 1

Note 6 - See Economic Calculation for 9 Month Production (Appendix 7C)
 Note 7 - See Economic Calculation for 9 Month Production (Appendix 7C)
 Note 8 - See Economic Calculation for 9 Month Production (Appendix 7C)

TABLE 3

LABOR COST FOR 2 ACRE GREENHOUSE COMPLEX

12 Month Operation

Total number of employees = 9

Breakdown: 2 Technical/Managerial @ \$10/hr. + \$2.25 O/H Charge = \$12.25
7 Manual/Semi Skilled
Workers @ \$3.55/hr. + 22.5% O/H = \$ 4.35

Monthly Salary Bill

Technical	\$12.25 x 173 x 2	=	\$ 4,239
Manual	\$ 4.35 x 173 x 7	=	<u>5,268</u>
			\$ 9,507/month
Yearly Total:	\$9,507 x 12	=	\$114,084

9 Month Operation

No change in labor costs is envisaged by curtailing production during 3 months of summer period.

TABLE 4

SUMMARY OF ESTIMATED ELECTRIC POWER COSTS
FOR 2 ACRE GREENHOUSE COMPLEX

Month	Days	Hr./Day	Demand	kWh	\$ Charge	Cost/kWh
December	31	15	208	96,630	2,868.16	.02968
January	31			96,630	2,868.16	.02968
February	29			90,390	2,708.11	.02996
March	31	24	234	179,096	4,886.36	.02807
April	30			168,480	4,742.31	.02815
May	31			174,096	4,886.36	.02807
June	30			168,480	4,742.31	.02815
July	31			174,096	4,886.36	.02807
August	31			179,096	4,886.36	.02807
September	30			168,480	4,742.31	.02815
October	31			174,096	4,886.36	.02807
November	30			168,480	4,742.31	.02815
Total	366			1,828,050	51,845.47	.02836

Total Annual Billing = \$51,845.47

Total Annual Usage = 1,828,050 kWh

Average Cost/kWh = .02836

NOTE: The above charges are based on Imperial Irrigation District Schedule A-1 Rate (C) which has a minimum billing of \$297.50 per month but results in savings to the customer over Rate (B) when the assumed quantities of energy are used.

TABLE 5

FUEL COST FOR HEATING OF 2 ACRE GREENHOUSE COMPLEX

Heating System

Heating will be required for 3 months of each year.

From heating calculations (Appendix 7A)

Water Flow Required = 330 gpm/module
(12 modules to 2 acres - 1 module = 120 x 60 ft.)

Total Flow = $330 \times 12 = 3,960$ gpm

Number of Supply Wells Required @ 350 gpm/well = 11

Energy Cost For Well Pumps

H. P. of pump in each well = 5-7 H. P. = 3.73-5.2 kW

Electrical Cost @ 2.8c*/kWh = $5.2 \times 11 \times 0.028 \times 24 \times 90 = \$3,459$

Energy Cost for Heating Fans

H. P. of Heater Fan = 2 H. P.

Electrical Cost @ 2.8c*/kWh = $12 \times 3 \times \frac{2}{0.746} \times 0.028 \times 24 \times 90 = \$5,837$

Energy Cost for Reinjection

Number of Wells Required = 11

Reinjection Pumps H. P. = $\frac{11 \times 350 \times 200}{3,960 \times 0.85}$

Reinjection Cost = 228 H. P. (20.7 H. P./Pump)
 $= 228 \times 24 \times 90 \times 0.028 = \$18,546$

Total Costs

Well Pumps = \$ 3,459

Heating Fans = 5,837

Reinjection Pumps = 18,546

Total \$27,842

*See Table 4 for Electrical Cost Breakdown

TABLE 6

FUEL COST FOR COOLING OF 2 ACRE GREENHOUSE COMPLEX

Evaporative Cooling System

Two systems were considered:

- (a) Cooling for 9 months/year
(b) Cooling for 6 months/year

Case (a) - Cooling for 9 Months

From Cooling Calculations Appendix 7A

Total Air Flow/Module = 84,000 C. F. M.

Using 3 Fans/Module @ $\frac{84,000}{3}$ = 28,000 C. F. M.

Fan H. P. = 6 Electrical Cost = 2.8c*/kWh

$$\text{Operating Cost} = 6 \times 0.746 \times 0.028 \times 12 \times 24 \times (365-90) = \$29,778$$

*See Table 4 for Electrical Cost Breakdown

Case (b) Cooling for 6 Months

$$\begin{aligned} \text{Cost (\$/Module/Month)} &= \text{HP} \times 0.746 \times \text{no. of days/month} \\ &\quad \times \text{cost/kWh} \times \text{hrs/day} \\ &= 15 \times 0.746 \times 30 \times 0.028 \times 24 \end{aligned}$$

Cost/Year = \$226/Module/Month
= \$226 x 12 x 6
= \$16,243

TABLE 7
FIXED COSTS

CUCUMBERS: Sample cultural costs for greenhouse production, 1974.
Based on soil bed culture, 3 crops per year, labor @ \$4.35/hour,
plant density, 825 plants/module

Cultural Operation	Labor		Per 2 Acres Growing Space/Crop Material and equipment		Total Cost
	Hours	Cost	Item	Cost	
Tillage	156			\$	\$
Pre-Plant Fertilization	48				
Media Sterilization	35		Fuel and Repair	234	
Planting	315		Fumigant and Fuel	120	
Support Strings	500		Plants	700	
Prune and Train	1,750		String	1,860	
Fertilizer and Irrigation	180		Fertilizer Materials	400	
			Water	1,799	
Pest Control	535				
Fuel					
Power					
Plant Removal	310				
Total Preharvest Costs	3,829	16,656		6,514	23,170

TOTAL ANNUAL COST = \$23,170 x 3 = \$69,510

trict. The annual cost for heating consists of the 11 well pumps and 33 air distribution fans (3 per module for 11 modules). The total cost was found to be \$27,842 per year.

The cooling system is of the evaporation type as described earlier. The cost of cooling is comprised of the kWh costs of operating the air distribution fans and the water spray pumps. These costs were found to be \$29,778/year.

The fixed annual costs cover the necessary work and materials required to enable production of the cucumbers. This included tilling, planting, sterilization of the soil, fertilization, pest control, purchase of plants, planting, pruning and hanging. The total cost per year for the above on a 2 acre complex is estimated to be \$69,510 for the 12 months production and \$67,779 for the 9 months production. The breakdown of the fixed costs is shown on Table 7.

Calculations were made at a 10% and 12% interest rate to provide for the Return on Initial Investment figure. These interest rates were chosen as realistic rates in the current money market. The 10% rate yielded a return of \$191,568/year and the 12% rate yielded a \$204,345/ year return.

Based on the 90% of total grown crop production it is estimated that an income of approximately \$617,000 will be generated. This figure is based on the market price obtainable in the Los Angeles market during 1977, the market prices are shown in Figure 9.

The profit for the greenhouse complex will consist of the remaining funds available from the annual income after all debit charges are subtracted from it. Table 1 summarizes all the cost factors for the 2 acre all-year-round production of European cucumbers. As shown in the table the net profits are \$180,281 for 10% rate of interest on capital profit and \$167,504 for 12% rate of interest on capital profit.

Table 2

Table 2 follows a similar pattern to Table 1; however, the cutback in production to save energy results in a dramatic loss of income and makes the economic picture much less attractive and depending on the rate of return on capital the complex would be a borderline economic loss.

7. FOSSIL FUEL DISPLACEMENT

A two-acre greenhouse complex operating on an all-year-round production schedule would consume approximately 19,000 gallons of #2 fuel oil per month. The total cost for the heating season of 3 months duration would be \$21,500. As can be seen from the above, the costs are approximately equal and therefore no net savings in energy will result. The calculations for the above are attached to this Appendix.

FIGURE 9 GREENHOUSE CUCUMBER WHOLESALE MARKET
PRICE (BASED ON 14-18 COUNT CARTON)

8.

OVERALL COST STUDY FOR A 2 ACRE COMPLEX WITH A REDUCED GROWING PERIOD

A study was undertaken to determine if a reduced growing period affects the overall profitability of the 2 acre complex. The results of this study indicated that an abbreviated season would be detrimental to the profit picture. Table 2 summarizes the cost factors for this study.

APPENDIX 7A

Heating and Cooling Requirements for
2 Acre Greenhouse Complex for 12 Month
Production.

Rogers

SUBJECT DESERT HOT SPRINGS

SHEET NO. 1 OF 2

JOB NO. 5-7602-2

BY LL DATE 2/24/76

CHKD. BY LL DATE 2/24/76

SUMMARY -

EACH BAY REQUIRES 46,800 CFM FOR EVAPORATIVE COOLING AND HUMIDIFICATION. LAYOUT AND ARRANGEMENTS REQUIRES A CENTRAL STATION SYSTEM.

IN A MIXING BOX OUTSIDE AIR (20% FOR WINTER; 100% IN SUMMER) MAY BE MIXED WITH RETURN AIR. THE MIXTURE IS DRAWN THRU A HEATING COIL AND THEN THRU THE SPRAY AND PAD TYPE COOLER (EVAPORATIVE).

ON LEAVING THE COOLER THE AIR IS PULLED THRU A HEATING COIL INTO THE SUPPLY FAN, WHICH DELIVERS IT THRU DUCT WORK TO THE FULL LENGTH OF THE GREENHOUSE.

TO PROVIDE FOR RELIEF AND EXHAUST FROM THE BAY PEAK AN EXHAUST FAN IS USED. THIS FAN CAN ALSO DELIVER RETURN AIR TO THE APPARATUS.

PNEUMATIC

EACH SYSTEM HAS ITS OWN AUTOMATIC CONTROL.

WE ESTIMATE THAT SUCH A SYSTEM COULD BE INSTALLED FOR ABOUT 2.40 PER CFM.

$$46,800 \times 2.40 = \$112,320 - \text{PER } 30' \times 120' \text{ BAY.}$$

THIS WOULD INCLUDE PIPING FROM UTILITIES WITHIN 15 FEET OF APPARATUS BUT EXCLUDES ELECTRICAL

THE FOLLOWING MOTORS ARE ESTIMATED
SERVICE H.P.

SUPPLY FAN	15
RETURN & RELIEF	7 1/2
RECIRC PUMP	1 1/2

Rogers

SUBJECT DESERT HOT SPRINGS

SHEET NO. 2 OF 3
JOB NO. 5-76023
BY EL DATE 7/24/78
CHKD. BY _____ DATE _____

SUMMARY CONTINUED
MOTORS

AN AIR COMPRESSOR $\frac{1}{2}$ HP PER DAY - CAN
BE CONSOLIDATED.

HEATING.

ON MAXIMUM CONDITIONS (COLDEST) THE
ENTERING AIR MIXTURE SHOULD BE HEATED
FROM 67°D.B. TO 86°D.B. (USE 50% FOR 6 MONTHS)

AIR LEAVING HUMIDIFIER SHOULD BE HEATED
 74°D.B. TO 79° (USE 1810° DAYS FOR AMOUNT)

Rogers

SUBJECT DESERT HOT SPRINGS

SHEET NO. 3 OF
 JOB NO. S-76523
 BY EC DATE 2/21/78
 CHKD. BY DATE

W/W : MAXIMUM CONDITIONS $90^{\circ} \pm 65\% RH - 80WB - 43.7 \frac{B}{H}$
 $0.020 \frac{B}{H}$

ALSO - CAN USE SPRAYS

2 MODULES

HEAT GAIN } WHITE PAINTS } FIBERGLASS STRATIFICATION
 ROOF $120 \times 60 = 7200 \times 273 \times 0.4 \times .77 \times .8 = 484,000$

WALLS

EAST $120 \times 9 = 1080 \times 42 \times 0.4 \times .77 = 13,970$

NORTH $60 \times 13 = 780 \times 40 \times .31 = 9,700$

WEST & SOUTH ARE INTERIOR

TRANSMISSION

ROOF $68 \times 120 = 8160$

EAST = 1080

N. = $780 \times 10020 \times 15 \times 0.7 = 105,000$
 $612,670$

VOLUME $7200 \times 13 = 93,600$

DELIVER GAIN ETC $61,330$

1180

$674,000$

$\frac{674,000}{96,400 \times 103 \times 93,600} = 7^{\circ}$ RISE IN MAC.

$90^{\circ} DB - 7 = 83^{\circ} @ 0.020 \frac{B}{H} 78.2 WB$

EVAPORATIVE COOLING

$105^{\circ} DB - 77^{\circ} WB @ 84\% \div 28 \times .84 = 23.4 \text{ DROP}$

$105 - 23.4 = 81.6^{\circ}$ DISCHARGE @ $77^{\circ} WB$ HEATED 7°

$88.6 \pm 65\%$ EVAPORATIVE COOLING $90 \pm 65\%$ MAX.

$\frac{674,000 \frac{B}{H}}{7200 \frac{B}{H}} = 93.6 \frac{B}{H}$

$\frac{93.6}{146} = .64$

CHANGE PAINT SF
 $\frac{70}{155}$

TO INCREASE LOAD

TO $146 \frac{B}{H}$ IN WRITE UP.

$\frac{93,600 CFM}{7200} = 13 \frac{CFM}{H}$

SUPPLY AIR CAN BE CONDITIONED EITHER BY A
 HIGHER RESISTANCE HUMIDIFIER, ^{FAN SYSTEM} TO 84% SATURATION EFF.
 OR CAN BE SATURATED BY FAN SYSTEM TO 40% AND
 FURTHER SATURATED BY ROOM SPRAYS.

Rogers

SUBJECT DESERT HOT SPRINGS

SHEET NO. 4 OF
JOB NO. S-76023
BY EL DATE 2/22/78
CHKD. BY DATE

(1) BY CENTRAL FAN SYSTEM

105°DB - 77°WB AIR IS EVAPORATIVELY COOLED ALONG 77°WB TO 81.6° & 82% RH. ON DELIVERY AND PASSAGE THRU ROOM THE AIR HEATS TO 88.6°F AND HUMIDITY IS LOWERED TO 65% RH.

(2) BY SMALL FAN SYSTEM

105°DB - 77°WB AIR IS EVAPORATIVELY COOLED ALONG 77°WB TO 93.8°. ON DELIVERY TO ROOM AND PASSAGE THRU ROOM THE AIR HEATS AND ABSORBS MOISTURE FROM ATOMIZING SPRAY HEADS TO GIVE 88.6°F & 65% RH.

1 1/2 GR/CF IS ABOUT MAXIMUM THAT CAN BE ABSORBED IN ROOM
7°DEOP PER GR.

$$1\frac{1}{2} \frac{\text{GR}}{\text{CF}} \times 13.5 \frac{\text{CFM}}{\#} = 20.25 \frac{\text{GR}}{\#} \div 7000 = .0029 \frac{\#}{\text{ON}}$$

ASHRAE CHART

FAN H.P. 2-FAN SYSTEMS @ 46,800 CFM @ 3/4"

BOS 1LG SWSI 9.2 B.P. USE 15 HP MOTOR

RETURN & EXHAUST FANS - 2-7 1/2 HP

(WALL FANS. $\frac{93,600}{7} = 13,400 \text{ CFM}$ 1LG PF36E @ 2 FT.) DO NOT USE

PEAK VENTS - 2@ 3540 ^{CFM} 1LG PY213 - 1/4 HP.

PUMP MOTORS 2@ 3/4 HP

PSYCHROMETRIC CHART

Normal Temperatures

WINTER
E - OUTSIDE RETURN MIX
F - ENTERING EVAPORATOR
G - LEAVING " " REHEATER
H - " " REHEATER

SUMMER
A - ENTERING, 105 DB - 77 WB
B - 84% EFFICIENCY
C - GREEN HOUSE AVG, 88.6 DB - 65% RH
D - 40% EFFICIENCY

DESERT HOT SPRINGS
5-76023 2/22/78 TC.

SHEET NO. 5

Rogers

SUBJECT DESERT HOT SPRINGS

SHEET NO. 6 OF 6

JOB NO. S-76023

BY SL DATE 2/22/78

CHKD. BY _____ DATE _____

HEATING REQUIREMENTS

75° D.B. - 85% ROOM. 71.5 WB 35.5 BTU/H

36 " 45° OUTSIDE 18.5 10.6 BTU/H

TAKE 20% OA

$$0.2 \times 10.6 = 2.12$$

$$0.8 \times 35.5 = 28.4$$

$$30.5 \text{ BTU/H} \quad 65.7 \text{ W.B.}$$

$$75 \times .8 = 60$$

$$36 \times .2 = 7.2$$

67.2° D.B. 65.7 W.B. MIXTURE ENTERING

HEAT AIR TO 86

SPRAYS USE

" " 74.6 TO 79 - 1450° DAYS $\times 1.25 = 1810$

WINTER HEAT LOSSES

TRANSMISSION $10020 \text{ ft}^2 \times (75 - 36) \times .73 = 285,000$

10% 28,500

313,500

$93,600 = 780 \times 1.08 \times 39$

120

32,500
346,000 BTU/H

$$\frac{346,000}{1.08 \times 93,600} = 3.5^\circ \text{ EFFECTIVE} + 75 = 78.5$$

SUBJECT

DESERT HOT SPRINGS

SHEET NO. 7

OF

JOB NO. S-76023

BY EL

DATE 1/7/78

CHKD. BY

DATE

Rogers

WEATHER - CHUCK PASSEVICH 876-2886
FIBERGLAS - TAP PLASTICS PETE AKPIN 357-3535

TRANSMISSION

24 GA - CORRUGATED IRON 1.4 BTU/HR/ft² °F CARRIER 1-68

3/8" CORR TRANSITE

1.16

25% OF ROOF LOAD - CONVECTIVE (STRATIFICATION

"

1-59

PAINTED LIGHT COLOR GLASS SHADE FACTOR 0.28 CARRIER 1-52

STRUCTURAL GLASS 1-79 $\frac{1}{2} = 0.1$ $f_i 0.92$ $f_o .17$ $\frac{1}{k} = \frac{.1}{1.19} = 0.084$

1970 PALM SPRINGS.

CLIMATOLOGICAL DATA (SOUTHEAST DESERT BASIN)

AVERAGE

MONTH

MAX

MIN.

H/414

LOW.

JAN

180

FEB

78.7

48.3

88

39

MAR

79.9

48.2

91

40

APR.

83.6

49.2

98

39

MAY

95.7

61

111

51

JUNE

104. -

68

120

56

JULY

109.8

76.9

116

67

AUG.

107.9

78.2

116

70

SEPT

101.7

64.9

112

57

OCT

88.9

56.2

105

40

NOV

79.3

48.7

94

41

DEC

Rogers

SUBJECT

DESERT HOT SPRINGS

REVISED
SHEET NO. 8 OF
JOB NO. S-76023
BY EL DATE 7/17/78
CHKD. BY DATE

SUMMER BTU - FIBERGLASS CORRUGATED PAINTED WHITE

NORTH EAST CORNER OF LARGER AREA

DESIGN
CONDITIONS: OUTSIDE

SUMMER 5% - 105°F DB - 77° WB

62° D.P. - 40.6 B/H

WINTER 36°F 45% RH - 18.5° DP - 10.6 B/H
.002 #H₂O/H

INSIDE
IDEAL 75° DB - 85% - 71.5° WB - 70° D.P. - 35.5 B/H

MINIMUM 24.80" - 65% 70.8° WB 67.5" 34.8 B/H

EVAPORATIVE COOLING CAN NOT PRODUCE THESE
DESIRED INSIDE CONDITIONS. WHAT CONDITIONS CAN BE OBTAINED

BTU GAIN

34° NORTH SOLAR HEAT - PAGE 389 - ASHRAE 1972 HANDBOOK

WHITE PAINT FIBERGLASS STRATIFICATION B/H

ROOF 120 x 60 = 7200 sq ft x 273 B/H x 0.3 x .75 x .8 = 360,000

WALLS

EAST 120 x 9 = 1080 sq ft x 42 x 0.3 x .75 = 10,200

NORTH 60 x 12 = 720 sq ft x 40 x .225 = 6,500

WEST & SOUTH ARE INTERIOR

TRANSMISSION.

ROOF 61.2 x 120 = 7340

E. 1080

N. 720

105-75
9140 x 30 x 0.84 = 230,000
606,700

$\frac{667,000}{7200} = 93 \text{ B/H/sq ft}$

MINIMUM DELIVERY GAIN SET

60,300

667,000

$\frac{86,400}{7200} = 12 \text{ CFM/sq ft}$

$\frac{667,000}{7200} = 7.5^\circ \text{F}$

14.1 CFM/sq ft → 1.03 x 86,400 (10)

120 x 60 x 12 = 86,400 FT³ - Vol.

1 AIR CHANGE PER MINUTE WILL ABSORB HEAT GAINS FROM
OUTSIDE WITH 7.5° F. RISE

90% SATURATION AT 105° DB - 77° WB

Rogers

SUBJECT

DESERT HOT SPRINGS

SHEET NO. 9 OF

JOB NO. S-76023

BY EL DATE 2/21/78

CHKD. BY DATE

$$(105 - 77) \times 0.9 = 25.2 \quad 105 - 25.2 = 79.8^{\circ} \text{DB LVC } 90^{\circ} \text{EFF}$$

79.8 DB - 77 WB - 88% RH LEAVING AIR FROM EVAP COOLER

$$79.8 \text{ DB} + 7.5 = 87.3^{\circ} \text{ DRY BULB} - 68\%$$

LOCAL CLIMATOLOGICAL DATA

ANNUAL SUMMARY WITH COMPARATIVE DATA, 1970

PALM SPRINGS, CALIFORNIA

NARRATIVE CLIMATOLOGICAL SUMMARY

The city of Palm Springs is located on the western edge of the Coachella Valley, in central Riverside County. It lies at the foot of the massive Mt. San Jacinto, which rises to a height of 10,831 feet above sea level. Beaumont Pass, leading from the Los Angeles Basin into the Valley is about 20 miles northwest of Palm Springs. The Coachella Valley itself is about 12 miles wide in the vicinity of Palm Springs and is about 50 miles in length.

Temperatures are mild during the winter and are hot during the summer. The average minimum temperature in January is 39°, and there are normally only 10 days per year with readings of 32° or colder, though readings occasionally drop much lower. In a 38-year period the coldest reading of record has been 19°. Even in mid-winter, afternoon temperature readings typically climb to around 70° and occasionally get into the upper 80's and low 90's. Summer temperatures are hot, with the minimum in July averaging 73° and the maximum averaging 108°. Typically, there are 181 days per year with readings of 90° or higher, and the all-time high has been 122°. The average maximum temperature exceeds 100° in 4 months of the year, and extreme highs of 100° or more have been observed in 9 months of the year.

Table 1 shows the frequency with which given maximum or minimum readings normally occur. This tabulation indicates that readings as low as 24° will occur only once in 10 years, on the average, while high readings of 121° occur with the same frequency. Table 3 shows the probability of observing various freezing temperatures on certain dates. The table suggests that there is a 50% probability that the last reading of 32° in the spring will have occurred by February 8th and that the first reading this cold will not occur in the fall until after December 6th.

A factor compensating for the hot weather is the relative humidity, which is quite low during the warm part of the year. Estimated values for July are around 40% in the early morning and between 20% and 25% in the afternoon. The periods of warmest weather would normally experience the driest air. Winter humidities

probably range from 50% in the morning to 35% to 45% in the afternoon.

The heating degree days for the year total just over 1,100 units, one of the smaller totals in the United States.

Precipitation is very light, averaging only 6.28 inches per year. The wettest months, December and January, have less than 1.5 inches in each month, and May and June average only .02 inch each. There are normally only 11 days per year with .10 inch or more of rain and only 16 days with any measurable precipitation. During 8 months of the year the total precipitation averages less than .50 inch per month.

Although the total rainfall is light there are occasions when intensities are heavy. Part of Table 1 and all of Table 2 refer to these occasional occurrences of heavy rainfall. Differences between the two tables result from the methods of computation. In Table 1 the data refer specifically to Palm Springs. Data in Table 2 are interpolated from maps that are drawn on the basis of a number of stations in the area. It frequently happens that the heaviest precipitation in a particular storm is measured at a nearby rain gage rather than at the Palm Springs gage. Table 2 reflects these heavier values and is useful for design purposes.

Summarization of a short record from the Palm Springs airport indicates that the wind blows from the quadrant north through west about 49% of the time and from the quadrant south through east about 24% of the time. Wind speeds are less than 13 mph about 84% of the time, and in only 2.4% of the time are they 25 mph or more. However, these stronger winds, usually from the northwest or north, occasionally result in blowing sand or blowing dust that temporarily impede highway travel. Winds of 50 mph or more are likely to occur about once in 10 years and more than 70 mph about once in 100 years.

C.R. Elford
ESSA State Climatologist
San Francisco, California

U.S. DEPARTMENT OF COMMERCE

MAURICE H. STANS, Secretary

ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

ROBERT M. WHITE, Administrator

ENVIRONMENTAL DATA SERVICE

AVERAGE TEMPERATURE

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1931	57.7	58.8	66.8	73.5	79.6	82.0	85.2	90.4	82.4	73.0	59.6	51.4	72.4
1932	50.2	56.6	65.6	68.8	74.4	82.4	88.8	89.0	82.4	72.6	66.8	52.6	71.2
1933	51.4	53.6	63.9	65.8	70.5	82.8	93.0	89.1	83.3	80.1	69.0	56.2	71.6
1934	61.5	62.7	74.2	75.7	80.7	79.6	91.7	90.6	82.4	76.8	66.3	58.2	75.0
1935	55.1	59.4	59.0	68.2	71.8	85.5	86.1	86.8	80.2	71.4	60.3	56.4	70.2
1936	56.2		63.2				89.4	88.4	84.1	73.6	63.2	54.5	
1937	43.9	57.1	63.4	69.7	76.8	83.9			87.2		67.2	59.8	
1938	58.2	56.2	59.6	69.6	74.7	82.1	91.8					58.2	
1939	54.6	50.9	62.3	71.7	76.0	82.4			80.3	75.8		60.4	
1940	57.4	57.8	66.5	70.4	79.8	86.8	88.5	90.6	80.7	73.0	60.2		
1941	55.3	58.6					88.5	84.3	80.6	72.4	64.0	53.8	69.1
1942	55.0	53.8	59.2	65.2	72.5	82.0	92.7	89.0	80.6	72.4	64.0	57.0	70.3
1943	54.8	59.2	64.5	70.6	77.2	78.8	88.9	87.8	84.9	72.0	63.2	54.4	71.4
1944	53.6	53.2	60.9	65.6	73.3	76.4		88.2	82.8	74.4	59.2	56.2	
1945	54.9		58.8		74.8	81.0	91.6	88.8	83.8	75.8	61.9	57.8	
1946	54.3	55.6	61.2	72.3	73.8	84.9	89.0	89.2	83.8	68.0	57.0	56.5	70.5
1947	53.6	61.6	63.3	69.4	77.2	82.8	90.2	84.8	86.5	74.0	59.0	54.2	71.4
1948	58.2	56.6	58.3	71.7	77.9	84.4	88.6	89.0	86.4	74.7	62.9	51.8	71.7
1949	45.0	52.2	60.5	73.1	75.8	85.8	90.2	88.7	88.5	72.4	70.6	54.8	71.4
1950	51.5	62.7	64.7	74.2	75.2	83.0	91.5	91.1	82.1	79.2	68.9	59.6	73.6
1951	51.7	57.9	63.7	69.7	77.9	82.7	92.5	89.2	85.8	73.8	60.4	52.2	71.5
1952	49.5	56.8	64.2	69.2	79.2	79.4	90.1	91.0	86.2	78.8	58.2	52.9	70.5
1953	58.7	56.4	60.3	66.3	69.8	80.0	91.9	87.9	84.4	73.1	63.6	54.5	70.6
1954	53.1	65.1	59.8	71.9	76.5	82.2	91.9	85.4	83.7	74.3	64.7	53.9	71.8
1955	49.9	53.3	61.5	65.7	73.3	80.8	86.7	90.6	84.1	75.3	60.5	55.3	69.8
1956	56.7	53.1	64.3	68.1	75.7	85.2	89.2	84.3	85.5	70.9	62.8	56.6	71.0
1957	52.9	63.5	64.1	68.7	73.2	88.6	92.0	89.3	83.2	70.5	58.2	56.9	71.8
1958	56.6	60.0	57.4	68.5	79.7	83.1	88.6	91.8	87.0	78.9			
1959	57.3	55.5	67.5	74.2	74.4	87.5	95.3	89.2	81.0	75.1	64.1	55.3	73.1
1960	49.5	56.5	67.1	72.2	76.7	88.6	92.8	90.1	86.5	73.9	62.0	55.5	72.6
1961*	58.8	61.6	63.1	71.7	73.9	87.9	92.1	91.3	81.4	74.0	60.7	54.8	72.6
1962*	57.2	57.1	58.5	74.9	73.2	83.8	89.2	91.5	85.9	74.9	65.5	57.6	72.4
1963*	52.7	64.4		66.9	77.1	81.7	90.4	89.7	87.1	76.9		56.6	
1964*			60.9	67.6	75.1	81.7	91.7	91.5	82.6	76.8	58.1	56.4	
1965*	56.5	60.4	61.1	66.2	75.6	79.4	91.2	90.5	85.0	73.6	64.3	54.0	72.0
1966*	53.5	55.8	66.1	74.3	79.5	85.2	90.7	92.2	85.4	74.5	64.5	56.3	73.2
1967*	55.3	62.0	63.8	60.7	76.5	80.6	94.4	94.3	84.2	77.0	66.2	51.9	72.2
1968*	55.3	65.1	65.6	70.3	77.2	85.5	90.4	86.8	84.2	73.8	64.2	50.8	72.4

*Not included in standard normal period

TOTAL PRECIPITATION

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1931	.44	2.72	0	.45	0	.19	0	.48	0	1.63	1.37	1.42	8.70
1932	.33	7.01	0	.20	.09	.37	0	0	0	1.49	0	1.39	10.88
1933	1.50	0	0	0	.12	0	.20	0	0	.13	.06	.79	2.80
1934	.75	.58	0	0	0	0	1.13	.26	0	.27	.10	1.65	4.69
1935	2.05	1.75	.54	.80	.07	0	0	.27	0	.10	.21	.61	6.40
1936	.20	2.55	1.72	.40	0	0	1.50	0	0	.91	.82	3.65	11.75
1937	1.80	1.39	1.94	0	0	0	T	.01	0	0	0	.53	5.67
1938	.28	1.21	3.01	0	0	0	0	.10	0	T	0	3.20	7.80
1939	1.60	1.50	.15	0	0	0	0	T	0	.25	.72	.22	9.46
1940	1.92	1.25	0	.22	.17	0	0	0	.03	.08	.04	.59	9.63
1941	.64	2.10	2.50	.46	.04	0	0	1.12	0	1.54	1.62	1.38	11.40
1942	.20	.82	.71	2.25	0	0	0	.29	0	.02	0	.25	4.54
1943	8.43	.59	2.20	.07	0	0	T	.05	.70	1.18	0	5.95	19.07
1944	.13	2.27	.79	.20	T	0	0	0	0	.07	1.69	.35	5.50
1945	.22	.67	.99	0	0	0	0	2.17	.68	.42	0	3.26	8.41
1946	0	.15	.25	T	0	0	0	T	.50	.03	1.54	.63	3.10
1947	.17	0	.04	.04	0	0	0	.81	.05	T	T	1.24	2.35
1948	0	1.61	.18	T	0	0	2.80	0	0	.50	0	.49	5.58
1949	2.08	0	.04	0	0	0	0	.03	0	.10	0	.38	2.63
1950	.67	.14	.25	.02	0	0	0	0	.47	T	0	0	1.36
1951	.16	.27	.31	.32	.05	0	.41	.15	.11	.02	0	2.48	4.28
1952	3.23	.07	1.01	.16	0	0	.15	0	1.46	0	2.26	2.08	10.42
1953	.17	.54	.57	.06	0	0	0	.26	0	0	.09	0	1.69
1954	2.47	1.02	2.64	0	T	0	.52	0	.66	0	.35	.05	7.71
1955	2.84	T	0	0	.02	0	1.05	.05	0	0	.11	.25	4.32
1956	.74	.02	0	.16	0	0	.07	0	0	T	0	.02	1.01
1957	3.30	.37	.25	T	T	0	0	.06	0	.74	.11	.64	5.47
1958	.31	2.19	1.63	1.41	.07	.03	.41	.10	T	.07	.02	0	6.24
1959	.47	1.35	0	T	0	0	T	.01	.35	.07	.65	1.20	4.10
1960	.83	.71	0	.13	0	0	T	.06	.32	0	.25	.21	2.51
1961*	.67	0	.05	0	0	0	0	.27	0	.01	.31	.58	1.89
1962*	.59	.76	.02	0	0	0	0	0	0	.53	0	.25	2.19
1963*	.06	1.17	.45	.18	0	0	0	.47	1.60	1.87	.34	0	6.14
1964*	.63	.26	.93	.12	.02	0	0	.03	.15	T	1.34	.14	3.62
1965*	T	.07	.63	1.04	0	0	T	.15	T	0	6.35	2.68	10.92
1966*	.28	.15	.31	0	0	0	.10	.23	.11	.42	.67	2.92	5.13
1967*	.63	0	.02	.65	0	0	T	.97	.68	0	1.07	1.15	5.17
1968*	0	.23	.61	0	.05	0	.83	0	0	.06	.01	.48	2.27

*Not included in standard normal period.

Extreme temperature and precipitation values occur with the frequencies indicated in the following table.

TABLE 1

Data	Average	Mode	1 Year in 2	1 Year in 5	1 Year in 10	1 Year in 25	1 Year in 50	1 Year in 100
Annual Maximum Temperature	118	117	118	119	121	122	123	125
Annual Minimum Temperature	27	29	28	25	24	22	20	18
24-hour † Precipitation	1.3	0.9	1.1	1.6	2.0	2.5	2.8	3.1
Monthly * Precipitation	2.8	2.0	2.4	3.7	4.5	5.6	6.4	7.2

† Observation day. * Calendar month.

Precipitation intensity-duration-frequency combinations occur as indicated in the following table. †

TABLE 2

Time interval	1 Year in 5	1 Year in 10	1 Year in 25	1 Year in 50	1 Year in 100
30 minutes	.6	.8	1.0	1.2	1.3
1 hour	.8	1.0	1.2	1.4	1.5
2 hours	1.0	1.3	1.5	1.7	2.0
3 hours	1.2	1.5	1.7	2.0	2.2
6 hours	1.5	2.0	2.3	2.7	3.0
12 hours	1.7	2.2	2.6	3.0	3.5
24 hours	2.2	2.6	3.0	3.5	4.0

† From WB Technical Paper No. 40.

Probability of receiving freezing temperatures after given date in spring or before given date in fall.

TABLE 3

	10%	20%	30%	40%	50%	60%	70%	80%	90%	GS
Spring										
32°	3-3	2-24	2-18	2-13	2-8	2-3	1-28	1-19	a	301
28°	2-13	2-5	1-29	1-22	1-13	a	a	a	a	352
24°	1-28	1-9	a	a	a	a	a	a	a	365
20°	a	a	a	a	a	a	a	a	a	365
Fall										
32°	11-12	11-20	11-26	12-1	12-6	12-12	12-20	b	b	
28°	12-11	12-23	b	b	b	b	b	b	b	
24°	b	b	b	b	b	b	b	b	b	
20°	b	b	b	b	b	b	b	b	b	

a = earlier than Jan. 1. b = later than Dec. 31. GS = Growing Season.

Latitude 33°49'
Longitude 116°32'
Elev. (Ground) 411 feet

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
IN COOPERATION WITH PALM SPRINGS CONVENTION AND VISITORS BUREAU

CLIMATOLOGICAL SUMMARY

Station: Palm Springs, Calif.

Means and Extremes for Period of Record 1927 - 1968 §

Month	Temperature (°F)					Mean Degree Days	Precipitation Totals (Inches)					Mean Number of Days				Mt. San Jacinto †		No. of Days			Year	
	Means			Extremes			Mean	Greatest Daily	Mt. San Jacinto † Snow, Sleet, Hail			Precipitation 10 in. or more	Temperature				Daily Maximum	Daily Minimum	Clear	Partly Cloudy		Cloudy
	Daily Maximum	Daily Minimum	Monthly	Record Highest	Record Lowest				Temperature													
									10° and above	12° and below	17° and below		1° and below									
(a)	(b)	(b)	(b)	(c)	(c)	(d)	(b)	(c)	(g)	(g)	(g)	(e)	(f)	(f)	(f)	(f)	(g)	(g)	(h)	(h)	(h)	
Jan.	68.5	39.3	53.9	92	19	324	1.26	4.57	18.9	35.8	35	2	0	0	5	0	43.8	21.5	18	7	6	Jan.
Feb.	72.0	42.6	57.3	98	24	186	1.18	2.30	27.2	89.1	100	1	1	0	1	0	43.7	19.5	16	7	5	Feb.
Mar.	79.0	46.3	62.7	100	25	121	.72	1.90	15.2	26.8	89	1	3	0	0	0	46.9	21.9	19	8	4	Mar.
Apr.	86.9	52.4	69.7	110	34	37	.25	1.25	8.7	31.1	51	1	13	0	0	0	50.1	25.6	19	8	3	Apr.
May	94.1	57.4	75.8	115	36	4	.02	.17	4.1	14.5	11	0	22	0	0	0	61.0	33.5	22	8	1	May
June	102.2	63.5	82.9	121	48	0	.02	.37	0	0	0	0	28	0	0	0	68.3	39.8	24	5	1	June
July	108.1	73.1	90.6	122	54	0	.28	2.80	0	0	0	0	31	0	0	0	74.0	45.5	20	7	4	July
Aug.	106.3	71.4	88.9	120	52	0	.21	1.84	0	0	0	1	31	0	0	0	74.0	45.5	20	7	4	Aug.
Sept.	102.5	65.6	84.1	121	47	0	.34	1.32	0.1	0	0	1	28	0	0	0	64.9	40.1	23	6	1	Sept.
Oct.	91.4	56.7	74.1	110	30	6	.26	1.60	0.5	2.1	2	1	21	0	0	0	61.5	32.9	21	7	3	Oct.
Nov.	78.6	46.4	62.5	102	23	123	.40	2.75	5.5	10.1	7	1	3	0	1	1	49.1	27.2	19	7	4	Nov.
Dec.	70.4	40.9	55.7	93	23	312	1.34	4.02	31.8	61.1	42	2	0	0	3	0	42.1	20.6	19	6	6	Dec.
Year	88.3	54.6	71.5	122	19	1113	6.28	4.57	112.0	89.1	100	11	181	0	10	0	56.5	31.3	241	84	40	

(b) 30 years, standard normal period (1931-1960); (c) 38 years, 1931-1968; (d) 18 years, 1951-1968; (e) 15 years, 1954-1968;
(f) 24 years, 1945-1968; (g) 4 years, 1965-1968; (h) 21 years, 1927-1947.

§ Various intervals used; see line (a).

* Less than one half.

† Data from Mt. San Jacinto Wilderness State Park.

Frequency Distribution of 4 P.M. Relative Humidity.*

Palm Springs

February 1960 - December 1968

Freq.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
10	13	9	9	5	9	7	5	7	5	7	12	17	6
20	19	15	14	11	13	10	10	12	11	12	20	25	13
30	24	20	19	15	16	13	14	16	15	16	26	30	18
40	28	24	23	19	18	15	17	19	19	19	30	37	22
50	32	28	26	22	21	17	20	22	22	22	35	41	26
60	36	32	30	26	23	29	23	24	25	24	39	46	29
70	40	36	33	29	25	22	26	28	29	27	44	51	33
80	45	40	38	33	28	24	30	31	33	31	49	57	38
90	52	47	44	39	32	26	35	36	39	36	57	65	45

* The table indicates, for example, that in May the 4 p.m. relative humidity is 10% or lower 20% of the time. For the year as a whole (4 p.m.) the humidity is 38% or less 60% of the time. The middle line (50% frequency) gives the average 4 p.m. relative humidity for each month and for the year.

APPENDIX 7B

Economics for 12 Month Production of European
Cucumbers in 2 Acre Greenhouse Complex.

Rogers

SUBJECT Desert Hot Springs
2 ACRE GREENHOUSE

SHEET NO. _____ OF _____
JOB NO. 576023
BY JAB DATE _____
CHKD. BY _____ DATE _____

QUOTE FOR GREENHOUSE

DOUBLE A TRUSS MANUFACTURING CO
MANTECA (209) 239-1271

COST OF GREENHOUSE CONSTRUCTION ON EXISTING
CONCRETE FOOTINGS

$\$3^{25} - 3^{50} / \text{sq ft}$

INCLUDING HOT WATER HEATERS &
EVAPORATIVE COOLERS.

CONSTRUCTION GALVANIZED STEEL FRAME.
WITH TEDLAR COATING FIBERGLASS PANELS.

SIZES UP TO 50' BAYS AND 10' HIGH

SIZES 30' BAYS x 8' HIGH WILL BE 10% HIGHER
THAN ABOVE FIGURES

$\$3^{57} \text{ TO } \$3^{85} / \text{sq ft.}$

1 ACRE = 43,560 sq ft.

COST / ACRE = \$155,509 TO \$167,706

AVERAGE = \$161,608

COST FOR 2 ACRES OF GREENHOUSE
= \$323,216.

Rogers

SUBJECT Desert Hot SpringsSHEET NO. 1 OF JOB NO. 576023BY JAB DATE CHKD. BY DATE Summary of EconomicsAnnual Basis

Total Income from production of cucumbers = \$616,751

Total Expenditures

Labor = 114,084

Fuel = 57,133

Fixed Annual Cost for Production Materials = 67,800

Return on Initial Capital Expenditure over 7 yr life = $(191,568)10\%$ $(204,345)12\%$

Total

430,585443,362

443,362

Difference =

\$186,266\$173,389

173,389

NOTES

The costs of fuel and the price of the product are both variable factors

The net profit of this operation is 30% @ 10% of Rtn and 28% @ 12% of Rtn when referred to the gross earnings.

No account is taken for tax credit.

Rogers

SUBJECT GREENHOUSE COMPLEX

SHEET NO. 2 OF

JOB NO.

BY JAB DATE 1/24/78

CHKD. BY DATE

TABLE 1.1

TOTALIZED COSTS FOR GREENHOUSE

INITIAL CAPITAL INVESTMENT	=	\$ 232,657
ANNUAL LABOR CHARGES	=	\$ 114,084
FUEL COSTS - HEATING	=	\$ 27,355
- COOLING	=	\$ 29,778
FIXED ANNUAL COSTS (MATS)	=	\$ 67,779
RETURN ON INITIAL INVESTMENT	=	\$ 191,568
ANNUAL INCOME	=	\$ 616,751

130

Rogers

SUBJECT

Desert Hot Springs

SHEET NO.

6

OF

JOB NO.

576023

BY

AB

DATE

CHKD. BY

DATE

Data received from Hunter Johnson
on 2/28/78.

Tolerance of Plants to Air Flow.

a) Minimum 40' / min.

b) Max 200' / min for cucumbers

Labor Rate for Manual workers.

\$4³⁵ / hr including O/H based on

\$3⁵⁵ / hour direct pay.

Electricity Cost

IID

Southern

California Edison. }

IID

A-1 schedule.

0 - 200 KWH

4.2 c / KWH.

variety of rates in between.

↓
21,000

1.45 c / KWH.

Rogers

SUBJECT Desert Hot Springs.

SHEET NO. 7 OF
 JOB NO. 576023
 BY JAL DATE
 CHKD. BY DATE

Example of level cost under operating conditions.

10 acre greenhouse complex.

Electricity bill for July \$5500

$$\Rightarrow \frac{5500}{10} = \$550/\text{acre.}$$

Heating & Cooling

a) 150,000 to 180,000 KWH/acre/year.

b) 30 HP/acre.

c) Cooling to 85°F with evap type cooling,
 using complete shade (paint on outside).

d) Budget of \$51,000 annually for elect.
 " " \$120,000 " " fuel oil.

Info later on actual measured KWH for
 this complex by Electric Co. for J/J/My.

Other areas

a) Typical energy usage in Arizona
 4.2×10^9 Kcal/hectare/year

2. Only the figure is 3.2.

Rogers

SUBJECT Desert Hot Springs

SHEET NO. 8 OF
JOB NO. 576023
BY JLS DATE
CHKD. BY DATE

LABOR FOR 2 ACRE GREENHOUSE

MANAGERIAL / TECHNICAL.

$$2 \text{ MEN @ } \$10 / \text{hour} + 22.5\% \text{ O/H} = \$12^{25} / \text{hour/man}$$

MANUAL

$$7 \text{ MEN @ } \$3^{55} / \text{hour} + 22.5\% \text{ O/H} = \$4^{35} / \text{hour/man}$$

MONTHLY SALARY BILL.

$$\text{TECH/MANAGERIAL} = \$12^{25} \times 173 \times 2 = \$4239$$

$$\text{MANUAL} = \$4^{35} \times 173 \times 7 = \$5268$$

$$\underline{\$9507}$$

$$\underline{\text{YEARLY SALARIES}} = \$9507 \times 12.$$

$$= \underline{\underline{\$114,084}}$$

Rogers

SUBJECT Desert Hot Springs

SHEET NO. 2 OF 2
 JOB NO. 576023
 BY JAB DATE
 CHKD. BY DATE

Production Rates.

No of plants in 1 module = 825 (fig 7.)

(Module equals 30' x 120' enclosed greenhouse area)

No of lbs of fruit / plant / harvest.

(Harvest is 12 weeks)

Summer and Winter harvests vary somewhat

As can be seen by Figure 'L' the production follows a curve which repeats on a 4 month cycle.

Winter Output

Assuming that the production rates of 825 plants will be the same as 1550 plants shown on the graphs on figures 'G' through 'J' the following production rates are achieved:

HARVEST DAY	LBS / module	825 PLANTS
0	0	
10	350	
20	1300	
25	1350	
30	1200	
40	700	
50	530	
60	450	
70	400	
80	400	
90	400

Rogers

SUBJECT GREENHOUSE COMPLEX
Dexter Hot Springs

SHEET NO. 19 OF 19
JOB NO. 576023
BY JAB DATE
CHKD BY DATE

TABLE 1.2

SEASONS.

WINTER	SPRING	SUMMER	FALL
DEC → FEB	MARCH → MAY	JUNE TO SEPT.	OCT & NOV

Rogers

SUBJECT Desert Hot Springs

2 Acre - 12 month production

SHEET NO. 11 OF

JOB NO. S76023

BY. JAB DATE

CHKD. BY. DATE

To calculate Cost of Cucumber / lb.

Let price of a carton of
cucumber = X

Number of cucumber / carton
average = 16

Average weight / cucumber = $\frac{3}{4}$ lbs

Average weight / carton = 12 lbs

Price / lb = $\frac{X}{12}$

Rogers

SUBJECT Desert Hot Springs
2 acre - 12 month production

SHEET NO. 12 OF 12
 JOB NO. 5-16-023
 BY JAB DATE
 CHKD. BY DATE

Estimated Production - Yield based on 12 weeks of harvest/plant, 23 modules and a distribution growth curve as shown in Table 1.2. sheet 10.

MONTH.	PRODUCTION FOR 23 MODULES AT 20%	COST (\$) PER LB BASED ON L.A. MARKET.	TOTAL VALUE
JAN	71400 x 0.9.	0.77	49,480
FEB.	70,000 x 0.9	0.77	48,510
MARCH	16200 x 0.9	0.604	41,422
APRIL	89175 x 0.9	0.47	37,721
MAY. ¹⁸	92700 x 0.9	0.425	35,458
JUNE	99200 x 0.9	0.56	49,997
JULY	102,900 x 0.9	0.65	60,197
AUG.	104,400 x 0.9	0.604	56,752
SEPT.	102,800 x 0.9	0.59	54,587
OCT.	92,600 x 0.9	0.685	57,088
NOV.	87720 x 0.9	0.77	60,790
DEC.	83,075 x 0.9	0.866	64,749
TOTAL	<u>1,072,170</u>		<u>\$ 616,751.</u>

$$\text{YIELD/1000 SQ FT} = \frac{1,072,170}{83490} \times 1000 = 12,842$$

Allow 10% loss
 10,000 lbs/1000 sq ft yields 11,557 lbs/1000 sq ft. (Agrees with reported from growers).

GREENHOUSE CUCUMBERS

WHOLESALE MARKET PRICE*

L.A. MARKET '77

PRICE/STN

* BASED ON 14-15 COUNT CARTON

	J	F	M	A	M	J	J	A	S	O	N	D
AVE. PRICE PER CARTON C	9 ²⁵	9 ²⁵	7 ²⁵	5 ⁶⁵	5 ¹⁰	6 ⁷⁵	7 ⁸⁰	7 ²⁵	7 ¹⁰	8 ²²	9 ²⁷	10 ⁴⁰
AVE. PRICE PER LB. C/12	0.77	0.77	0.604	0.47	0.425	0.56	0.65	0.604	0.59	0.685	0.77	0.966

FIGURE 1

SAT 15

GRAPH SHOWING HARVEST YIELD
FROM BLISS GREENHOUSES # 2
#3 & #5 AND AVERAGE YIELD CURVE

FIGURE

GRAPH SHOWING HARVEST YIELD
FROM BLISS GREENHOUSES # 5 #6 & #8
AND AVERAGE YIELD CURVE

WINTER MONTHS DECEMBER THROUGH FEB. FIGURE.

Rogers

SUBJECT Desert Hot Springs

SHEET NO. 27 OF

JOB NO. 576023

BY JLB DATE

CHKD. BY DATE

Annual Capital Recovery

Using a 7 years recovery period, this would be approx the maximum period that the greenhouse would last without major maintenance.

$$\text{for 7 years @ 10\% } R = 0.2054$$

$$\text{@ 12\% } R = 0.2191$$

Capital Recovery

$$\text{@ 10\%} = 0.2054 \times 932657 = \$191,568$$

$$\text{@ 12\%} = 0.2191 \times 932657 = \$204,345$$

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Rogers

SUBJECT Desert Hot Springs

SHEET NO. 28 OF
 JOB NO. 576023
 BY JAB DATE 3/31/78
 CHKD. BY DATE

Fossil Fuel Energy Displacement

Normal heating system would be by fuel oil #2.

Cost of fuel oil is \$0.36/gall.

Amount of heat required for greenhouse per hour.

From calculation #1 page 6

1 module requires heat input of 346,000 Btu/hr

for hotel 2 acre complex

Heating = $346000 \times 12 = 4.152 \times 10^6$ Btu/hr

No of gallons of #2 fuel oil

$$= \frac{4.152 \times 10^6}{150,000 \text{ (C.V. of fuel oil)}} = 27.68 \text{ gal/hr}$$

Cost/gallon = \$0.36

Gallons/month = $27.68 \times 24 \times 30 = 19,926$

Cost/month = $19926 \times 0.36 = \$7173$

Cost for 3 months = \$21,523

Comparison with geothermal fuel costs

Geothermal = Well pumping + reinjection

$$= 3459 + 18,546 = \$22,005$$

Refined-products prices

Following quotations are realistic spot prices for refined products moving intrastate on Tuesday of each week. They may differ from refiner's prices for branded products. They should not be considered as postings.

Light products are in cents per gallon. Residual prices are in dollars per barrel.

Gasoline

Mid-Centinent (Group 3):	
Regular (92 octane)	37.00-38.00
Unleaded	39.00-40.75
Premium (90 octane)	39.60-41.45

California (track) Los Angeles:	
Regular (94 octane)	37.60-38.10
Unleaded	40.00-40.70
Premium (100 octane)	40.00-40.70

Chicago:	
Regular (94 octane)	37.80-39.50
Unleaded	40.00-41.50
Premium (100 octane)	40.80-42.50

Kerosine, distillate

Chicago:	
Distillate No. 1	38.00-39.00
Distillate No. 2	36.00-37.00

Gulf Coast (cargoes):	
Kerosine (48-52)	33.75-34.00
Distillate No. 2	33.50-33.75

Mid-Centinent (Group 3):

Kerosine (42-43)	34.50-35.50
Diesel oil (52 d.i. & above)	34.10-35.10
Distillate No. 1	35.50-38.20
Distillate No. 2	35.00-35.85

New York Harbor (barges):

Kerosine (42-44)	33.00-38.80
Distillate No. 2	36.50-37.00
Diesel fuel (48-52 d.i.)	36.80

Residual fuel

Mid-Centinent (Group 3):

No. 6 (Max. 2% S or less)	12.30
---------------------------	-------

Chicago:

No. 6 (max. 1% S)	13.50
No. 5 (max. 1% S)	14.25

New York Harbor (barges):

No. 6 (max. 0.3% S)	13.95-14.48
No. 5 (0.3% S)	14.35-14.83

Gasoline prices

(Suggested prices for major-brand regular)

	Price ex. tax	Pump price	Pump price
	1-17-78	1-17-78	1-18-77

- Albany	53.2	65.2	63.1
Albuquerque	50.9	61.9	60.4
Amarillo	45.4	54.4	52.3
- Atlanta	48.6	60.1	58.8
- Baltimore	49.4	62.4	60.0
- Birmingham	52.2	63.2	60.1
- Boston*	46.6	59.6	59.8
- Buffalo	53.2	66.2	63.1
- Charlotte	51.3	64.3	61.1
Cheyenne	55.6	66.6	62.3
- Chicago*	51.1	64.1	62.2
Cleveland	52.4	63.4	60.1
Corpus Christi	45.9	54.9	52.8
Dallas	45.9	54.9	52.8
Denver	54.0	65.0	60.7
Des Moines	53.0	64.0	62.0
Detroit	51.0	64.0	60.7
Fort Worth	45.9	54.9	52.8
Houston	44.5	53.5	52.4
Indianapolis	53.4	65.4	62.1
- Jacksonville	51.2	63.2	60.1
Kansas City	52.0	63.0	60.5
Little Rock	50.5	63.0	61.0
Louisville	52.4	65.4	62.1
+ Los Angeles	50.8	61.8	58.8
Memphis	53.0	64.0	62.0
- Miami	49.3	51.3	52.8
Milwaukee	52.4	63.4	61.1
Minn.-St. Paul	52.0	65.0	63.0
- Newark	51.4	62.4	60.6
- New Orleans	50.2	62.2	59.1
- New York*	50.7	63.7	64.0
- Norfolk	45.7	58.7	57.8
Okla. City	49.8	60.4	60.6
Omaha	49.9	63.4	62.1
- Philadelphia	50.2	63.2	61.1
+ Phoenix	52.9	64.9	62.1
- Pittsburgh	50.2	63.2	61.1
+ Portland, Ore.	51.3	63.3	59.9
Salt Lake City	50.1	61.1	58.3
San Antonio	43.4	52.4	51.3
+ San Diego	52.1	63.1	60.1
+ San Francisco	51.2	62.2	59.4
+ Seattle	51.5	66.5	61.5
+ Spokane	51.8	66.8	61.9
Springfield, Ill.*	51.5	64.5	63.5
St. Louis	53.3	64.3	61.6
- Tampa	49.2	61.2	58.8
Texarkana	46.5	55.5	53.4
Tulsa	52.4	63.0	61.0
Wichita	51.4	63.4	61.1
Wichita Falls	44.4	52.4	52.3
Week's avg.	50.35	61.92	59.61
Dec. avg.	50.70	62.27	59.81
Nov. avg.	51.08	62.65	59.94
1978 to date	50.52	62.09	
1977 to date	48.13	59.60	

+ Increase, - decrease from previous week.
*Pump price includes local tax ranging from 0.5 to 2.0 cents/gal.

API imports of crude and products

	(Thousands of barrels daily)						TOTAL U.S.		
	DISTRICTS 1-4			DISTRICT 5			1-13 1-6 1-14		
	1-13 1978	1-6 1978	1-14 1977	1-13 1978	1-6 1978	1-14 1977	1-13 1978	1-6 1978	1-14 1977
Gasoline	128	171	103	5	10	6	133	181	109
Special Naphthas									
Kerosine	20	15	5				20	15	5
Distillate	131	110	460	5	5		136	115	460
No. 4 Fuel Oil	50	63	11				50	63	11
Residual	1,302	1,114	1,683	81	20	6	1,383	1,134	1,689
Jet Fuel (Naphtha)	8	15	5	7		5	15	15	10
Jet Fuel (Kerosine)	15	14	35	34	12	88	49	26	123
Asphalt	3	5	10				3	5	10
LP-Gas	176	180	107	10	10	11	186	190	118
Petrochem Feedstocks	6	3	3				6	3	3
Unfinished	22	54	25		15	8	22	69	33
Plant Condensate	39	41	40	5			44	41	40
Total Prod.	1,950	1,765	2,487	147	72	124	2,047	1,857	2,611
Canadian Crude	193	178	273	13	28	20	206	206	293
Other Foreign	4,909	5,193	4,691	544	695	980	5,453	5,299	5,671
Total Crude	5,102	5,371	4,964	557	724	1,000	5,659	6,095	5,964
Total Imports	7,042	7,156	7,451	704	796	1,124	7,706	7,952	8,575

APPENDIX 7C

Economics of 9 Month Production of European Cucumbers in 2 Acre Greenhouse Complex

Rogers

SUBJECT DESERT HOT SPRINGS

SHEET NO. 1 OF 1

JOB NO. 576023

BY Job DATE 2/23/79

CHKD. BY Job DATE 2/23/79

SUMMARY OF ECONOMICS.

Annual Basis

TOTAL INCOME FROM SALE OF CUCUMBER CROP = \$ 442,237

TOTAL EXPENDITURES:

LABOR	=	114,084	}
FUEL	=	46,455	
ANNUAL PRODUCTION FIXED COSTS	=	67,800	
ANNUAL RETURN ON INITIAL INVESTMENT @ 10%	=	191,568	
FOR 7 YEARS @ 12%	=	204,345	}

DIFFERENCE	10%	22,330
	12%	9553.

The complex when operating with a 3 month summer outage is not economic.
No account is taken for tax credit.

Rogers

SUBJECT DESERT HOT SPRINGS

GREENHOUSE Complex

SHEET NO. 2 OF
JOB NO. 57-023
BY JAB DATE 2/23/79
CHKD. BY DATE

The new study was undertaken using a reduced growing period to limit the ambient conditions. The reduced growing period cut out cucumbers production during the high summer months of mid June through mid September.

The maximum ambient temperature is now 105°F

From the data generated it was found that the system could be cooled to within the interior temperature specifications of max 90°F.

1.) Estimated cost/month/module during cool mode

$$\begin{aligned} \text{Cost } \$/\text{module/month} &= \text{HP} \times 0.746 \times \text{no of days/month} \\ &\quad \times \text{cost/kw H} \times \text{hrs per day} \\ &= 15 \times 0.746 \times 30 \times 0.023 \times 24 \\ &= \underline{\$226} / \text{module/month} \end{aligned}$$

2.) Cost \$/module/month for heating

$$\begin{aligned} &= \frac{\text{Annual Cost } \$}{\text{No of months of heating} \times \text{No of modules}} \quad (\text{from Calc #2 for 12 month growing season p. 14}) \\ &= \frac{30,212}{3 \times 12} = \$839 / \text{module/month} \end{aligned}$$

Total Energy cost for year for 2 acre complex

$$\begin{aligned} \text{Heating} &= \$30,212 \\ \text{Cooling} &= \$226 \times 12 \times 6 = \$16,243 \\ \text{TOTAL} &= \$46,455 \end{aligned}$$

Rogers

SUBJECT DESERT HOT SPRINGSGREENHOUSE COMPLEXSHEET NO. 3 OF JOB NO. 576023BY JAB DATE CHKD. BY DATE PRODUCTION YIELD

PRICE / LB = Varies as shown from month to month.
 (From Fig 1)

Average Yield/month = Ave yield figure $\times$ 6 (N^o of harvests/month)

Production Figures

MONTH.	AVERAGE YIELD/MONTH.	NO. OF HARVESTS/mo.	AVERAGE YIELD PER MONTH.	PRICE /LB	100% OF TOTAL YIELD
JAN.	8130 x	6	48,780	0.77	\$37,560
FEB.	11683 x	6	70,098	0.77	\$53,975
MARCH	16170 x	6	97,020	0.604	\$58,600
APRIL	17166 x	6	102,996	0.47	\$48,408
MAY.	11500 x	6	69,000	0.425	\$29,325
JUNE.	7750 x	3	23,250	0.56	\$13,020
JULY	0	—	0	0.65	0
AUG.	0	—	0	0.64	0
SEPT.	1291 x	3	3873	0.59	\$2285
OCT	10833 x	6	64998	0.689	\$44783
NOV	16333 x	6	97998	0.77	\$75458
DEC.	15170 x	6	91020	0.666	\$78823

TOTAL \$442,237

Rogers

SUBJECT DESERT HOT SPRINGS

SHEET NO. 4 OF

JOB NO. 576023

BY Job DATE

CHKD. BY DATE

LABOR COSTS.

FOR YEARLY OPERATION.

SALARIES @ 22.5% mark up factor on basic rate (per info from U.C. RIVERSIDE)

= \$114,084.

FIXED ANNUAL COSTS

MATERIALS ETC.
(INFO PROVIDED BY U.C. RIVERSIDE.)

\$67,800

RETURN ON INITIAL CAPITAL INVESTMENT @ 10% / YEAR.
for 7 years. @ 12% / yr for 7 years.
Capital Recovery factors = 0.2054 & 0.2191

Annual Cost 10% = $0.2054 \times 932,657 = \$191,568$

12% = $0.2191 \times 932,657 = \$204,345$

TOTAL OUTGOING EXPENDITURE.

LABOR + FUEL COST + ANNUAL COST + RETURN ON INVESTMENT.

$114,084 + 20,949 + 67,800 + 191,567 \text{ or } 204,345$

10% = \$394,400 (No account taken for tax credits.)

12% = \$437,178

152

Rogers

SUBJECT DIRECT HOT SPRINGS

SHEET NO. 6 OF

JOB NO. 2-76023

BY EL DATE 7/14/58

CHKD. BY DATE

SUMMARY -

EACH BAY REQUIRES 46,800 CFH FOR EVAPORATIVE COOLING AND HUMIDIFICATION. LAYOUT AND ARRANGEMENTS REQUIRES A CENTRAL STATION SYSTEM.

IN A MIXING BOX OUTSIDE AIR (20% FOR WINTER; 100% ± IN SUMMER) MAY BE MIXED WITH RETURN AIR. THE MIXTURE IS DRAWN THRU A HEATING COIL AND THEN THRU THE SPRAY AND PAD TYPE COOLER (EVAPORATIVE).

ON LEAVING THE COOLER THE AIR IS PULLED THRU A HEATING COIL INTO THE SUPPLY FAN WHICH DELIVERS IT THRU DUCT WORK TO THE FULL LENGTH OF THE GREEN HOUSE.

TO PROVIDE FOR RELIEF AND EXHAUST FROM THE BAY PEAK AN EXHAUST FAN IS USED. THIS FAN CAN ALSO DELIVER RETURN AIR TO THE APPARATUS.

PNEUMATIC

EACH SYSTEM HAS ITS OWN AUTOMATIC CONTROL.

WE ESTIMATE THAT SUCH A SYSTEM COULD BE INSTALLED FOR ABOUT 2.40 PER CFH.

$46,800 \times 2.40 = 112,320$ - PER 30'x120' BAY.

THIS WOULD INCLUDE PIPING FROM UTILITIES WITHIN 15 FEET OF APPARATUS BUT EXCLUDES ELECTRICAL.

THE FOLLOWING MOTORS ARE ESTIMATED

SERVICE	H.P.
---------	------

SUPPLY FAN	15
RETURN FAN	7 1/2
RECIRC PUMP	1 1/2

Rogers

SUBJECT DESERT HOT SPRINGS

SHEET NO. 7 OF 3

JOB NO. 3-76023

BY EL DATE 7/24/78

CHKD. BY EL DATE 7/24/78

SUMMARY CONTINUED

MOTORS

AN AIR COMPRESSOR $\frac{1}{2}$ HP PER DAY - CAN
BE CONSOLIDATED.

HEATING

ON MAXIMUM CONDITIONS (COLDEST) THE
ENTERING AIR MIXTURE SHOULD BE HEATED
FROM 67° D.B. TO 86° D.B. (USE 50% FOR 6 MONTHS)

AIR LEAVING HUMIDIFIER SHOULD BE HEATED
 74° D.B. TO 79° (USE 1810° DAYS FOR AMOUNT)

OWNING AND OPERATING COSTS WILL BE
ABOUT $22,000$ PER YEAR

Appendix 7D

Cost Estimate Sheets for 2 Acre
Greenhouse Complex
Dispatch Office

CONSULTING ENGINEERS

COST ESTIMATE

FOR

ITEM
TITLE Desert Hot Springs

SHEET _____ OF _____

PROJECT.....

Greenhouse Complex &

PREPARED BY **JAB** CHECKED BY

DWG. NO.

Office/Dispatch Area.....

PRELIM. ☐ % FINAL ☐

[illegible]

GE-001

SUB TOTAL

FIGURE IV - 6

156

PRELIM. ☒ % FINAL ☐

SUB TOTAL

158

PRELIM. ☒ % FINAL ☐

GE-001

CONSULTING ENGINEERS

... REVISED.

... OF

... CHECKED BY

3. FINAL ☐23,882.00

CONSULTING ENGINEERS

DWG. NO.

Cold Storage & Office Bldg. - Elec.

PRELIM. ☒ % FINAL ☐[illegible]

GF-001

SUB TOTAL

ROGERS ENGINEERING CO., INC.
CONSULTING ENGINEERS

COST ESTIMATE

JOB NO. S-76023

DATE Jan. 17, 1978

REVISED _____

FOR _____

ITEM TITLE Desert Hot Springs

SHEET 5

OF _____

PROJECT _____

Geothermal Project

PREPARED BY HL

CHECKED BY _____

DWG. NO. _____

Cold Storage & Office Bldg. - Elec.

PRELIM. ☒

% FINAL ☐

ACCOUNT NO.	DESCRIPTION	QUAN.	UNIT	UNIT LABOR	LABOR	UNIT MATERIAL	MATERIAL	OTHER	TOTAL
	<u>Electrical</u>				\$		\$		\$
	Metering Panel	1	EA.	50.00		230.00	230.00		280.00
	Main Panel, 120/208V-3Ø-4W,	1	EA.						
	18circ., Including:								
	225A, 3P Main C.B.	L/S		200.00	200.00	154.00	210.00		410.00
	20A, 1P C.B.	14	EA.			2.45			
	30A, 1P C.B.	1	EA.			2.45			
	50A, 3P C.B.	1	EA.			19.00			
	Ind. Fluorescent Fixtures - 2/40 W	52	EA.	23.00	1,196.00	35.00	1,820.00		3,016.00
	E40 CW Lamps - 40WRS	104	EA.	1.50	156.00	1.80	187.00		343.00
	Duplex Receptacles - 15A	30	EA.	4.00	120.00	3.50	105.00		225.00
	Fixture Boxes	52	EA.	3.00	156.00	.55	29.00		185.00
	Fixture Pendant Supports	38	EA.	4.00	152.00	6.00	228.00		380.00
	Recept. Boxes w/Surface Cover	30	EA.	5.00	150.00	1.25	38.00		188.00
	2" R.S. Conduit	20	LF.	2.70	54.00	1.40	28.00		82.00
	3/4" R.S. Conduit	500	LF.	2.00	1,000.00	.50	250.00		1,250.00
	#10 THW Wire	100	LF.	.40	40.00	.54	54.00		94.00
	#8 THW Wire	200	LF.	.12	24.00	.12	24.00		48.00
	#12 THW Wire	2000	LF.	.09	180.00	.04	80.00		260.00
	Ltg. Switches - 15A S.P.	10	EA.	3.00	30.00	1.50	15.00		45.00
	Sw. Boxes w/Surface Cover	10	EA.	5.00	50.00	1.25	13.00		63.00
	#10 THW Terminations	4	EA.	9.00	36.00	---	---		36.00
	#8 THW Terminations	6	EA.	5.00	30.00	---	---		30.00
	#12 THW Terminations	350	EA.	4.50	1,575.00	---	---		1,575.00
	SUB TOTAL				5,199.00		3,311.00		8,510.00

GE-001

CONSULTING ENGINEERS

... **REVISED.**

... OF

... CHECKED BY

...& FINAL ☐

[illegible]

ROGERS ENGINEERING CO., INC.
CONSULTING ENGINEERS

JOB NO. S-76023
FOR _____
PROJECT _____
DWG. NO. _____

COST ESTIMATE

ITEM TITLE Desert Hot Springs
Greenhouse Bldg.

DATE 1/24/78 REVISED _____
SHEET 7 OF _____
PREPARED BY JAB CHECKED BY _____
PRELIM. ☐ % FINAL ☐

ACCOUNT NO.	DESCRIPTION	QUAN.	UNIT	UNIT LABOR	LABOR	UNIT MATERIAL	MATERIAL	OTHER	TOTAL
	Electrical								
	Power & Lighting System								12,000.00
SUB TOTAL									12,000.00

GE-001

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CONSULTING ENGINEERS

PRELIM. ☐ % FINAL ☐

SUB TOTAL

CONSULTING ENGINEER'S

JOB NO. S-76023

FOR

PROJECT

DWG. NO.

COST ESTIMATE

ITEM
TITLE Desert Hot Springs

Greenhouse Complex

Geothermal Heating System

DATE 1/24/78 REVISED _____

SHEET 9 OF 10

PREPARED BY JAB CHECKED BY _____

PRELIM. ☐ % FINAL ☐

[illegible]

GE-001

BACK UP SHEET

SUB TOTAL

167,825.00

ROGERS ENGINEERING CO., INC.
CONSULTING ENGINEERS

JOB NO. S-76023

COST ESTIMATE

DATE.....1/24/78.....

... REVISED:

FOR

ITEM
TITLE.....Desert Hot Springs.....

SHEET.....10

... OF:

PROJECT.....

Greenhouse Complex

PREPARED BY... JAB

... CHECKED BY

DWG. NO.....

Geothermal Heating System

PRELIM. ☐

.....FINAL ☐

[illegible]

GE-001

BACK-UP SHEET

SUB TOTAL

81,075.00

Cost of Construction of a 2 Acre Greenhouse

Quote by Double A Truss Manufacturing Co. Manteca

Cost of Greenhouse Constructed on Existing Concrete Footings:

\$323,200

Price includes:

- a) Hot water heaters suitable for geothermal water
- b) Evaporative coolers

Construction:

Galvanized Steel Frame with Tedlas coated fiberglass panels

Size:

30' wide bays with 8' high wall

APPENDIX 8

DETAILED ANALYSIS OF A GEOTHERMAL
AQUACULTURE FACILITY

1. Aquaculture Potential at Desert Hot Springs

Much interest has been shown in recent years in the culture of aquatic organisms in the United States. Most of the commercial applications to date have been concentrated in Hawaii, due to the ideal climatic conditions. However, there is considerable potential in the contiguous 48 states where geothermally heated water can be utilized for maintaining elevated temperatures.

The city of Desert Hot Springs offers a very attractive location for an aquaculture operation. Not only is the city blessed with an extensive geothermal resource, but the desert climate offers an extended natural growing season for aquatic organisms thriving on elevated temperatures. In addition, the high quality of the geothermal water at DHS has a good potential for direct contact use with most of the more promising aquaculture candidates. Direct use of the geothermal water is very important from an economic standpoint since it eliminates costly heat exchanger units and their associated maintenance.

2. Aquaculture Candidates Considered

Many species of aquatic organisms have been studied for aquaculture operations; however, not all would be compatible with or could take advantage of the unique desert environment and geothermal resource at DHS. 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 as commercial food products, and also tropical fish for the hobbyist market. The following paragraphs summarize some of the advantages and disadvantages of these species.

• Trout

The success of several extremely large trout farming operations in Idaho and elsewhere has provided the market with an adequate supply of food fish and it is doubtful whether a relatively small operation in southern California could compete effectively. The elevated temperatures at Desert Hot Springs are also too warm for reliable culture of salmonids. In fact, it appears that cooling of the water below average air temperatures would be required. This would not be a cost-effective proposition.

• Catfish

The warm temperatures of the Desert Hot Springs area might be ideal for common cultured catfish, if the range could be maintained between approximately 65° and 85°F. However, a considerable problem may exist in finding an adequate market for this product. Several catfish farms in southern California have gone out of business in recent years. One major facility is still operating, in Niland, but the entire output is utilized in commercial catch-and-pay fish ponds rather than as a retail food fish. The Niland operation is well established and would be difficult to compete against in the sport fish area.

• Tilapia

Tilapia are omnivores, eating both plant and animal material. Although they are very temperature-tolerant and can be cultured inexpensively, there is very little present market for this small and bony fish. Only a small ethnic market exists in New York, where it is sold at St. Jude's fish. For this reason it would be difficult to attract private industry to develop a culture operation for this species at present.

• Tropical Fish

The sale of freshwater and marine tropical fish to the home aquarist is a multi-million dollar business. Many of the species have temperature tolerances which would be ideal for the geothermal waters. Unfortunately, however, few U.S. producers can compete with the large-scale production coming from Singapore and the East. Labor, land and food costs there are extremely low. There may be place for limited production of certain species which are very highly prized for special color patterns or strains and for which a higher profit margin might be available. According to one expert, these might include koi carp, discus fish and black angels.²⁵ More research would be required to determine the extent of this market. It does not appear to be warranted at the present time.

• Striped Bass

The striped bass, Morone saxatilis, is a member of the sea bass family, Serranidae. Its great fighting ability and excellent tasting white flesh make it an important game and commercial fish on both the Atlantic and Pacific coasts of North America. M. saxatilis is an anadromous fish occurring in fresh, brackish, and saltwater. It is fairly temperature tolerant and might adapt easily to geothermal waters.

Naturally reproducing stocks of striped bass have been established in some freshwater reservoirs in the U.S. through stocking programs. Stocking programs also support extensive recreational fisheries in over 20 reservoirs in 12 states on a put and take basis. The major purposes for introducing striped bass into inland waters were to create a highly desirable sport fishery and to control shad population. The economic value of this recreational fishery for striped bass is very large. In California alone it is valued at \$18 million per year.²⁶

Prior to 1966, large scale artificial culture of striped bass was primarily limited by a lack of proper spawning techniques. Complete pond culture techniques for stocking, rearing, and harvesting striped bass fingerlings have now been reported by numerous investigators. Larvae are extremely sensitive to handling stress and must be transferred carefully. Water quality does not appear to be a limiting factor in fingerling production as Regan et al.²⁷ has reported dissolved oxygen levels as low as 3 ppm and pH as high as 10 without any mortalities. All striped bass fingerlings currently cultured in the U.S. are used in stocking programs. For this type of purpose, fingerlings are usually grown to the 30-80 mm size in earthen ponds.²⁸ Pond reared striped bass can reach a length of 170 mm in one year as compared with 110 mm for bass in natural waters.²⁹

Striped bass do not appear to be seriously affected by any diseases and standard aquaculture disease treatments work effectively on most of the reported diseases in striped bass.

Results from fingerling production vary greatly among researchers. These results vary because of the difficulty in controlling the environment of an outdoor pond. This problem could possibly be alleviated by rearing striped bass in more highly controlled environments utilizing tanks or raceways. The major obstacle to using this approach is the development of adequate artificial foods for larval development (to 30 days) and for rearing fry to the advanced fingerling size. Initial results indicate that 30 day old striped bass can be reared in raceways to a 600 gm size in 15 months on a diet of floating catfish food or trout chow. Many researchers report difficulty in conditioning bass fry to artificial food.

Discussions with officials of the California Fish and Game Headquarters in Sacramento indicate that there are certain legal restrictions regarding striped bass culture in California. It is currently illegal to import any striped bass into the state unless they are dead. Therefore, an application to the Director of California Fish and Game would have to be made asking for a suspension of the rules to allow the importation of fingerlings. Another approach would be to apply for an anadromous fish breeders license, with specific stipulation written in allowing possession of live striped bass.

Current laws also prohibit the sale of any striped bass caught in California waters. Only striped bass imported from out of state, dead and specially tagged, are allowed to be sold. Because of increasing poaching pressure on the California striped bass populations, there is currently a move to strongly consider the prohibition of all striped bass sales in California.

Wardens in Sacramento indicated that striped bass culture to the market stage has never been tried in California and would be a unique project. Current laws were structured without this project being considered. They, therefore, recommend that if a commercial group wishes to develop a striped bass aquaculture program a detailed proposal be sent to the Director's Office, and they would help to resolve any legal problems currently restricting this type of culture, perhaps by means of either of the two approaches mentioned: 1) suspension of rules or 2) special anadromous fish breeders licenses. Quite recently a private company in central California has been successful in obtaining the necessary permits to culture and sell striped bass.

Thus, two potential problem areas have been identified relative to any aquaculture potential for striped bass in Desert Hot Springs. The development of an aquaculture program at Desert Hot Springs would require alteration of existing regulations which prohibit the importation of striped bass into California. A permit would be required to possess and rear live fingerlings. The second concern is the development of a suitable artificial food source for larvae and fry.

● Freshwater Shrimp

Freshwater shrimp of the genus Macrobrachium (family Palaemonidae), are found throughout the world in tropical, fresh, and brackish waters. There are over 100 species in this genus, less than a dozen of which are currently exploited commercially for food. The best researched species for commercial aquaculture applications is M. rosenbergii, the giant Malaysian prawn.

M. rosenbergii is an omnivorous scavenger. Its natural diet consists of small aquatic animals, plants, insects, larvae, molluscs, crustaceans and detritus. The prawn is also cannibalistic if insufficient space or food is available. Larval stages feed on zooplankton, small worms and detritus.³⁰

Growth rate in M. rosenbergii is rapid. When cultured in ponds with good conditions, these prawns can reach a size of 21 cm and an average weight of 100 gm in 7-9 months.³¹ Males are larger than females. Little growth occurs in females beyond an overall length of 22 cm and 120 g in weight, with males growing to more than 25 cm and 200g in weight.³² Male shrimp measuring 31 cm in total length have been collected and Lagler³² reported one male in Bangkok at a market weight of 470 gm.

Macrobrachium farming, in various degrees of intensity, has been practiced in South-east Asia for many years. The prawns are cultured in ponds, either alone or with fish (milkfish, carp, mullet). An ever increasing market demand for shrimp and prawns, has prompted an intense interest in freshwater prawn culture throughout the world. The interest in culturing M. rosenbergii has also come about because of its many desirable characteristics as a potential candidate for aquaculture. These include: 1) fast growth; 2) omnivorous diet; 3) ready reproduction in captivity; 4) large number of larvae produced per female; 5) relatively short larval phase; 6) very hardy and disease resistant; 7) good food conversion ratios; 8) excellent taste and 9) high market value.

Labor, food, and electricity are the major cost factors in larval production. Even though larval rearing techniques are now reliable, research is needed to keep the cost of larval production low. Use of thermal effluent or geothermal energy for heating would be beneficial. Also, the formulation of a balanced artificial food for the larvae would greatly lower feeding costs.

Under proper conditions, healthy and mature prawns can breed year-round in captivity. By maintaining a constant temperature of 27.5°C and a photoperiod of 14 hours light, previous investigators were able to easily produce gravid M. rosenbergii year-round.

Maintaining good water quality is important for regular reproduction in these prawns³³ and so is a good varied diet. The adults may be fed ground fish, mussels, trout chow, tubifex worms, rolled oats, etc.

Cultivation practices and research on the rearing of juvenile M. rosenbergii are generally being carried out utilizing two methods: 1) intensive pond culture in areas with suitable temperatures, and 2) intensive culture in tanks or raceways with a controlled environment.

Most pond culture research in the U.S. has been conducted in Hawaii and the south-eastern United States. There is a growing season of approximately nine months in Hawaii (March-November) and six months in the southern U.S. Yields of 3000 lb/acre/year are currently being achieved.³³ Stockable juveniles are reared to market size in .10- .20 hectare ponds using a supplemental feed composed of broiler starter and fish flesh. The ponds are seined once a month to cull those prawns that have reached marketable size and a like number of juveniles planted back into the ponds in order to keep them in constant production.

M. rosenbergii are highly disease resistant as compared with other crustaceans. The major conclusion is that poor culture techniques, in terms of holding tank design, water quality and/or inadequate nutrition is the major cause of prawn disease. If these factors are all well maintained, disease problems in M. rosenbergii are very minimal.

The major problems with pond culture in the U.S. at this time appear to be: 1) formulation of a suitable prawn food, 2) development of less labor intensive harvesting methods, 3) finding sites for ponds that provide sufficiently long growing seasons, and 4) cost of land. Lack of adequate outdoor growing temperatures is one of the major factors limiting prawn culture in the U.S. However, the use of geothermal energy to heat the culture ponds or raceways appears to offer a reasonable solution to this problem.

The use of geothermal waters to provide heated water for prawn culture has been investigated on a preliminary basis by researchers at Idaho State University, at the Raft River Geothermal Site of DOE. Initial results have been encouraging.³⁴ A similar study being conducted by researchers at Oregon State University and funded by Sea Grant has also shown positive results.

3. Final Aquaculture Candidate

The previous section presented the various species that were considered for an aquaculture project at DHS. The two most promising species were the striped bass and the giant Malaysian 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 mentioned previously.

Hence, the giant 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, a recent experiment by Oregon Institute of Technology at Klamath Falls, Oregon has indicated that prawn can be grown successfully in the geothermal fluid if the temperatures is properly maintained.³⁵ The water quality of the geothermal fluid at DHS appears to offer no problems for direct aquacultural applications in the opinion of Jon Van Oist, aquaculture consultant on the program. Thus, M. rosenbergii seems well-suited for an aquaculture project at Desert Hot Springs.

4. Market Assessment for Prawn

The commercial viability of direct utilization of the geothermal resource underlying the City of Desert Hot Springs will be largely determined by the marketability of the product produced. Previous sections have selected the the giant Malaysian freshwater prawn as the aquaculture choice. This section examines the structure of the fisheries market with respect to shrimp and lobster. Particular emphasis is placed on price and consumption of these two shellfish.

Discussions were held with fisheries distributors, wholesalers, processors and retailers to assess the existing market for freshwater prawn. Little or no quantitative data was 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, the shrimp would initially, most probably, enter specialty retail markets in Southern California. It is not clear whether the Macrobrachium, primarily because of its size, would compete with saltwater shrimp or lobster for a place in the shellfish market. The data presented indicates the extent and structure of existing shrimp and lobster markets. The purpose of this analysis is to assess what would be required to penetrate the shellfish market.

4.1 Shrimp Prices

From 1968 to 1975 exvessel (referring to the catch as off-loaded from the boat), wholesale, and retail prices of raw headless shrimp (21-25 count) have generally increased from year to year with two exceptions; the wholesale and exvessel prices dropped in 1972 and 1974, the 1974 decrease being the more significant (see Figure 1). The 1974 decrease may reasonably be explained by the depressed economic conditions throughout the U.S. at that time, i.e., the recession. In contrast to the exvessel and wholesale prices, the 1974 retail prices continued to rise.

A reasonable explanation for this retail price anomaly is that as demand for shrimp in the consuming sector fell, fishermen were forced to sell at a lower price exvessel. To maintain their income in the face of falling prices they may have tried to increase the catch. The wholesale market became saturated but wholesalers continued to buy shrimp at a lower price. The wholesalers may have had to acquire additional cold storage to handle the exvessel increases. This continued buying was based on the on the assumption that retailers would sell the shrimp at lower prices to stimulate demand and thereby increase the quantity sold. However, the retailers, who were already operating on a narrow margin, took the opportunity to capture a larger margin by buying at a reduced price but continuing to sell at a higher price. The retailers assumed that due to general inflation, demand for these luxury items would not be further stimulated by reduced prices. They envisioned increased revenues from selling a smaller quantity at a higher price rather than a larger quantity at a lower price.

To determine the existence of a seasonal trend, the month-to month variation of exvessel prices were examined. Wholesale and retail prices are discussed in the following sections in a similar light.

4.1.1 Exvessel Prices

The exvessel prices herein discussed are for raw headless shrimp (21-25 count). (Data for smaller sized shrimp are available but are not analyzed here since the freshwater prawn is a larger animal). The available data consist of the weighted average for all shrimp species from the south Atlantic and the Gulf. For the years 1968 to 1970, the prices were relatively stable. For the remaining years to 1976, the first quarter of the year has generally been characterized by an increase in price, except for 1972 and 1974. The second quarter of each year prices usually continue to increase. The third quarter price increases occurred in 1973 and 1975, decreasing in 1972, 1974, and 1976. In the final quarter, prices have generally continued to increase (Figure 2). The highest prices paid for shrimp during the year have generally been in December although the highest prices in 1976 were in May. A reasonable inference can be drawn that prices have generally risen month-to-month in the past few years, excluding the 1972 and 1974 decreases. Even though the prices dipped in 1972 and 1974, the long term price trend was soon reestablished.

4.1.2 Wholesale Prices

The wholesale price data consists of the following:

- 1) Average wholesale prices for processed, frozen shrimp (large 26-30 count, brown, 5-lb package). Point of pricing: Chicago, 1973-1976. (See Figure 3).
- 2) Average wholesale prices for processed, fresh shrimp (large - 26-30 count, headless). Point of pricing: New York, 1973-1976. (See Figure 4).
- 3) Wholesale prices of raw headless shrimp, (21-25 count). Point of pricing: New York, 1968-1975. (See Figure 5).
- 4) Average wholesale prices for processed, frozen shrimp (raw, breaded, 15-20 count, 4-lb package). Point of pricing: selected areas 1973-1976. (See Figure 6).

As was the case with exvessel prices, the month-to-month wholesale price fluctuation over the period 1968 to 1970 was relatively stable. As might be expected, 1972 and 1974 again showed a downward movement of prices. In 1976 an unusual situation occurred in that the price fluctuated greatly, reaching a high point in the second quarter and a low point in the third quarter. The extrema of these fluctuations were significantly greater than in previous years. If the remaining years can be considered to be representative, then the anomalous fluctuations notwithstanding, wholesale prices have generally tended to increase through any given year.

4.1.3 Retail Prices

Retail data consists of the following:

- 1) Retail prices of raw, headless shrimp (21-25 count). Point of pricing: Baltimore, MD., 1968-1975. (See Figure 7).
- 2) U.S. Average retail prices of frozen shrimp. (41 cities) 1972-1976. (See Figure 8).

The month-to-month retail prices over the period 1968 -1970, and for 1972 are relatively stable. The years 1971, 1973 and 1975 showed relatively continuous price increases, the latter two years showing steep increases in the second and third quarters respectively. Aggregated data used to determine U.S. average of 41 cities does not evidence the extrema of fluctuations as do the individual year prices. (See Figure 8).

Figure 2. Exvessel Prices of Raw, Headless Shrimp (21-25 count), All Species, Weighted Average, South Atlantic and Gulf

1968-1975, monthly

Sources: (1) Shellfish Market Review and Outlook (April 1975, November 1975) 36, 37

(2) Fisheries of the U.S. 1976. 38

Figure 4. Average Wholesale Prices for Processed, Fresh Shrimp (large, 26-30 count, headless)

Point of Pricing: New York
1973-1976, monthly

Source: Fisheries of the United States
1973, 1974, 1975, 1976 39, 40, 41, 38

Figure 5. Wholesale Prices of Raw, Headless Shrimp (21-25 count)

Point of Pricing: New York
1968-1975, monthly

Figure 6. Average Wholesale Prices for Processed, Frozen Shrimp
(raw, breaded, 15-20 count, 4-lb pkg)

Point of Pricing: selected areas
1973-1976, monthly

Source: Fisheries of the United States 1973, 1974, 1975, 1976 39,40,41,38

Source: Shellfish Market Review³⁷
and Outlook (April 1975)

Figure 8. U. S. Average Retail Prices of Frozen Shrimp, 10 oz.

Point of Pricing: 41 cities
1972-1976, monthly

Source: Fisheries of the United States 1973, 1974, 1975, 1976^{39,40,41,38}

4.1.4 Summary

Overall trends in the prices of shrimp over the period 1968 to 1975 have increased from year to year, exvessel, wholesale and retail. However, it is more difficult to generalize the month-to-month and seasonal trends. Since 1968 to 1970 was a period of relative stability, and 1972 and 1974 were years of sharp downward price trends, only a few years may be used to assess what may be called seasonal variations in price. Thus, it is reasonable to conclude that the shrimp market is rather volatile and highly sensitive to overall economic conditions.

4.2 Lobster prices

Only exvessel and wholesale price data were available. Data on the American or northern lobster is used in the analysis. Both exvessel and wholesale prices of lobsters have risen steadily from year to year over the period 1968 to 1976. (See Figure 9 and Figure 10). The month-to-month data are very consistent, making it much easier to generalize trends for lobster prices.

4.2.1 Exvessel

The month-to-month variation in exvessel prices for 1970 to 1976 exhibits a fairly consistent decreasing trend from January to December each year. Prices tend to be highest early in the year, decreasing through September, and thereafter, rising to but never reaching the initial price level at the start of the year. (See Figure 11). It should be noted that the 1970 and 1971 prices fluctuated less than in other years.

4.2.2 Wholesale Prices

The 1970 to 1975 wholesale prices exhibit time variations similar to the exvessel prices. (See Figure 12). From January through April, the price generally rises, it then falls to the lowest point in May. From May the prices again rise to a second peak during the summer months. Prices then decrease through to the end of the year.

4.2.3 Summary

Lobster prices exhibit a continual upward trend from year-to-year. The seasonal variation is pronounced with the highest prices in the winter months at the beginning of the year and the lowest prices in mid-spring. The extreme variation in prices is a function of the lobster season.

4.3 Consumption - Fish and Shellfish, Aggregated

Fresh and frozen fish and shellfish comprise the bulk of the fish and shellfish market. Canned and cured fish and shellfish are a significantly smaller portion of the market. The per capita consumption of fresh and frozen fish and shellfish reflects the overall market. In the early to mid 1950's, per capita consumption fell and remained relatively stable at that level up to the late 1960's. In more recent years the per capita consumption of fresh and frozen fish and shellfish has risen steadily. (See Figure 13). The per capita consumption of commercial fish and shellfish from 1950 to 1976 has averaged about 11.2 pounds per person per year. The low point was 10.2 pounds per person in 1957 and the high was 12.9 pounds per person in 1975 and 1976. For comparison, the U.S. population has increased steadily from 1950 to 1976 at an average rate of 2.4 million persons

Figure 9. Index of Exvessel Prices for American (Northern) Lobsters

Simple averages of the 12 monthly indexes.
1968-1976, annually

Sources: (1) Fisheries of the United States, 1973³⁹
(2) Fisheries of the United States, 1976³⁸

Figure 10. Averaged Wholesale Prices for American Lobsters

Point of Pricing: New York
1970-1975, annually

Figure 11. Index of Exvessel Prices for American (Northern) Lobsters

1970-1976, monthly

Figure 12. Average Wholesale Prices for American Lobsters

Point of Pricing: New York
1970-1975, monthly

Figure 13. U. S. Per Capita Consumption of Commercial Fish and Shellfish
(edible meat, pounds)

1950-1976, annually

Source: Fisheries of the United States, 1976³⁸

a year. Thus, when the per capita consumption was relatively constant the total fish products consumed per year increased at approximately the same rate as the population grew. As the per capita consumption began to rise in the 1970's, the total fish consumption necessarily also increased. Comparing 1968 with 1976, fish consumption per capita over that period increased about 17.3 percent while population grew 8.1 percent. This is a growth of about 2 percent per year in fish and 1 percent in population. Therefore, the total fish product consumption is considerably higher than in the past. (Bell, 1974).⁴⁴

4.3.1 Shrimp - Consumption

The U.S. aggregate consumption of shrimp has increased fairly steadily over the period 1947 to 1974, rising from 100 million pounds in 1947 to 347 million pounds per year in 1974. (See Figure 14). The per capita consumption of shrimp over the period 1947 to 1976 has likewise increased with the exceptions of 1957 and 1975. The average for the period is about 1.13 pounds per person per year; the lowest consumption was 0.69 pounds per person in 1947 and the greatest consumption was 1.64 pounds per person in 1974. (See Figure 15). The percentage increase from 1947 to 1974 was 137.7 percent, a growth rate of about 3.3 percent per year. The population grew slightly over one percent per year over the same period.

4.3.2 Lobster Consumption

Unfortunately, the only data gathered to date are lobster consumption in the form of lobster tails. It is unknown whether overall lobster consumption may be projected from the consumption of lobster tails with any reliability. The total consumption of lobster tails has increased slightly during the period 1960 to 1974. (See Figure 16). The average over this same period is 32.4 million lbs. per year with the low being 26.7 million lbs. in 1961 and the high 38.1 million lbs. in 1970. The per capita consumption of lobster tails has remained fairly constant, with the largest rises occurring from 1967 to 1970. Consumption decreased in both 1971 and 1974. (See Figure 17). The average consumption for the period from 1960 to 1974 is 0.16 pounds per person per year, the low being 0.15 pounds per person in 1966 and the high 0.19 pounds per person in 1969 and 1970.

4.4 Conclusion - Establishing a Market

Although there has only been a small increase in the per capita consumption of all fish and shellfish over the period 1957 to 1975, both the aggregate and per capita consumption of shrimp has risen dramatically. The per capita consumption of lobster tails has also risen over this period. As has previously been demonstrated, the shrimp market is volatile and sensitive to the economic conditions in the country. Nevertheless, introducing a new product, that is, freshwater prawn, into the shellfish market seems promising based on the apparently continuing increase in per capita consumption of shrimp.

At present, the market for freshwater prawn is quite small and non-differentiated from the saltwater prawn (shrimp) market. Much of the data presented here is drawn from personal communication with several persons involved in research and commercialization of prawn. Based on these discussions, there seems to be a general feeling that the potential for freshwater prawn is great. The data presented on the increasing shrimp consumption lend credence to the potential market for freshwater prawn.

Figure 15. U. S. Per Capita Consumption of Shrimp
(edible weight, pounds)

1947-1976, annually

Figure 16. Total Consumption of Lobster Tails
(product weight, million pounds)

1960-1974, annually

Source: Shellfish Market Review and Outlook (April 1975)³⁷

Figure 17. Per Capita Consumption of Lobster Tails
(product weight, pounds)

1960-1974, annually

Source: Shellfish Market Review and Outlook (April 1975) 37

There are a number of factors which must be considered in establishing a market for freshwater prawn. Those characteristics discussed below are generally believed to define the parameters of the potential freshwater prawn market.

4.4.1 Reputation

Freshwater prawn, at present, are generally not differentiated from saltwater prawn. If it could be said that freshwater prawn had a reputation at present it would probably be negative. Currently, freshwater prawn in the U.S. are imported from India and southeast Asia. The poor quality of this product has led to a depressed image for the prawn. In contrast, freshwater prawn raised by aquaculturists in an artificial environment is of a higher quality. Because the population on the U.S. mainland has generally not been exposed to freshwater prawn, the problem lies in convincing the consumers that superior quality freshwater prawns exist.

4.4.2 Taste

The taste of the freshwater prawn is said to be bland and not fishy. This may or may not pose a problem depending on consumer expectations. If the consumer thinks he is eating a saltwater prawn and is looking for the appropriate taste, he will be disappointed. On the other hand, if the freshwater prawn is presented in such a way to prepare the consumer for a different product, the chances of successful marketing are greater.

4.4.3 Market Approach

There are two approaches to marketing the prawn which have been implemented to date. The first is what might be termed the "gourmet restaurant" approach. Recently, Sun Oil Company launched a seven-month test marketing program for freshwater prawn on the east coast. The freshwater prawn was placed in competition with lobster by introducing it in a size near to that of typical lobster tails and serving the prawn heads on. The price was comparable to that charged for lobster. They reported good success. The second marketing method might be called the "family-oriented restaurant" approach. This has been implemented by some restaurants by serving the prawn heads off in a manner similar to shrimp. They, too, have reported good success.

4.4.4 Product Identification

The name used to identify the freshwater prawn in the market place may or may not be a problem. When Sun Oil carried out their test marketing they identified the freshwater prawn as such to the restauranteers. However, they left it up to the restaurants to call it what they wanted on the menu. It is difficult to find a noun in the English, as well as Spanish, language which distinguishes it as a product in itself. On the west coast the word "prawn" implies a large animal. In Maine and New England it implies a small animal. In England the small animals are only called "prawn", while other species of shrimp are never referred to as such. In Puerto Rico they are called "camarones" but this refers to marine shrimp. Central America, and only Central America, reserves the word "langostinos" specifically to mean freshwater prawn. One contact commented that one party tried to call the freshwater prawn "blue lobsterette" but the lobster industry would not allow it. However, associating freshwater prawn with shrimp might pose problems because of the volatile shrimp market. In one Texas case, the product was called, "Royal Titan Prawn" but the Food and Drug Administration (FDA) required that it be parenthesized with "freshwater shrimp"; due to the fact that there is a difference between saltwater and freshwater prawn, there was a need to differentiate the two.

4.4.5 Education

Two types of product education programs may have to be launched, in attempting to reach chefs and the general public. Based on discussions with shrimp experts, it has been concluded that freshwater prawn must be prepared differently than salt-water prawn due possibly to the high water content. Thus, the question has been raised whether there would be a need to educate chefs in methods of preparing the freshwater prawn. However, it has been argued that if the "gourmet restaurant" approach is implemented, high caliber chefs would be the ones involved and therefore would have their own recipes already. Secondly, for any new product to be successfully marketed, the public attitudes must be conditioned to accept the new product and an appropriate marketing strategy developed.

In conclusion, there are a number of factors which will have to be evaluated to determine their impact on a potential market. The general feeling among the market researchers contacted was that the major problems with a prawn aquaculture facility would be technical rather than marketing. In contrast, however, the opposite opinion was expressed by the technical researchers contacted.

4.5 Market Strategies

The foregoing analysis has demonstrated that the consumption of shellfish, shrimp and lobster in particular, has been increasing steadily in recent years. In addition, the rate of growth of per capita consumption of shellfish has been greater than the rate of population growth. While prices have generally trended upward, both shrimp and lobster prices exhibit large fluctuations over any given year. The question to be addressed here is the strategy which most appropriately would facilitate introduction of Macrobrachium into the existing shrimp and lobster market in Southern California.

The overall market for Macrobrachium consists of two components, demand for the prawn by consumers and supply by producers. Demand is defined as the quantities of prawn per unit of time that consumers will purchase in the market at all possible alternative prices, all other things being equal among consumers. The quantity of prawn the consumers will take from the market will be affected by factors such as the price of prawn, consumers tastes and preferences, the number of consumers under consideration, consumers incomes, the price of other related goods, the range of goods available to the consumer, and the consumer's expectations regarding future prices of all products. Although there are other factors which could be enumerated, these are considered to be the most important. The higher the price of any item the less the consumer will take of that item the lower the price of the item, the greater the quantities the consumer will take, other things being equal and constant. That is, there is an inverse relationship between price and quantity demanded. In the economist's perspective this is the basic relationship known as the demand curve.

Correspondingly, the supply of prawn is defined as the various quantities of prawn which sellers will place on the market at all prices, with all other things being equal. Other factors being held constant in defining a supply curve are basically the set of prices of the resources used to produce the prawn and the range of production techniques available. Usually the supply curve is upward sloping to the right, since a higher price will induce sellers to place more prawn on the market and may induce additional sellers to come into production.

The demand curve and the supply curve for prawn may be placed on a single diagram to show the forces determining the market price and the quantity of prawn which will be consumed. (See Figure 18.) Here a downward sloping demand curve and an upward sloping supply curve have been replicated. If the market is in equilibrium, there is a certain price and quantity of prawn which will satisfy both the consumers and the sellers. This price is known as the equilibrium price, and the quantity as the equilibrium quantity, represented by P^* and Q^* respectively in Figure 18.

Figure 18. Supply and Demand Curves
vs Market Price and Quantity
of Prawns

In economic analysis the concept of elasticity of demand is quite useful. Elasticity of demand for prawn is a measure of the responsiveness of the quantity of prawn that will be taken in the market to changes in price given the demand curve for prawn. If a quantity taken is highly responsive to small price changes, a price increase will cause the total expenditures of the good to decrease; a price decrease will cause them to rise. If the quantity is not very responsive to price changes, an increase in the price will increase total expenditures on the good, whereas a price decrease will cause them to fall. There are many theoretic and practical considerations which are relevant to the discussion of elasticities, but are beyond the scope of this report. For our purposes, it is sufficient to simply define elasticity and look at empirical research work which has been done on the fisheries market, in particular the shrimp market. Elasticity is defined as percentage change in quantity divided by the percentage change in price, when the price change is small. Mathematically, the definition is:

$$\epsilon_p = \frac{\Delta q}{q} \div \frac{\Delta p}{p} \quad (1)$$

Equation 1 relates directly to Figure 19.

Figure 19. Demand Elasticity Curve for Prawns

Elasticity coefficients are divided into three categories with respect to their numerical magnitudes. Assuming a downward sloping demand curve, when the elasticity is less than -1, the demand is said to be elastic. When elasticity equals -1, it is said to have unitary elasticity; and when elasticity is greater than -1, the demand is said to be inelastic. This relationship is graphically presented in Figure 20. The implication is that when demand is elastic there will be more than a corresponding percentage change in quantity when the price changes. That is, if price increases one percent, then quantity would be expected to decrease more than one percent. Correspondingly, if the demand is inelastic, a one percent increase in price would result in a less than one percent decrease in quantity. These price elasticities may be used to indicate a strategy for Macrobrachium penetration into the market.

Figure 20. Elasticity Coefficient Representations

A cursory search of the economic literature revealed two econometrically derived estimates for the price elasticity for the shrimp market. John P. Doll estimated that the price elasticity of the demand at the mean of price and consumption to be -0.63 (Doll, 1972).⁴⁶ The National Marine Fishery Service estimated the price elasticity to be -0.36 (National Marine Fishery Service, 1973). Both the investigators reported price elasticities which are inelastic, that is, a one percent decrease in price would result in a less than one percent increase in quantity. One way of looking at the numerical values is to say that to increase the quantity demand by one percent would require an approximate three percent drop the price of shrimp. The Doll elasticity is closer to unitary elasticity, and may be interpreted as requiring an approximate three percent decrease in price for a two percent increase in quantity demanded.

The implication of this analysis for Macrobrachium grown at Desert Hot Springs is that if the Southern California shrimp market is basically inelastic, the Macrobrachium will have to be priced significantly lower than saltwater shrimp to cause a shift in consumption of their fish commodities. People substitute between products as prices rise or fall. Thus, if saltwater shrimp prices are at a given level, the introduction of Macrobrachium at a level below that for shrimp would be required for the Macrobrachium to capture a corresponding portion of the market. Thus, the lower the price of the Macrobrachium relative to the price of saltwater shrimp, the more of the market Macrobrachium will be able to capture.

In terms of a marketing strategy, the objective is to introduce Macrobrachium into the market at a time when shrimp prices are quite high and the shrimp are scarce. Given the seasonality of the shrimp market the aquaculture operation would most logically attempt to provide commercially marketable shrimp at those times of the year when saltwater shrimp are not readily available, i.e., off season when prices are high. If the Macrobrachium in fact competes with the lobster rather than shrimp, the argument is even more forceful. No econometrically estimated price elasticities for the lobster market have been uncovered to date. However, referring to Figures 11, 12 and 16, the fluctuation of the lobster market appears to provide opportunities for the introduction of Macrobrachium as a competitor. Given that the market for shrimp is inelastic, it may be reasonably argued that the lobster market is also inelastic. Therefore, Macrobrachium would have to be priced sufficiently below both of these products to capture a portion of the market. This argument is highly speculative and must be investigated in considerable detail to arrive at reliable estimates of elasticity for shrimp and lobster. Its usefulness is that it indicates a general strategy which must be followed to create a market for Macrobrachium.

Income elasticity may be defined in a manner analogous to price elasticities. Income elasticity is the change in the quantity demanded for a given change in the income of the household. It is defined on the basis of percentage change as price elasticity:

$$\epsilon_Y = \frac{\Delta q}{q} \bigg/ \frac{\Delta Y}{Y} \quad (2)$$

The econometric work which has been done on the shrimp market verifies what one would suppose to be the relationship between rising income and consumption of shrimp. As household income rises, the quantity of shrimp consumed as part of the food budget increases. Doll, supra, found the income elasticity to be 1.12 at the means of price and consumption while the National Marine Fishery Service, supra, estimated the income elasticity to be 1.52. Both of these elasticities indicate that for a one percent increase in income there is a more than one percent increase in the quantity of shrimp demanded. The implication for aquaculture of Macrobrachium at Desert Hot Springs is that as incomes in Southern California continue to rise the quantity of shrimp demanded in the household food budget will also continue to rise. Thus, the market will expand making it easier to introduce Macrobrachium.

4.6 Summary

The creation of a market for Macrobrachium in Southern California is a function of two factors: the first being the introduction of the Macrobrachium at a price sufficiently below the then current price for shrimp and lobster, and second, introduction at a time when lobster and shrimp prices are high. The lower the price of the Macrobrachium relative to shrimp and lobster, the greater portion of the market which will be captured. Conversely, the closer the price of Macrobrachium to saltwater shrimp and lobster, the smaller portion of the market it will capture. Arguments advanced relative to the requirements of product differentiation, alternative names, competitors in the field, 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 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.

5.0 Major Aquaculture Variables

In seriously considering any aquaculture undertaking, the following key areas need to be looked at in some detail: nutrition and disease control, water quality management and treatment, temperature control, and harvesting. Each of these items will be addressed in the following sections.

5.1 Nutrition and Disease Control

While nutrition has been studied for years and is well understood in most areas of agriculture, the same cannot be said of aquaculture. This is a relatively new area and there is still much to be learned. However, 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. Shrimp growth on this artificial diet is still slower than that observed in nature. The cost of ingredients in a feed is particularly important since the food conversion rates are poor with diets presently in use. For this reason, an attempt should be made to make maximum use of ingredients which are waste products or at least inexpensive in the area where the shrimp are likely to be raised.⁴⁷

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. The actual feeding is very simple in an outdoor pond. The proper amount of food is sprayed over the pond surface as evenly as possible. Raceway feeding is more complicated, however, due to the presence of artificial substrates used to increase prawn densities. If these substrates take the form of vertical nets, the food can still be distributed over the surface area, since it will sink to the raceway bottom where the prawn have easy access. However, if the nets are horizontal, another scheme would have to be used since the prawn's access to the bottom is poor. One possible solution is illustrated in Figure 21. A portion of each layer would be solid (as opposed to netting) to catch the food that fell on top of it, and the various solid sections at each different level would be staggered, as shown, to provide food at all levels. The food could be dispensed by a feeder system rolling lengthwise over the top of the raceway, much in the same way a lawn fertilizer operates (see Figure 21).

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 being conducted in Galveston, Texas 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. As mentioned earlier, the prawn themselves are quite disease resistant.

FIGURE 21
RACEWAY FEEDING SYSTEM

SIDE VIEW OF RACEWAY SHOWING HORIZONTAL NET SUBSTRATES AND STAGGERED
FEEDING TRAYS

5.2 Water Quality Management and Treatment

In order to design a full-scale culture system which can take advantage of geothermally-heated water, it is necessary to determine the required water flowrates from both a biological (for aeration and removal of metabolites such as ammonia) and a thermodynamic standpoint. The thermodynamic analysis will be discussed in the next section.

Since prawn aquaculture is still a fairly new area, the specific requirements pertaining to the effluent from a facility have not yet been fully covered by EPA Documents. The applicable documents are currently being revised. One EPA specification for the effluent from an aquaculture facility for native fishes contained the following limits:

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

While these figures do not necessarily pertain to prawn, they are believed to be representative. An analysis was performed to determine if the actual ammonia buildup for prawn would pose a problem. The ammonia production rate for prawn is 0.036 mg per gm of dried prawn per hour. Using the fact that a dried prawn weighs only one-fourth the weight of an undried prawn and converting the units to those used in the specification, yields an ammonia production rate of 0.022 kg/100 kg/day. This is a factor of four less than the 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.⁴⁸ The worst case for ammonia production would be at harvest time when the prawn are largest. Assuming 15 count shrimp at a density of one per square foot, results in 284 gm of ammonia produced per day. If the water in the raceway were at the 0.14 mg/l level to begin with, the addition of 284 gm would raise the level to 0.595 mg/l for the case of no fresh water into the raceway. An inflow of new water at 87.4 gpm would be required 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.

The options available for the ultimate disposal of the effluent are as follows: reinjection, percolation, irrigation, or disposal into the city sewer system. At the present time this last choice appears to be excluded. The final resolution is site-specific, involving city, county, and water district regulations and ordinances.

5.3 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. Figure 22 shows a monthly plot of the average, the extreme, and the average minimum and maximum temperatures for Palm Springs over a 30-year period.⁴⁹ Temperatures are mild during the winter. The average minimum temperature in January is 40°F, and there are normally only

FIGURE 22
PALM SPRINGS TEMPERATURE DATA

10 days per year with readings of 32°F or lower. Over the 30-year period, the coldest reading was 22°F. Summer temperatures are hot, with the minimum in July averaging 73°F and the maximum averaging 109°F. Typically, there are 181 days per year with readings of 90°F or higher, with an all-time high of 122°F.

The relative humidity is quite low during the warm part of the year, with July figures averaging 40% in the early morning and between 20 and 25% in the afternoon. Winter humidities range from 50% in the morning to 35 to 45% in the afternoon. Wind speeds are less than 13 mph about 84% of the time, and in only 2.4% of the time are they 25 mph or more. However, winds in Desert Hot Springs are considerably higher due to the proximity to the mountains and the San Geronio Pass.

Based on these data, the worst-case cold day conditions were selected as 30°F, 10 mph wind velocity, and 40% relative humidity. The corresponding worst-case hot day conditions were 120°F, 20 mph, and 20%. In order to calculate the net heat loss (or gain) from the 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.^{50,51} The equations consider the total heat flow from radiation, convection, and evaporation. Table 1 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 the variables, and hence the initial assumptions. Table 2 shows the same data for the outdoor raceway system.

In comparing the two tables, it can be seen that the heat losses from the raceway are only 5% of the losses 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 have been determined, they can be converted into flowrate requirements, both for the geothermal well and for the pond (or raceway) circulation pump. The following example will illustrate the procedure for the worst-case cold day for the pond, which was the most severe case as seen in Table 15.

The water lost by evaporation is:

$$\begin{aligned} \dot{m}_{\text{evap}} &= \frac{q_{\text{evap}}}{H_v} ; \quad H_v \text{ is the heat of vaporization} \\ &= \frac{5.2 \times 10^6}{970} \\ &= 5318 \text{ lb/hr} \end{aligned}$$

$$\text{or, } Q_{\text{evap}} = 10.6 \text{ gpm}$$

Table 1
Heat Losses For A One-Acre Pond

Water Temp. (°F)	Air Temp (°F)	Wind Velocity (mph)	Relative Humidity (%)	Heat Loss From Pond (Million Btu/hr)			
				Radiation	Convection	Evaporation	Total
75*	30	10	40	2.3	4.4	5.2	11.9
85**	120	20	20	-0.7	-6.1	16.4	9.6
85***	30	20	20	2.8	9.6	16.4	28.9
80	30	20	20	2.6	8.8	14.3	25.6
75	30	20	20	2.4	7.9	12.3	22.5
85	35	20	20	2.7	8.8	16.4	27.8
85	40	20	20	2.5	7.9	16.4	26.8
85	30	10	20	2.8	5.4	9.2	17.4
85	30	30	20	2.8	13.5	23.0	39.4
85	30	20	40	2.8	9.6	12.3	24.8
85	30	20	60	2.8	9.6	8.2	20.7

* Worst-case cold day, allows pond water temperature to drop to 75 F

** Worst-case hot day

*** Baseline case for sensitivity analysis

Table 2
Heat Losses For A High Density Raceway

Water Temp. (°F)	Air Temp. (°F)	Wind Velocity (mph)	Relative Humidity (%)	Heat Loss From Raceway (Million Btu/hr)			
				Radiation	Convection	Evaporation	Total
75*	30	10	40	0.12	0.22	0.26	0.60
85**	120	20	20	-0.035	-0.31	0.83	0.48
85***	30	20	20	0.14	0.48	0.83	1.46
80	30	20	20	0.13	0.44	0.72	1.29
75	30	20	20	0.12	0.40	0.62	1.14
85	35	20	20	0.14	0.44	0.83	1.40
85	40	20	20	0.13	0.40	0.83	1.35
85	30	10	20	0.14	0.27	0.46	0.88
85	30	30	20	0.14	0.68	1.16	1.99
85	30	20	40	0.14	0.48	0.62	1.25
85	30	20	60	0.14	0.48	0.41	1.05

* Worst-case cold day, allows raceway water temperature to drop to 75 F

** Worst-case hot day

*** Baseline case for sensitivity analysis

The amount of inlet water required to replace the total heat lost can be expressed as a function of the inlet water temperature as follows:

$$\begin{aligned}\dot{m}_{\text{geo}} &= \frac{\sum q}{c_p (T_{\text{geo}} - T_{\text{pond}})} \\ &= \frac{11.9 \times 10^6}{(1) (T_{\text{geo}} - 75)}\end{aligned}$$

Hence, for selected values of geothermal water temperature:

T_{geo} (°F)	$\dot{m}_{\text{geo}}$ (lb/hr)	Q_{geo} (gpm)	Overflow ($Q_{\text{geo}} - Q_{\text{evap}}$)
120	2.6×10^5	528	518
140	1.8×10^5	366	355
160	1.4×10^5	280	269
180	1.1×10^5	226	216

Now, in order to reduce this source temperature to the acceptable 90°F limit for introduction to the pond, the required quantity of mixing water can be calculated as follows:

$$\dot{m}_{\text{pond}} c_p (90 - 75) = \dot{m}_{\text{geo}} c_p (T_{\text{geo}} - 90)$$

$$\text{or, } \dot{m}_{\text{pond}} = \dot{m}_{\text{geo}} \frac{T_{\text{geo}} - 90}{15}$$

For the above values of geothermal water temperature, the appropriate quantities of pond mixing water are:

T_{geo} (°F)	$\dot{m}_{\text{geo}}$ (lb/hr)	$\dot{m}_{\text{pond}}$ (lb/hr)	$\dot{Q}_{\text{pond}}$ (gpm)
120	2.6×10^5	5.3×10^5	1057
140	1.8×10^5	6.1×10^5	1220
160	1.4×10^5	6.5×10^5	1306
180	1.1×10^5	6.8×10^5	1359

Hence, it can be seen from the above analysis that substantial peak flowrates would be required to maintain the pond temperature during cold periods. These peak flowrates, in turn, size the pumps which affect the capital outlay. One method for shaving these peaks might be to maintain the pond at a higher temperature (which is favorable to prawn growth but trades off against increased energy cost) and allow the pond temperature to drop to a minimum acceptable limit during a cold spell. Thus, in cold weather the pond temperature would follow a diurnal cycle.

The same analysis for the outdoor raceway yields the following results:

$$\dot{m}_{\text{evap}} = 269 \text{ lb/hr}$$

$$\text{or, } \dot{Q}_{\text{evap}} = 0.5 \text{ gpm}$$

T_{geo} (°F)	$\dot{m}_{\text{geo}}$ (lb/hr)	$\dot{Q}_{\text{geo}}$ (gpm)	$\dot{m}_{\text{race}}$ (lb/hr)	$\dot{Q}_{\text{race}}$ (gpm)
120	13.4×10^3	26.8	2.7×10^4	53.6
140	9.3×10^3	18.5	3.1×10^4	62.0
160	7.1×10^3	14.2	3.3×10^4	66.2
180	5.7×10^3	11.5	3.4×10^4	68.3

As can be seen by comparing these numbers with those in the previous table for the pond, the required flowrates are reduced by almost 20 times. Thus, the raceway system greatly reduces the waste treatment and disposal problems in addition to reducing the energy requirements (pumping costs). The detailed economic analysis and additional engineering studies which were necessary to determine the final system best suited for Desert Hot Springs are included in Section 6.0.

5.4 Harvesting Techniques

As was the case for feeding, harvesting is much simpler for the pond than the 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.

For the raceway system, the substrate layers complicate the harvesting process. Raceway systems are commonly drained to facilitate harvesting, but this compounds the waste treatment problems. Where horizontal layers of substrate are used, a second method would be to lift the layers out of the filled raceway and tilt them vertically over the water so that the prawn are shaken loose into the raceway. Then the raceway could be harvested with either a seine or horizontal grading bars.

A variation of the aforementioned raceway system is being studied in New Jersey which promises to greatly simplify both feeding and harvesting. The project is jointly sponsored by the National Science Foundation and the Public Service Electric and Gas Company in New Jersey.⁵² The variation involves vertical nets instead of horizontal nets, as illustrated in Figure 23. Feeding is accomplished by spreading the food over the surface of the water and allowing it to sink to the bottom of the raceway. The prawn then leave their positions on the nets to feed on the bottom, before returning to an unoccupied location. The nets do not reach to the raceway bottom in order to allow maximum mobility during feeding.

Harvesting is also simplified with this configuration. Each net is slowly pulled out of the water, accompanied by gentle shaking to remove the prawn. Then the raceway is harvested with a seine or horizontal grading bars as before.

FIGURE 23

ALTERNATE RACEWAY SYSTEM

VERTICAL NETS

20 NETS
10 x 104 FT.
SURFACE
AREA-1 ACRE
(NETS AND
BOTTOM)

6.0 Final Aquaculture Design Selection

This section presents the various trade-off studies that were performed to select the final system design, and then presents a first-cut economic analysis to determine if such a design would be economically viable.

In selecting a final aquaculture design, three separate trade-off studies were performed: facility configuration selection, harvest cycle optimization, and facility size optimization. Each of these studies will be addressed in detail in the following sections.

6.1 Facility Configuration Selection

The first 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, especially where the climate is mild, such as Hawaii. 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.

Figure 24 shows a typical layout for a pond culture system suitable for Desert Hot Springs. The pond is an earthen structure that covers one acre and is 3-4 feet deep. The bottom could be made impermeable by either the application of special sprays or by the use of conventional plastic pond liners. The bottom should be flat, well compacted and sloped at 0.5%. The pond berm is approximately one foot above the water level and ten feet wide (to allow a vehicle to drive on for harvesting, etc.)

The mixing chamber shown at the top of Figure 24 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 $\leq 90^{\circ}\text{F}$.

The design selected by this study was the indoor raceway. Table 3 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.

FIGURE 24

POND CULTURE SYSTEM FOR PRAWN

TABLE 3
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

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. The upper water temperature limit for prawn is 90°F for any sustained period of time. Data from outdoor catfish hatchery ponds located in the Salton Sea area have shown that surface temperatures regularly exceed 90°F during the summer months (although temperatures drop some 10°F at three feet below the surface), and peak of over 100°F have been recorded.⁵³ The combination of reduced surface area, increased water depths and environmental control (evaporative cooling) offered the best solution to this problem.

The major disadvantage to the indoor raceway is the higher capital cost, but this is offset somewhat by the decreased pumping costs associated with the reduction in fluid requirements mentioned earlier.

Figure 25 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.

6.2 Harvest Cycle (Optimum Growout Period) Trade-off Study

Once the particular facility configuration has been selected, the next question to be answered is "What is the best harvest cycle to make optimum economic use of the facility?" Is it better to select a brief growout period and maximize the number of harvests per year, or select a longer period and take advantage of exponential growth characteristics inherent with prawn?

The first step to determine the optimum harvest cycle was to identify all the parameters that are a function of growout period:

- 1) Annualized larvae cost
- 2) Harvesting labor cost
- 3) Feed cost
- 4) Pumping cost
- 5) Prawn growth rate
- 6) Prawn survival rate

FIGURE 25
RACEWAY CULTURE SYSTEM

GREENHOUSE
COVERED
RACEWAYS

CROSS SECTION VIEW OF RACEWAY
AND PLUMBING SYSTEM

The first two cost items increase inversely as a function of the length of the harvest cycle; that is, the shorter the growout period, the greater the number of larvae to be purchased in a given year and the higher the total labor costs associated with harvesting. For the purpose of this study, larvae costs were assumed to be 5 cents each if purchased or 1.8 cents each if raised in an onsite hatchery.⁵⁴

The next two cost items increase directly as a function of the length of the harvest cycle. Food costs of \$0.25 per pound and food conversion ratios of 3:1 were assumed, and electrical energy rates of \$0.035/kW-hr were used in the study.

In determining a reasonable prawn growth rate to use for this study, an extensive search of available literature on the subject of prawn culture was performed. The data pertaining to prawn mass as a function of time from post-larval stage presented a very confusing picture with results varying widely from one report to the next. In an effort to arrive at a relationship that would not be overly optimistic, only the more conservative data were plotted and then curve-fitted using the following exponential relationship:

$$\text{Weight (gm)} = 3.4 \times 10^{-9} X^{4.234}, \text{ where } X \text{ is in days}$$

Finally, the last variable affecting the selection of the optimum harvest cycle is the prawn survival rate. Due to disease, natural causes, and cannibalism, the longer the growout period the fewer the number of prawn that survive. Experience has shown that in order to harvest prawn at a density of one per square foot after six months time, it is necessary to stock initially at a density of 1 1/2 prawn per square foot. This relationship was assumed to be linear over the range of harvest cycles considered in the study.

Table 4 shows the results of the trade-off study to determine the optimum harvest cycle. 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 begin 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; 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 4

Harvest Cycle (Months)	Harvest Cycle Duration		
	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.

6.3 Facility Size Optimization Study

In order to determine how sensitive the economic analysis of the selected aquaculture operation was to the size of the operation, three different sizes were considered: 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. Some of the assumptions used in performing the economic analysis are listed below.

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. 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. Feed costs of \$0.25/pound were used, with prawn food conversion ratios of 3:1. Finally, in order to compare future annual expenses and revenues with current capital expenditures, all figures were expressed in terms of present worth dollars. In order to do this, the facility was assumed to have a 15 year life and the cost of capital was assumed to be 10%.

With the above assumptions, figures were generated for annual expenses and revenues for each of the three differently sized facilities; then, the present worth of the net operating income was compared against the actual capital investment required for each facility. Table 5 shows the comparison based on 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 improves markedly for a prawn selling price of \$3.50/pound, as shown in Table 6. 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.

6.4 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, it is by no means a detailed economic analysis. Such an analysis would take into account pre- and post- tax figures, depreciation, projected changes in future expenses and revenues, investment credits, etc. 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 problems. If the answers proved positive with respect to culturing, then a detailed analysis could be performed to verify economic viability of a given operation.

TABLE 5
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 6

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

APPENDIX 9

Detailed Discussion of Proposed Energy Cascading Systems for DHS

1.0. Introduction

An effort was made to consider various options for optimum utilization of the limited Desert Hot Springs resource temperature through the use of energy cascading techniques. 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 that can each effectively utilize thermal energy at a different temperature level. Thus, the various applications can be arranged, in series or in parallel combinations, in order of decreasing inlet temperature requirements.

For higher resource temperatures, the number of possibilities for energy cascading is large since the number of geothermal applications increases rapidly with increasing resource temperature. Hence, for a 350°F resource temperature, an energy cascading system could begin with electrical energy production and explore such options as petroleum, chemical, food and paper pulp processing, refrigeration, and commercial and residential heating and air conditioning, to name a few. However, since the hottest known well at DHS is only 208°F, this eliminates a large number of the possible applications that might otherwise have been selected. In addition, only nonelectrical applications were considered within the scope of the DHS project.

Two different energy cascading systems were considered for DHS. The first was a combination industrial complex involving prawn culturing and greenhouse cucumbers. Such a complex could utilize the geothermal energy first (at its hottest level) to produce refrigeration for cucumber storage and air conditioning as required throughout the complex. The geothermal fluid at a reduced temperature could be utilized for space heating as required. Next, the effluent from space conditioning could be channeled directly into the pond or raceway for prawn culturing. Finally, the overflow from the aquaculture operation could be either disposed of by reinjection (after any necessary treatment) or used for open field irrigation in a nursery operation.

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 design 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. Finally, 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. This scheme appeared to offer the best possibility of providing air conditioning economically at DHS, in spite of the relatively low resource temperature available (208°F maximum).

The proposed system would involve the construction of a 100-unit mobile home park. A mobile home park offered a distinct advantage over a conventional district space conditioning system because of the high density, and hence minimum network, inherent with mobile home parks.

2.0 Mobile Home Park General Plan

The proposed energy cascaded mobile home park would provide the following functions: space cooling, space heating, hot water (potable) heating and Spa use. Figure 1 depicts a simplified schematic of the proposed system. The left side of the schematic shows the water heating system, including the heat exchanger, insulated storage tank, and distribution loop. The right side of the schematic shows the space cooling system, which includes the absorption chiller unit, cooling tower and lines, and the chilled water distribution network. The space heating system is represented on the schematic by the heat exchanger symbol through the distribution network. Note that part of the effluent from the absorption chiller unit is routed to the water heating system, as well as the space heating network (for those times when cooling might be required in some homes and heating in others). The effluent from the water heating system is routed into the space heating network, while the Spa utilizes water, as necessary, from either space conditioning system. The total system was designed so that effluent temperatures were compatible with corresponding inlet requirements.

3.0 Parametric Space Cooling System Design

One important fact was obvious from the outset of the study - - the space cooling system was the economic driver in the overall system. This is true from two standpoints: the desert environment at DHS results in approximately a 2:1 ratio between cooling and heating, and space cooling using a geothermal fluid (or any heat source) requires substantially higher quantities of heat than direct space heating due to inherent conversion inefficiencies. Thus, the first step in designing an energy cascaded system was to take a serious look at the cooling portion of the system.

In order to analyze the space cooling system, the capital cost and operating and maintenance costs were treated parametrically as a function of inlet temperature for a range of 180 to 220°F. However, the final energy cascaded system design, presented in the following section, assumed that only 180°F geothermal fluid was available at DHS. The reason for parametrically sizing the cooling system was to determine the sensitivity of the economic analysis to the available geothermal source temperature, in the eventuality that a hotter resource could be located (either in a surrounding region or at deeper well depths).

The first step in performing the parametric analysis was to identify all the major variables with respect to inlet temperature: absorption unit efficiency (and hence the size unit required), absorption unit costs, geothermal fluid flowrates, cooling water flowrates, cooling tower size and costs, and pump and pumping energy costs. The relationship of the first two of these variables to inlet temperature is shown in Figure 2. Note that a constant output of 200 tons of air conditioning was assumed for all cases. From the unit cost curve it can be seen that a savings of 33% is possible in going from 180 to 200°F, while a savings of 50% results for an increase from 180 to 220°F.

FIGURE 1

ENERGY-CASCADED SYSTEM SCHEMATIC

FIGURE 2

PARAMETRIC COOLING SYSTEM SIZE AND COST

*ALL UNITS PROVIDE 200 TONS COOLING

Figure 2 addresses only the absorption chiller unit costs without considering the other variables mentioned above. The relationship of the entire cooling system cost and performance as a function of the inlet temperature is expressed in Table 1. In order to compare initial capital investments with the annual pumping costs, the pumping costs were expressed in present worth dollars assuming a 30-year equipment life and 10% capital costs. 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.

4.0 Total Project Cost Analysis

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 question to answer was, "Does the net operating income justify the required capital investment?" As was mentioned earlier, only 180°F inlet water was assumed for this analysis.

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 total capital costs were estimated at \$765,000, as broken down in Table 2. Also shown in Table 2 are the estimated operating expenses and revenues, both expressed in present worth dollars. The difference between the latter two figures is the net operating income of \$480,000, or \$285,000 less than the required capital costs. For the figures shown, both the operating expenses and revenues were frozen at current levels throughout the life of the project. This reflects a very conservative posture. A calculation was made to determine what escalation rate for both revenues and expenses (pumping costs, i.e., electric rates) would result in a break-even point with the capital investment, and it was found to be 5% per year. This 5% escalation rate represents a very conservative value, considering past historical data and future forecasts, and probably 7-10% would be a more reasonable value. These higher rates would naturally result in a profitable operation.

5.0 Conclusions and Recommendations

Because of the limited resource temperature at DHS, the only chance of achieving economical geothermal-powered air conditioning appeared to be with an energy cascading system. The most promising of the energy cascading systems considered was a mobile home park, due to the high population density and hence reduced network costs.

TABLE 1

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

TABLE 2.

ENERGY CASCADED MOBILE HOME PARK ECONOMIC ANALYSIS

Capital Investment		Cost (\$)
Cooling Network		356,800
Heating/Hot Water Network		101,200
Wells and Plumbing		132,500
Equipment, Miscellaneous		<u>174,500</u>
Total		765,000
Operating Expenses (PW\$)	47,000	
Revenues (PW\$)	527,000	
Net Operating Income (PW\$)		480,000

Assumptions: 100-Unit Mobile Home Park
 180°F Inlet Temperature
 30-Year Equipment Life
 10% Cost of Capital
 One Each, Source and ReInjection Well
 Source Well 1/4 Mile From Park

A 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 would not justify the required capital investment. 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.

In looking over the capital costs in Table 2, one final point can be made. The network costs make up almost 60% of the total capital investment. This observation suggests that a new Spa installation at DHS, with a close-coupled (i.e., minimum network) chilled/hot water space conditioning system (installed new rather than retrofitted) appears to be a very attractive possibility.

APPENDIX 10

REGULATORY REQUIREMENTS

This appendix contains background information relating to the discussion of regulatory agency authority over geothermal development in Desert Hot Springs. Further information on this subject is in the Self Start Manual on Non-electric Geothermal Development.

1.0 Review Agencies

The first agencies discussed here are those having neither permit requirements nor regulations but who comment on the actions of other agencies by reviewing permit applications and Environmental Impact Statements (EIS) or Reports (EIR). An EIS is the federal environmental report mandated by the National Environmental Policy Act (NEPA). An EIR is California's environmental report mandated by the California Environmental Quality Act (CEQA).

Many agencies previously not directly involved in development review other agency actions under NEPA, and CEQA. Both these legislative enactments require that comments be solicited from all agencies, "...having jurisdiction or special expertise, and agencies with specific statutory obligation from the federal government to coordinate or consult with any other federal or state agencies".¹ In California, to facilitate circulation and distribution of EIR's to appropriate agencies, a standard circulation list was created by the State Clearinghouse. The lead agency, the agency with primary permitting power over a project, is required to send copies of any EIR's prepared under their purview to the State Clearinghouse, which then circulates them to other state agencies. Each agency defines its own role as a reviewer. It can take an active posture of detailed review and comment or choose not to respond at all. This procedure is designed to insure the developer that he has fulfilled his obligation to notify all interested agencies of his project without the necessity of contacting each individually. It also insures each agency that it will be notified of all projects in which it may have an interest.

1.1 NEPA and CEQA

1.1.1 NEPA's applicability extends to all projects which are:

"...directly undertaken by Federal agencies or supported in whole or in part through Federal grants, subsidies, loans, or other forms of funding assistance; or involving federal lease, permit, license, certificate, or other entitlement for use".⁵⁵

In Desert Hot Springs, the heating and cooling of the City Hall and Library with geothermal energy may be feasible. If this option is pursued the City will undoubtedly seek a Federal loan or a grant to fund this project. If funding is obtained, the City must then comply with NEPA. This does not necessarily mean an Environment Impact Statement (EIS) must be prepared.

The City may only have to prepare a Clearance Notice and submit it to the appropriate EIS officer for review. If the EIS officer determines that the project conforms with the City's general plan, and will result in no significant impact to the environment, he may then issue a Negative Declaration, thereby ending Federal NEPA review. The next step would be to meet the City's own environmental review procedures, which would probably be City issuance of corresponding Negative Declaration. However, if the EIS officer determines that the project is not in conformance with the City's general plan, or that the impact of the project on the environment will be significant, an Environmental Impact Statement must be prepared. The agency with the responsibility to do the Impact Statement, or to see that it is done, that is, the lead agency, would either be the City, or, most probably, the federal agency from which funding is requested. However, the City's application for funding may contain much of the information required to prepare an Environmental Impact Statement. Funding agency roles are discussed in another section of this report.

The City may have to comply with NEPA regardless of whether federal funding is obtained. If geothermal waste water is reinjected after use, Environmental Protection Agency regulations may apply. Legislation passed in December, 1974 gave the EPA authority to regulate liquids injected into geologic strata. The EPA has yet to develop guidelines to implement this law, but may do so at any time. Once the guidelines are promulgated, all disposal of liquids into geologic strata may be subject to their review. At the present time, geologic disposal is regulated by local and state agencies such as the Water Quality Control Board, and the California State Division of Oil and Gas. However, it has not yet been determined that reinjection may be required. Additionally, the EPA may not have authority over the disposal of all liquids, but may be restricted to the disposal of municipal and industrial waste. If the EPA does become involved, because it is a federal agency, the requirements of NEPA would have to be met.

EIS's are submitted for review in draft form. Administrative action may not be taken on the draft report within ninety days of submission to reviewing agencies. The final report contains the comments of all reviewers, and the responses of the lead agency to these comments. When complete, the final EIS is submitted to the Council of Environmental Quality (CEQ), the agency responsible for implementing NEPA. No action may be taken on the EIS within thirty days of the time it is submitted to CEQ. Public hearings may be, and often are required on both the draft and the final versions of the EIS. Public hearings may be held no sooner than fifteen days after the final or draft EIS is available to the public.

The enabling legislation of some agencies require reports to be submitted which contain much of the same information included in an EIS. Two of these acts are: The Fish and Wildlife Coordination Act
The National Historic Preservation Act

When reports to satisfy these laws must be prepared for a project in addition to an EIS, it is desirable that the requirements of the two be combined to yield a single document meeting all applicable requirements. This is not presently required; however, the requirements of

the Fish and Wildlife Act are discussed below with the requirements of the State of California's Fish and Game Agency. The requirements of the National Historic Preservation Act are discussed under agencies with passive project review.

1.1.2 The requirements of the California Environmental Quality Act (CEQA), are applicable to:

"discretionary projects proposed to be carried out or approved by public agencies, including, but not limited to, the enactment and amendment of zoning ordinances, the issuance of zoning variances, the issuance of conditional use permits, and the approval of tentative subdivision maps ..." 56

The geothermal projects in the City of Desert Hot Springs fall into these categories. The EIR process is initiated when the application for a use permit is filed. If the project is outside the city limits, the permit is filed with the County of Riverside Planning Department; if the project is within the city limits of Desert Hot Springs, the permit is filed with the City of Desert Hot Springs Planning Department. The planning department which has jurisdiction will be the lead agency indetermining whether an EIR is required. If an EIR is required, that department will be the lead agency in seeing that the report is performed. If funding is obtained from any State agency, then that agency will have lead agency responsibility.

The first step in complying with CEQA is determining whether the project will have a significant effect on the environment, assuming the project is not categorically exempt. Projects which are categorically exempt include:

"Continuing administrative or maintenance activities, such as purchases for supplies, personnel-related actions, emergency repairs to public service facilities, general policy and procedure making feasibility or planning studies". 56

It is clear that geothermal development projects do not fit into any of these categories. They may involve new construction of wells, installation of pipelines, construction of use and disposal facilities. If the lead agency determines the project will have no significant impact, they issue a Negative Declaration to that effect and file it with the County Clerk. If they determine the project will have a significant effect on the environment, they will prepare a Draft EIR. When it is complete a Notice of Completion is filed with the California State Secretary for Resources and the County Clerk. The information contained in a state EIR is virtually the same as in a federal EIS. If an EIS must be prepared on a project, it may fulfill the requirements of CEQA also; but it must be reviewed by state agencies.

When the EIR is completed, the draft is circulated for comment. A Notice of Completion is filed with the State Secretary for Resources. The comment period of the agencies by law shall not exceed forty-five days, unless an agency applies for an extension period. Extension periods shall not exceed fifteen days.

Following the comment period, the lead agency prepares the final EIR, incorporating the comments of the reviewing agencies. Some of the more important agencies with the responsibility to review EIR's and EIS's which may be written on projects using geothermal resources in the City of Desert Hot Springs, are discussed below.

1.2 Discussion of Review Agencies

1.2.1 Historical Preservation

The National Historic Sites Act of 1935, established the National Register of Historic Places, a catalog of places and buildings deemed to have had significance in the country's past, and it is maintained by the Secretary of the Interior. The National Historic Preservation Act of 1966, established the Advisory Council of Historic Places and gave it the responsibility to maintain and update the National Register of Historic Places. To implement this responsibility, the Council has established a review process similar to the environmental impact review process.

The Council first determines if a site is eligible for inclusion in the National Register by using this criteria:

"The quality of the site with respect to significance in American History, architecture, archeology, and culture; that posses integrity of design, location, setting, materials, workmanship, feeling and association." 57

If there may be a significant effect on any of the sites listed in the National Register of Historic Places, by a proposed project and it is not considered adverse; a memorandum of understanding between the lead agency, the Historical Council and the State Liason Officer is needed to substantiate this claim. A memorandum of this nature is also required if there is adverse impact on an historic site which can be mitigated. To determine if the adverse impacts on a site are mitigable, a report similar to an environmental impact report must be prepared. The Council has established guidelines for this entitled, Procedures for the Protection of Historic and Cultural Progress. This report may fulfill NEPA's requirement to assess the historical aspects of a project, and similarly, if an EIS is performed for a project it will fulfill the requirement of the Historical Council if the analysis is done in accordance with its standards. If a particular site is not included in the Historical Register, but it is considered eligible for inclusion, a determination of eligibility may be obtained from the Secretary of the Interior. Even if a site is eligible for inclusion in the Register, but not actually included; the process of determining significant impact described previously must be followed.

The State of California's requirements for attention to the historical aspects of a site prior to project licensing is very similar to those described above for the federal government. CEQA, like NEPA requires an historical assessment of a site be included in an environmental impact report. An inventory of historical sites is maintained in Sacramento by the State Office of Historical Preservation. When an archeological site

is, or may be, involved, the regional office is notified. In the case of Desert Hot Springs this is the Archeological Research Unit at the University of California, Riverside. Depending on the nature of the project sometimes only literature searches may be adequate, other times an on-site archeological survey must be performed. Desert Hot Springs already has several archeological sites listed in the National Register of Historic Places. Because of this, an archeological survey would undoubtedly require some field work.

To comply with the requirements of federal and state agencies responsible for preserving historic and archeological places, a project in Desert Hot Springs must include in any environmental impact report, either an EIR or an EIS, an analysis by the University of California, Riverside, Regional Office. Their findings will be reviewed first by the State Office of Historic Preservation and then by the National Advisory Council if the project must write a federal environmental impact statement, and by only the State Office of Historic Preservation if the impact report is written for the state. Native Americans will also be consulted. There is no legal stipulation requiring agencies to comply with the findings of these historical agencies, however most do. National Advisory Council Procedures are contained in 36CFR PT800 and should be fully complied with prior to conclusion of the NEPA process for any federal undertaking.

1.2.2 Additional Review Agencies

Other agencies which may be interested in reviewing the EIR or EIS written on a geothermal utilization project in Desert Hot Springs are:

- The Department of Energy - federal
- The Energy Resources Conservation and Development Commission - state
- The Division of Mines and Geology - state
- The Desert Hot Springs County Water District - local

The Department of Energy

The Department of Energy (DOE) has inherited the responsibility of promoting the development of new energy sources primarily from the Energy Research and Development Administration. DOE sponsors and promotes the development of alternate energy technologies, but does not directly regulate them. Regulation of most energy development occurs at state and local levels.

When a project receives funding from DOE, and an Environmental Impact Report must be prepared, DOE assumes the lead agency role. In Desert Hot Springs if DOE were to fund the space conditioning of a commercial enterprise, they would have the responsibility for meeting NEPA requirements. It should be noted, however, that research, development and demonstration facilities are legislatively exempt from NEPA.

The California Energy Commission

The State of California Commission (CEC) plays an active role in the siting of power plants, including the siting of geothermal power plants. Their role with respect to non-electric geothermal development is limited to review.

Like DOE, however, CEC has a more active role when a project is receiving funding from it. In this case they are the lead agency for the environmental review process. CEC would take the lead in the environmental report preparation and review process for a project receiving its funding in Desert Hot Springs.

The Division of Mines and Geology

The Division of Mines and Geology is responsible for research and resource characterization involving geophysical studies, defining resource location; evaluation of site stability; seismology, and determination of hydrological budgets. The Division's budget includes funding for resource evaluation. Resource evaluations are performed based on priorities set by the Division. The priority given any specific area may be influenced by a request from a local agency or municipality.

The City Council of the City of Desert Hot Springs has contacted the Division of Mines and Geology and requested high prioritization of a geophysical study in the Desert Hot Springs area. Timely characterization of the resources in the area may identify more development options than those which have been presented in this report.

Desert Hot Springs County Water District

It may seem unusual to classify the Desert Hot Springs County Water District as a review agency when the project under discussion is the development of geothermal resources. However, the County Water District is responsible for the potable water supply and geothermal resources in Desert Hot Springs are not potable. Potable water is distinct from geothermal water in both quality and the uses to which it is put. The water systems are as separate as the supply of energy and water in cities without geothermal resources. The systems are also separate geographically. The potable water aquifer lies on the south side of Mission Creek fault; the geothermal resources are found on the north side of the fault.

Potable, or fresh water is used for drinking, cooking, washing and other domestic uses. The geothermal water currently used in Desert Hot Springs is used for its heat content. The users of the geothermal resources are individually responsible for both the supply and distribution of the resource, whereas the users of drinking water are responsible for neither the Water District performs this service.

Because these two water systems are separate systems, the Water District has no regulations which apply to the use of geothermal resources, and does not expect to be involved in the future. However, because there is a possibility that spent geothermal water may be seeping over the fault and into the potable water aquifer, an environmental impact report on future geothermal development, especially waste water disposal plans, may be of interest to the Water District. If the geothermal resource is piped throughout the City along the same basic routes of the potable water mains, the Water District may be interested in ascertaining that these pipes are installed so as not to pose a threat to the quality of the City's drinking water supply.

2.0 Agencies with Permitting Power and Regulatory Authority

All the agencies discussed in future sections of this appendix, especially state and local agencies, will review EIS's and EIR's written on the proposed utilization projects in addition to their roles as regulatory and/or permitting agencies.

The last section of this appendix describes the roles of agencies with either permitting authority, or the regulatory power to halt development. Their scope of responsibility encompasses all phases of project development. The acquisition of use rights, well development, utilization, and waste water disposal. For clarity, the regulatory requirements are presented in a sequential order. In reality they overlap and their order varies.

Acquisition of use rights-- Bureau of Land Management,
U. S. Department of the Interior
California State Lands Commission
Riverside County Planning Department
Desert Hot Springs City 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

2.1 Acquisition of Use Rights

The first step of a development project once it has been conceptualized, is to find an appropriate site. A geothermal development project must have access to the resource. In most cases in Desert Hot Springs, the surface owner of the land also owns the mineral estate. That is, when a parcel of land is purchased, all the resources on and under that land are owned by the purchaser, including geothermal resources; if he chooses to develop them he has the right to do so. However, if the land is owned by the State of California or the federal Bureau of Land Management, leases must be obtained from these agencies and the planned uses of that land must conform to the land use plans of that agency. The State Lands Commission follows a procedure similar to the environmental review process of CEQA before granting a permit for either geothermal exploration or development. Neither of these agencies have any land holdings in the Desert Hot Springs area. (See Appendix 13 for a further exposition of geothermal resources property rights.)

On County land, land outside the city limits of Desert Hot Springs, a conditional use permit (CUP) is required before development. A conditional use permit is generally required for any development project where the county feels the impacts of the development are sufficiently indefinite without further research to warrant case by case evaluation. The conditional use permit process allows the County to review a project to identify and evaluate any significant adverse effects. The application for the conditional use permit also initiates the environmental assessment required by CEQA. Thus, geothermal development is handled no differently than any other development project. Riverside County expects to handle all future geothermal development under the Energy Element of the General Plan on a case by case basis. It does not expect to assign any overall zoning to the area allowing geothermal development without requiring a conditional use permit for each development.

The County of Riverside has a well ordinance which applies primarily to potable, or fresh water wells. The ordinance is applicable only to wells which provide water which will be used as water; it is not applicable to geothermal wells used as an energy source. It is unclear how this ordinance applies to spas utilizing the hot geothermal water. Are they using the water as water, or are they using the water as an energy source? And, who makes this determination?

Within the City of Desert Hot Springs all development projects must comply with its zoning ordinance. There are areas of the City which are zoned as open land uses. This means that all development projects must acquire land use permits prior to development. Permit applications must be filed with the City Planning Department, where they will be evaluated. Filing the application initiates the environmental assessment process in which the City Planning Department acts as the lead agency.

Siting development to conform with land use plans and existing land use, comprises the major involvement city and county governments have over geothermal development. However, by mandating well spacing and limiting the number of wells within an area, they can control the use of the resource to some extent.

2.2 Well Development

The next development phase is the well development. The agency having the greatest authority in this phase is the California Division of Oil and Gas.

The Division of Oil and Gas

The Division of Oil and Gas (DOG) has authority to regulate all well drilling operations, regardless of the use of the well. Before drilling, a Notice of Intention (NOI) to Drill a Geothermal Resource's Well, an indemnity or cash bond and the approval of the Oil and Gas Supervisor must be obtained from the regional branch of the DOG. If drilling does not commence within a year of filing, the Notice and approval are considered cancelled.

The Notice requires information concerning the location, mineral right lease, and a map showing the boundaries of the well site. The Division must know whether the mineral-rights and the surface rights coincide, and if they do not, a legal description of both leases and map depicting the leased areas must be included. Location of the well in relation to property lines must be shown; it must be indicated if the well is to be directionally drilled, the elevation of the well head above sea level must be reported and the place where depth measurements will be taken must be indicated. Additionally, the proposed casing program must be reported and, of course, the depth of the well.

The present bonding requirements for low temperature wells are as follows:

<u>Well depth</u>	<u>Bond</u>
5,000	\$10,000
5,000-9,999	\$15,000
10,000	\$25,000

Additional bond requirements are necessary for well expansion, or alteration as is a supplementary NOI.

Also, before a permit is granted, an agent must be designated, "upon whom may be served all notices and processes of the supervisor, a board, or any court of law" to represent the individual, partnership or corporation developing the resource.

The Division reviews the NOI. If a permit is granted, the permit requirements will be stated thereon. Once the drilling permit is granted a well summary is required, with the following information to be included:

- Location, name and ownership
- Depth
- Dates of drilling and production
- Geologic data
- Production test data
- Static test data
- Casing record

The well history must also include, "a full account of all important operations during the drilling and testing of the well or during redrilling, permanently altering casing, plugging, or abandonment, with the dates thereof." Hole size, formation test details, volumes of cement used, top and bottom of plugs, perforation details, side tracked junk, bailing tests, shooting and initial production data and zone temperature all must be reported in the well history.

The DOG requires well log information on each well. During the well's production life, a Monthly Geothermal Resources Report must be submitted to the DOG. The number of wells producing, idle or shut-in, completed or abandoned during the month is reported by the well operator or owner in the Monthly Geothermal Resources Report to be submitted to the DOG. Failure to do so is a misdemeanor, California Public Resources Code 3745.

The monthly report is to contain the following information:

Total mass produced	Flow temp.
Dry steam produced	Flow pres.
Water produced	Method of operation
(If no mass produced) Gross energy produced	No. of days well produced
Minerals produced	If well not producing, state reason

If the well is a reinjection well, a different reporting form is required. The information requested is the number of days the well injected, the volume injected, the surface injection pressure, the Packer depth, the source of water, kind of water, or the reason the well is not injecting. The pressure used to reinject water cannot be above 0.8 lb/ft of well depth. Any pressure above this would create springs, which the DOG would like to prevent.

To abandon the well, a Notice of Intention to Abandon Well must be submitted to DOG. Information required includes the name and number, location, present condition of the well, and when it last produced. For a dry well additional information is requested such as the bottom hole temperature, maximum temperature and its depth, the stratigraphic markers and their depth, the formation and age at total depth and the depth of the base of fresh water sands. Finally, the proposed work to be done to abandon the well must be described.

For each of the above described activities, there is a form on which all the required information must be provided.

The DOG also reviews EIR's or Negative Declarations on any projects involving well drilling. If the DOG determines that well development in any particular project does not comply with their regulations, they can deny permits to that project and halt development.⁵⁹

The Solid Waste Management Board⁶⁰

The State Solid Waste Management Board (SWMB) has authority over the disposal of solid waste generated by municipalities and development projects in the State of California. Their main concerns are the proper disposal of solid wastes to prevent the creation of health hazards, eyesores, and pollution.

In regulating geothermal development, SWMB permits drilling sumps. During well drilling, a lubricant consisting of a loose mud, often graphite mud is used to prevent the drill bit from becoming stuck. When the well is complete, this mud is extracted and must be disposed of. The site of disposal is called a drilling sump.

Presently, there are two permits which must be granted by the Solid Waste Management Board, for drilling sumps. Under SB 1797, the Solid Waste Board can only grant a permit for drilling sumps if the proposed sump conforms with the County's Solid Waste Management Plan. However, legislation has been enacted which will enable drilling sumps to be exempt from this requirement as soon as the administrative code is amended.

The second permit required is called a Facilities Permit and is the result of AB 2439. The State Solid Waste Board designates a county agency, usually the County Health Department, to administer this permit. Upon application, the designated County department sends a copy of the application (which is a state form) to the Solid Waste Management Board for review. When the permit form returns to the county department, the county department draws up the conditions of the permit, incorporating the state's comments.

In Desert Hot Springs, the application for a drilling sump permit is received by the County Solid Waste Management Facilities Agency.⁶¹ They are responsible for administering the permit conditions once they are approved by the State Solid Waste Management Board.

The Air Resources Board⁶²

The State Air Resources Board (ARB) is charged with protecting the quality of the air in the State of California. To implement this charge they have adopted standards for the emission of major pollutants as defined by the Environmental Protection Agency (EPA). The major pollutants controlled by the ARB and their current allowable levels of emission are:

	<u>lbs. per hour</u>
Nitrogen oxides (NOx)	15
Organic oxides	15
Particulate Matter	15
Sulfur oxides (SOx)	15
Nonmethane hydrocarbons	15
Carbon Monoxide (CO)	150

The allowable levels of pollutant emissions listed above are much lower than the levels of these same pollutants allowed by the EPA for the remainder of the United States. If the new source releases 15 lb/hr or more of the first four pollutants listed above, and 150 lb/hr or more of CO, that source must use the best available pollution control technology in order to operate. That is, if the polluting source is unable to lower its levels of these pollutants he must be using the best currently available pollution control devices or practices, to commence operation. However, if the pollution source releases more than 25 lb/hr of the listed pollutants and 250 lb/hr of CO, even if using the best abatement, or pollution control control equipment, a "new source review" assessment must be performed. A new source review consists of an air quality analysis to determine if the pollution source is producing higher levels of pollution than the federal standards allow. If this is the case and there are no mitigating circumstances, an operating permit can be denied.

With respect to well development, the ARB is primarily concerned with the emission of Hydrogen sulfide. If the emissions exceed 0.03ppm/hr, the ARB makes a determination whether the emissions should be controlled and to what level. Emissions lower than this level are only of concern if a complaint is filed to the effect that the emissions are a public nuisance. The geothermal resource in Desert Hot Springs does not produce H₂S in quantities exceeding 0.03 ppm/hr.

Desert Hot Springs is very close to Joshua Tree National Monument which has air designated as clean. This means that developments on its borders capable of polluting the air are carefully regulated. At the same time the pollutant levels of particulate matter and oxidants exceed the national standards, because of the proximity of Los Angeles. These two factors make air quality in the Desert Hot Springs a very sensitive issue.

2.3 Utilization

Once the right to use the land for geothermal development has been obtained, and the well to bring the resource to the surface has been permitted, permits and regulations controlling the facilities which use the resource must be obtained. To some extent the City and County approve the use facility when issuing a conditional use permit, but aspects other than land use may require permits.

Air Quality

Since air quality in the Desert Hot Springs area may be a sensitive issue, development projects may be evaluated more carefully with respect to their impact on the air quality, than in other areas with less sensitive air quality. The Riverside County Planning Department does not feel it is likely that a generic environmental impact statement will be prepared for the Desert Hot Springs area which would encompass all future geothermal development there.⁶³ This means environmental impact reports on every development project will address the impact of that particular project on air quality, but no one will examine the total impact on air quality from all development projects combined. No analysis will be done of possible secondary impacts (such as increased traffic), that new development may cause, either. However, because of the sensitivity of the air quality issue, the South Coast Air Quality Management District (SCAQMD) may choose to take such a broad viewpoint in regulating the area's air quality. In that case the responsible planning agency either city or county may have to prepare a generic EIR on the air quality effects due to future geothermal development.

The SCAQMD is a regional agency with responsibility for air quality in the southern California area. Because of the large population and numerous pollution sources in this region, this agency is very familiar with complex air quality management problems. They have set standards for the major pollutants which are similar to ARB's standards.

The SCAQMD is the issuer of National Pollution Elimination and Discharge Permits (NPEDP) permits. The requirements for this permit are:⁶⁴

Filing fee - \$25.00

Rule 202 Permit to Construct - will act as a permit to operate until the permit to operate is granted or denied
- expires within 2 years.

Rule 203 Permit to Operate - application will expire within 2 years unless extension time has been approved by APCO and must be renewed annually.

Rule 206 Permit to Operate must be posted.

Additionally, the initial permit fee for the issuance of a Permit to Operate must be paid according to the following schedule. - For each ton of air contaminants in excess of 24 tons per year for any of the following air contaminants:

SO₂
Organic Gases
NO₂
Particulates

and in excess of 249 tons per year for carbon monoxide shall be assessed a fee as set forth in the following schedule:

<u>Air Contaminant</u>	<u>Dollars per ton</u>
Total organic gases	\$12
Carbon Monoxide	\$0.10
Nitrogen dioxide	\$7
Sulfur dioxide	\$8
Particulate Matter	\$9

It is not expected that any of the herein identified development projects in the City of Desert Hot Springs would exceed the regional, state or federal air quality standards. However, if the SCAQMD chooses to evaluate all future development as a single entity, then the combined air contaminants of all the possible development projects must be assessed. Given the time period required for reaching a significant level of increased utilization, this is highly unlikely. Also, this decision may be taken out of the purview of the SCAQMD by a recent amendment to the Clean Air Act.

The Clean Air Act was amended in 1977 to encompass the Prevention of Significant Deterioration (PSD). The purpose of the PSD requirement is to prevent air now clean, from becoming polluted. The introduction of industry into an area which has formerly been undeveloped industrially or commercially will degrade the air quality even if this industry is conforming to the emission standards described above because not all emissions are controlled. This is what PSD is meant to prevent.

To implement the PSD requirements clear air must be defined. The wording used in the amendment calls clean air "pristine". The method of determining whether an area's air is pristine or not is unclear as is the definition of pristine itself. These ambiguities arise from the newness of the PSD concept in the Clean Air Act. Ideally, an area wishing to implement the PSD requirements must have its air designated pristine by EPA, and by state and regional air quality control agencies once they adopt PSD requirements themselves.

Because of its recent addition to the Clean Air Act, PSD has only been adopted by EPA. It is anticipated that California's air quality control agencies will adopt PSD requirements in the near future. Until then, PSD requirements will be under the sole authority of EPA; once adopted by other agencies, PSD will be implemented by them.

In February 1978, another amendment to the Clean Air Act took effect. This amendment stipulates that not only new sources which are known to emit excessive quantities of the five major pollutants should be controlled, but that new sources with the "potential" to emit excessive quantities of the five major pollutants must be controlled.

Implementation of PSD requirements in Desert Hot Springs depends on how the air there is classified. It will be especially applicable if the development of geothermal resources in the City attracts new business and more people to the area. This would increase the pollution in the area from many different sources, but would only be important if geothermal development were viewed holistically instead of incrementally. The high levels of oxidants and particulate matter in the air already may prevent classification of the air as "pristine".

Agriculture and Aquaculture

Several utilization options involve the production of a product for human consumption. These options are the heating and cooling of greenhouses, and the use of geothermally heated water to raise fresh water prawn, or shrimp.

The Food and Drug Administration⁶⁵

The primary concern of the Food and Drug Administration (FDA) is to protect the public from harmful substances in the food they consume. Their authority is derived from the Food, Drug and Cosmetics Act. In administering the Act, they routinely inspect food processing and handling plants and food products involved in interstate commerce. Additionally, they respond to complaints of unsanitary or contaminated conditions. In most cases, when conditions are unsatisfactory, the FDA recommends that corrective measures be taken. However, if the violation poses a real threat to the health, safety and welfare of the public, legal proceedings of seizure, prosecution and injunction may be initiated.

The involvement of the FDA with the agriculture and aquaculture operations proposed as options for geothermal utilization in Desert Hot Springs would be focused on the quality of the final product. They would become involved if, and only if, the prawn and/or cucumbers proved detrimental to human health when consumed. The FDA's role would be no different for a geothermal operation than for a conventionally powered system.

In neither case is the food product expected to come into direct contact with the geothermal water.

In both the case of the greenhouse and aquaculture, the permitting requirements are not the result of utilizing geothermal water, but are inherent in the uses themselves. Once a land use permit is obtained for a greenhouse, there are very few regulatory requirements which must be met. There are requirements of the FDA for labeling the produce boxes correctly, routine building permits must be obtained, there is little agricultural waste water because drip irrigation is used in most cases, and the water is absorbed into the ground with very little runoff. The labor regulations must be followed, and the use of pesticides is regulated by the California State Department of Agriculture.

The regulatory requirements for aquaculture are more complex but many of the regulatory requirements on aquaculture operations near the coast would not apply to operations inland. Some of the agencies which might be involved in the regulation of aquaculture operations which would not be involved in any of the other utilization options are:

U. S. Department of Commerce
National Marine Fisheries Service,
Fish and Wildlife Service, U. S. Dept. of Commerce
U. S. Department of Agriculture

The involvement of these agencies is not direct regulation; Aquaculture operations cross their lines of jurisdiction, thus they are legally responsible. The impacts associated with aquaculture are still relatively unknown, and it is unlikely that any of these agencies are very knowledgeable about it; even more unlikely is that they have or will have regulations specific to aquaculture. As aquaculture becomes more established, many of these agencies may be eliminated from the list of those having jurisdiction over it, and regulation will be concentrated in one of them or a new agency or branch may be created.

Department of Fish and Game ⁶⁶

One agency with direct permitting authority over aquacultural operations in the City of Desert Hot Springs is the State Department of Fish and Game (F & G).

To initiate an aquaculture operation to raise fresh water prawn, an application for a fishbreeders license must be submitted to the regional branch of F & G for approval. In the case of Desert Hot Springs, this is in Long Beach. The entire aquaculture system must be described. Fish and Game is primarily interested in preventing the spread of exotic organisms into water bodies where they could disturb the ecology. Usually, the permit is granted from analysis of the application. If there is any question, a warden will perform a site inspection. Fish and Game requires inlet and outlet screens to prevent organism migration. This is not expected to be a problem with the Desert Hot Springs aquaculture proposal. Additionally, the species to be raised must be approved by the Department. The species of prawn considered by this study is an approved species. Once the application is approved, a Stocking Permit and Fishbreeders license will be granted. To transport the prawn, a transportation permit must be obtained but again in Desert Hot Springs this is not anticipated to be a problem.

Space Conditioning

Other utilization options of the geothermal resource in Desert Hot Springs include space conditioning. That is, the heat from the geothermal water will be used for air conditioning in the summer, and heating on cold winter nights. The most probable option to be implemented is the space conditioning of the City Hall-- Library Complex. The City Hall and Library are located across the city from the hottest geothermal resources. This will require piping the resource across the City underneath the streets, or along the easement of sewers. Depending on their location, other utilization options may also require piping the resource.

The State Department of Health as well as local health departments are concerned with water quality with respect to its suitability as public drinking water. Waste discharges must be prevented from contaminating potable water supplies. With regard to geothermal resource development, health departments are interested in the manner the resource will be transported and disposed of so that potable water will not be contaminated. The quality of the geothermal water in Desert Hot Springs is not significantly lower than the quality of water in the potable water supply, however the total dissolved solids in the geothermal water are high enough that the Water Quality Control Board prevented its disposal into the municipal wastewater treatment facility. In particular, health agencies want to prevent cross-connections between potable water lines and pipes transporting geothermal water around the city.

Siting geothermal development projects and the placement of pipelines crossing the city will be of some interest to the Department of Fish and Game. One of their charges is to protect stream channels from disruption. Disruption includes anything from crossing the channel to releasing toxic chemicals into it. A project which involves a stream channel must submit a Notification of Action to the Department. Within 30 days, the Department must respond with recommendations. If the project does not comply with Fish and Game regulations, the issue is submitted to an arbitration panel, however, this is an infrequent occurrence.

Fish and Game is also concerned with a project's possible impact on water supplies which support wildlife areas. A project will only be satisfactory if in utilizing an area's water supply which supports wildlife, an equal quantity and quality of water be supplied to wildlife habitats by some other means.

If percolation or settling ponds are used to dispose of wastewater, the Department of Fish and Game requires it be treated to remove all toxic materials.

All the utilization options will require building permits, may involve the City's Department of Public Works for pipelines, may require easements for pipelines that cross private property, and other compliance with City regulations. These departments require specific project descriptions before their requirements can be determined. This analysis only attempts to identify the major regulatory and permit requirements for several development options considered, so the City of Desert Hot Springs and other cities interested in developing their geothermal resources would have a general picture of the types of agencies they would be required to contact, and the scope of the permits and regulatory requirements which must be met. The regulations herein discussed are neither comprehensive nor exhaustive.

2.4 Disposal

Disposal of the geothermal wastewater is another aspect of geothermal development all the utilization options share. An inadequate waste water disposal plan can prevent a project from acquiring permits. The agencies involved in permitting the disposal phase of geothermal development are the State Water Resources Control Board, and the Regional Water Quality Control Board.

The State Water Resources Control Board (WRCB)⁶⁷ sets the standards which the Regional Water Quality Control Boards (WQCB)⁶⁸ implement. Actually the two agencies act as one in many respects. The regional agencies tend to be the enforcement and administrative branch, while the State agency sets the policies and oversees the actions of the regional agencies.

The Environmental Protection Agency (EPA) has powered the State board to act as its agent in reviewing and granting National Pollution Elimination and Discharge Permits (NPEDP), authority which the State Board has in turn delegated to the regional boards to implement. The State Board has also been responsible for setting groundwater discharge requirements. Recent legislation indicates that EPA may be assuming a larger role in this area. The EPA is in the process of publishing guidelines on the discharge of waste into geologic strata. When these guidelines are available they will supersede the regulations of the state and regional water boards until the time when these boards adopt and implement guidelines of their own, following the federal guidelines. It should be noted that under the Supremacy Clause of the U. S. Constitution, the federal government has the authority to preempt jurisdiction over matters deemed to be of national concern. Areas not specifically preempted are the responsibility of the States to regulate.

Development projects in Desert Hot Springs must comply with the regional Water Quality Control Board's regulations prior to commencing operations. The regional WQCB requires any proposed project which will discharge liquid wastes to file a Report of Waste Discharge before commencing construction. A filing fee for this report of between \$100 and \$1,000 is charged as a function of the proposed quantity of waste to be discharged.

The Report of Waste Discharge contains the project's plans for discharging their liquid wastes describing quantity, quality and method. The WQCB analyzes the Waste Discharge Report and may require more information to be provided. When they have completed their analysis, the WQCB adds its recommendations and sends it for review to other agencies. Some of the agencies who review Waste Discharge Reports are:

- State Water Resources Control Board
- State Department of Health
- State Department of Fish and Game
- State Geologist
- County Health Department
- County Agriculture Department
- Local Water Districts

These agencies have approximately six months to comment to the WQCB. After the close of the comment period, the WQCB conducts a hearing wherein the public is given an opportunity to comment on the waste discharge plans. Following this they notify the applicant of the adopted waste water discharge requirements, the conditions under which a permit is granted.

The basic policy of the Water Quality Control Boards in the State of California is one of nondegradation. This means, in practice, that any liquid wastes disposed of into a water body, be it a lake, stream, pond,

or underground aquifer, must be of equal quality to that water, or proven to be suitable for the uses that particular water body is serving. There are several ways waste water may be disposed of in Desert Hot Springs. Each of these alternatives will have to be evaluated by the WQCB to determine the method of disposal which best conforms to their nondegradation policy.

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

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

In Desert Hot Springs municipal wastewater is percolated following treatment. The geothermal waste water from the health spas was disposed of in the municipal wastewater system until the WQCB determined that the salinity of the geothermal fluids had the potential for increasing the salinity in the aquifer underlying the percolation basin. Geothermal water can no longer be disposed of in the municipal wastewater system. This does not mean that a suitable location for a percolation basin to dispose of geothermal water cannot be found in the Desert Hot Springs area.

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

Even though disposal of geothermal fluids in the municipal wastewater system has been curtailed in Desert Hot Springs, at the present time a new disposal system exclusively for geothermal water is, according to the WQCB, unnecessary.⁶⁹ However, with expanded use of the resource, disposal may become a problem. It was hypothesized that with future development the WQCB may require centralized disposal, but the WQCB at this time sees future regulation of geothermal disposal as an individual

developer's responsibility. If centralized disposal is required at some point because complex disposal requirements cannot adequately be met by individuals, implementing a central disposal system would probably be the responsibility of the City of Desert Hot Springs.

APPENDIX 11

ENVIRONMENTAL IMPACT
ASSESSMENT

1.0 Introduction

The purpose of this analysis is to identify any significant adverse environmental factors which may result from the implementation of any of the proposed demonstration projects at DHS. The applications currently under consideration and the mode of geothermal use are shown in Table 1. Once the anticipated environmental impacts of the various alternatives are portrayed, it will be possible to recommend reasonable mitigating measures. The goal of this exercise is to provide input for the selection of one of the projects which will then undergo the next step in the evaluation process. Other factors entering into the selection procedure are social, legal, institutional, economic, and design constraints.

The project selected will hopefully be the one which presents the smallest potential for unavoidable adverse environmental impacts. At the current point in the DHS study, none of the alternative geothermal uses are beyond the conception stage. Therefore, the environmental evaluation is a generic or qualitative assessment based upon a survey of what is known about the characteristics of the DHS area as well as what has been gleaned from various published reports and from experts on the development of geothermal energy. Furthermore, at such an early stage, it is wiser to address categories of projects rather than the individual applications themselves. The reason for this is that not enough information is currently known to be able to produce a specific environmental ranking for each proposal. Therefore, the environmental analysis at this point in the DHS study is devoted to major areas of impact for the project categories.

2.0 Major Categories of Environmental Impact

The current understanding of geothermal resources and their non-electric uses indicates that the major areas of environmental concern relate to factors which:

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

Site specific factors would be those that are particular to the Desert Hot Springs area itself. These would include the nature and location of the geothermal resource as well as the location of faults, zoning restrictions, and pertinent historic sites. The second factor relates to the implementation of the specific projects. In this context, it is obvious that retrofitting an existing operation to geothermal use would have a much lower potential for creating adverse environmental impacts during construction than a project which must be entirely planned and built. The third major area of concern is the use and

TABLE 1
DESERT HOT SPRINGS
CANDIDATE APPLICATIONS - GEOTHERMAL USE

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

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

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. There also exists on the positive side a chance to substitute a "clean" source of energy for fossil fuel and, on the negative side, some potential for creating additional subsidence activity.

The remainder of this analysis will characterize the geothermal resources at DHS as well as other important site specific factors. It will address the most important adverse environmental impacts of the several project categories, as well as the potential geothermal problems relating to the use of the resource itself. A discussion of possible mitigating actions will also be presented where appropriate.

2.1 Important Site Specific Factors

2.1.1 Characterization of Geothermal Resources at DHS

The minimum temperature needed for any of the applications (the aquaculture option) is about 90°F. Therefore, the extent of this isotherm for the DHS geothermal aquifer has been identified. It extends from the central portion of DHS southeast to the vicinity of Dillon Road (see Figure 1). This area which covers about 5.45 square miles contains two hot anomalies. One is at the eastern side of DHS in the vicinity of the Angel View Children's Hospital. This portion of the geothermal aquifer exceeds temperatures of 150°F. The other anomaly is near Dillon Road. Its temperatures are known to exceed 130°F.¹³

The geothermal aquifer lies north of the Mission Creek Fault which cuts through the center of DHS from northwest to southeast. The City's potable water supply generally lies south of this fault. The geothermal water is tapped by drilling a well down to the source and then by pumping it or a heat exchange medium to the surface, where it is used directly or indirectly. Care must be taken in locating the extraction area so that unstable foundation conditions or landslide prone areas are avoided. Natural seismicity is normally associated with geothermal resources, so the potential active faults should also be delineated and avoided.⁷⁰ However, this may not be so important at DHS since the geothermal aquifer is not very deep.⁷¹ If recharge of the aquifer is to take place after use, the best area for doing this is north of the Mission Creek Fault so that the City's potable water which has lower concentrations of total dissolved solids, fluoride, chloride, and sulfates, is not contaminated. The Blind Canyon area on the northeast side of the City currently appears to be the optimal location for disposal of water withdrawn from the hot area in DHS.¹³

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

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

2.1.2 Zoning and Historical/Archeological Considerations

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

The area surrounding the hot anomaly in DHS is primarily zoned residential. Exceptions to this are a commercially zoned area just to the west of the hottest resource up and down Palm Drive and another small commercial location at the western end of the anomaly at Hacienda Avenue (see Figure 1). The nearest industrially zoned site is about 1/2 mile south of the hot spot, east of Palm Drive.⁷² However, it should be noted that large portions of undeveloped land are near enough to the hot area in DHS that there should be no trouble in placing any of the proposed applications. Furthermore, the DHS Planning Director has indicated that planning restrictions should be no major problem within the City providing the chosen application has the necessary permits.⁷³

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

The last important site specific consideration is the presence of archeological or historical sites. Eight such potential sites have thus far been identified in the DHS vicinity.⁷⁴ Only two of these are within the 90°F isotherm. One was a major occupation site and lies just south of the hottest area in DHS. It contains manufacturing waste, food remains, tools, facilities, and human remains of the Desert Cahuilla. It is eligible for inclusion on the National Register of Historic Places. The other site is an aboriginal trail south of the Dillon Road area. If the first site is intruded upon by any construction, compliance with the California Environmental Quality Act may be necessary which could cause time delays. The site south of the Dillon Road area is not as important and is located in an open area where there should be no placement conflict. It must be noted, however, that only about five percent of Riverside County has been surveyed for historical sites. Therefore, the services of an archeologist would probably be necessary for any construction undertaking.⁷⁵

2.2 Placement of Proposed Applications

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

The fact that some of the proposed applications' facilities already exist could alleviate some siting problems. The Angel View Clinic, City Hall, library, mobile home parks, and various spa-tels already exist in DHS. These facilities would have to be retrofitted for geothermal use. The clinic and several spa-tels are located over the hot geothermal source in DHS. There they would be able to use the hottest possible water. Pipes from the source to the user would cause minimal, if any, impacts. Any accidental geothermal water losses would be minimized, since the piping distance would be so small and since these facilities are north of the Mission Creek Fault. There would be no large problems of tearing up main thoroughfares or of violating any channels. These facilities also lie in the vicinity of Blind Canyon so they are near the optimal water disposal site, should recharging of the geothermal aquifer be undertaken. There are also several spa-tels at the Dillon Road site which would be in a similarly favorable location. It should be noted, however, that there is some flooding potential at Dillon Road.⁷⁶ The construction of a small dike around a facility there would mitigate any potential flooding problem. There are also several mobile home parks near the Dillon Road area, which aside from the minor flood potential, lie in a fairly good location for utilizing and disposing of the geothermal resource.

The City Hall and library lie one mile from the DHS hot anomaly. Therefore, transport of the heating medium to and from this site could result in thermal inefficiencies. However, since this option does not include cooling, the thermal losses should not be a very critical factor. This site is south of the Mission Creek Fault, and any accidental geothermal water losses may wind up in the potable water aquifer. It would require piping from the source and possibly to the disposal area that would disrupt Palm Drive and Pierson Blvd. during construction. Of the facilities which already exist, the location of the City Hall and library appears to be not as favorable for geothermal use as some of the other options from an environmental viewpoint.

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

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

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

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

TABLE 2.

DESERT HOT SPRINGS

CANDIDATE APPLICATIONS - SITING CONSIDERATIONS

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

2.3 Applications of the Geothermal Resource

The use of the geothermal resources by the proposed applications can be categorized in two ways: (1) direct use of the hot water in a proposed operation or (2), indirect use of the resource by transferring its heat to other mediums. The proposed applications fall into either of these categories or some combination of the two as shown on Table 1.

2.3.1 Indirect Uses

The indirect uses can be differentiated into several categories such as space conditioning (which includes air heating and cooling), water heating, air heating, or cold storage.

Heating can be generally accomplished by retrofitting forced air systems in those facilities which already exist. In those facilities which are still in the conception stage, a heat exchange system can be implemented. In transferring the heat from the source to the user, the geothermal water or transfer fluid would be piped to the use site.¹³

Cooling would be implemented by the use of either absorption-type coolers or an organic Rankine engine. There are two types absorption cooler systems under consideration; the ammonia-water combination and the lithium bromide-water combination.¹³ In the first, water (not the geothermal water) acts as the absorbent, and cooling ammonia is pumped from the source to the user site. This presents the potential hazard of toxic ammonia escaping into the City if a mechanical failure occurs. The lithium-bromide water combination, in which water acts as the refrigerant is presently under more favorable consideration. Lithium-bromide would be harmless if released, and its cycle is not as complex. Water would be piped, possibly under main arterials, to the user as opposed to ammonia in the first system. The present trouble with using the lithium-bromide absorption cooler system is that its efficiency is quite low (less than 50 percent) at the temperatures currently known to exist at the two hot areas. It may be possible to improve this situation by drilling for hotter water at lower depths. The organic Rankine engine coupled with a conventional vapor compression unit would be used for producing liquid refrigerant at the site which would then be transported via distribution piping to the user.¹³ The use of such a system for cooling is quite unlikely, however, due to high production costs. In evaluating heating and cooling systems, it should be considered that if a specific option will only use heating and not cooling, such as in the City Hall/library, then the quantity of geothermal water needed is reduced, especially in the summer. Furthermore, if cooling is not included in an option, then temperature requirements of the specific use are also reduced.

2.3.2 Direct Uses

The only proposed application which would directly utilize the geothermal water with no indirect use is the aquaculture operation for the growing of Malaysian prawns. The system under consideration is a covered raceway which would be the equivalent of a one to five acre pond. The raceway would require less area than the pond but

would be several layers deep so that the same quantity of shrimp could be grown. Since it would have a smaller surface area exposed than the pond it is more energy and waste treatment efficient. The optimum aquaculture temperature is considered to be 85°F. The geothermal water to be used in the raceway would be mixed with a sufficient supply of cooler water already in it, so the resultant temperature of the entering water would be approximately 85°F-90°F. One obvious benefit of the raceway system relates to site placement which was discussed earlier.

2.3.3 Combination Uses

The remaining applications refer to both direct and indirect uses of the geothermal resources. These applications include the agribusiness operation, the mobile home park, and the spa-tel application. The agribusiness system would consist of the greenhouse option in conjunction with using the effluent geothermal water for irrigation purposes. The mobile home park would involve space conditioning and water heating for 100 units plus use of the effluent in a swimming pool. The spa-tel application would involve space heating and cooling as well as direct use in a spa pool.

2.3.4 Environmental Impacts Arising From the Utilization of the Geothermal Water

Environmental impacts arising from indirect use of the geothermal resource are not a major consideration since the heat properties of the water are transferred to some other medium. As discussed earlier, if the ammonia-water absorption cooling system is used, there is a possibility that toxic ammonia could be piped under the City's streets, in some cases as far as one mile. If an accident were to occur and the pipe broke, a hazard to the community could result. The lithium bromide-water system would not present such a problem. The other environmental consideration of note arising from indirect use would occur when potable water is used as the transfer agent for the geothermal heat. If an accident were to occur, the geothermal water might contaminate the potable water. Also, if there is an accidental release of geothermal brine and the project is located south of the Mission Creek Fault, the potable aquifer may be affected. Proper planning and design of any project should minimize the possibility of either of these two accidental intrusions from occurring. It should also be remembered that the closer the user is to the source, the smaller the chance of accidents since there is less machinery and piping to maintain.

The geothermal water's chemical composition is of concern when it is used directly. This aquifer has concentrations of total dissolved solids, fluoride, chloride, and sulfates which make it unacceptable for disposal into the City's sewage system. The concentrations of these chemicals are safe but are close to borderline levels. For instance, if fluoride levels were any higher, than the prawns developed from the aquaculture operation might be unsaleable.¹³ There is also some doubt as to whether the radon levels of the geothermal water are of a background nature or not. What is needed in the aquaculture option is a bioassay to determine on a pilot project basis, whether the water is of quality good enough to successfully raise the prawns.⁷⁷ If not, it might be possible to treat the water before it is fed into the aquaculture facility.

In the case of the irrigation use in the agribusiness operation, high levels of boron or fluoride can adversely affect edible and non-ornamental plants.⁷⁸ The current boron levels are probably low enough so as not to present a problem. It may be possible to precipitate fluoride out of the water by using a soil that is high in calcium. It may also be possible to grow plants such as palms which are not susceptible to fluoride.

The last direct use would be in spa pools in either the spa-tel or mobile home park option. There do not appear to be any adverse effects from swimming in the geothermal water. In fact, many of the City's residents have cited the beneficial health effects arising from bathing in the water. This is the primary reason for the abundance of spa-tel and clinic establishments in Desert Hot Springs.

In conclusion, the major environmental intrusions resulting from indirect use would be accidental contamination of potable water supplies with geothermal water, or if ammonia-water absorption cooling systems are used, the accidental release of ammonia would create a potential hazard. In the direct use options, further tests are probably needed to determine the possible adverse effects of the geothermal water on either the aquaculture or irrigation options.

2.4 Disposal of the Geothermal Fluid After Use

This last section will address the various available options for disposing of the geothermal fluid after use and any attendant environmental consequences. If the geothermal resources are used for heat exchange in situ, the environmental impacts arising from this use would result only from well drilling and construction of the selected project. There would be no disposal to consider since the geothermal water would not be removed from the ground. This type of use could only be applied to the options which call for indirect uses. If the geothermal water is extracted from the ground but is still used indirectly the potential environmental problems could increase during accident conditions such as by contaminating the potable water supply. Further, disposing of the water after use must be addressed. This also applies to direct uses, although in the direct use options potential environmental hazards during use are greater. The presently available disposal systems fall into two broad categories; the first where the geothermal aquifer is not recharged and the second where it is. Options falling into the first category are disposal into the City's present sewer system or evaporation from ponds, while options in the second category include percolation or reinjection. The decision of whether or not to recharge deserves careful consideration, since, if recharging is decided upon, the costs of implementing any option may increase greatly. It has been calculated that the amount of water used in any of the

candidate applications will be within the safest safe yield of the geothermal aquifer. This means that the geothermal aquifer is naturally recharged at a rate greater than at which water is removed. Therefore, recharging the aquifer with water extracted for project use should not be necessary. However, it has also been indicated by the consulting geologist for DHS that subsidence is presently taking place. This is due to the fact that underground fluid pressures have been reduced and have drawn down the water table, thereby causing settling in DHS.⁷¹ This may be occurring because much of the geothermal water presently extracted is not returned to the aquifer. If this is, in fact, actually happening, it would be necessary to recharge the aquifer through reinjection or percolation, so that the subsidence phenomenon would be minimized.

Reinjection of geothermal water used indirectly would create the fewest physical changes in the aquifer since it would always (barring accidental release) be within a closed system. However, a reinjection location must be chosen carefully so (1) as mentioned earlier in the environmental analysis, the aquifer is indeed recharged, and (2) so that the thermal content of the extracted water is not lowered by the cooler reinjected water. This second constraint would probably apply to the location of other present users of the geothermal resource as well, so that siting the reinjection well would become doubly important.⁷⁹ Therefore, reinjection in a good recharge site such as the Blind Canyon area would be best. It might be possible to set up several reinjection wells so that the existing geothermal users could also make use of them on a communal basis. This could solve all present and future disposal problems.

Percolation ponds can also be used to recharge the geothermal aquifer, or the effluent can irrigate crops in a field that is arranged so that the water recharges the aquifer. However, some water will evaporate during percolation. This will become the concentration of pollutants in the water such as total dissolved solids. There are nondegradation laws which prohibit the addition of water to any water body which is of better quality. The same problem would also arise in the case of directly using the resource and then reinjecting it. In fact, if reinjection is applied to the aquaculture option, the water would have high levels of ammonia and waste products, in addition to the concentration of pollutants through evaporation. It may, therefore, be necessary to treat the geothermal water before it is used for recharging.

If, however, after investigation by qualified experts, there does not prove to be a subsidence problem, it would be possible to add the geothermal effluent to the City's sewage system or evaporate it from ponds. The sewage disposal option contains some problems, however. Since the geothermal water is too high in total dissolved solids, fluoride, chloride, and sulfates as compared to the City's potable water,⁸⁰ its disposal in the sewage system is currently prohibited. Therefore, the water would have to receive

some treatment before entering the sewage system. This is also the same reason why care should be taken to make sure that if water losses occur they should be confined to the north side of the Mission Creek Fault, since most of the City's potable water supply lies south of the fault and could become contaminated. The other available alternative for water disposal if recharge is not undertaken is to let it evaporate from several large ponds. These might require a large land area as would percolation ponds. However, as indicated earlier, there is much unsettled land in the DHS area. A possible benefit arising from the use of ponds could be the design of a future park encompassing them.

Table 3 presents the most important environmental problems to be faced with the various disposal options. Where an entry is not filled in, the particular disposal option could not be utilized with the specific application. For instance, the agribusiness includes direct irrigation of crops. The water would then percolate through the soil to the aquifer. This would eliminate disposal options such as reinjection or evaporation. The only two entries on the matrix which would probably create no concern are indirect uses coupled with reinjection or in-ground heat transfer. This does not mean that any other combination is not feasible. Just that some mitigating measures may be necessary. Any chosen project must be carefully planned so any potential disposal problem is solved or mitigated before a project is implemented.

3.0 Conclusions

The conclusion of the environmental analysis is that some applications appear to present somewhat more obstacles than others. However, there are no major problems currently foreseen for any application which would prohibit implementation from an environmental viewpoint. The best way to mitigate potential problems and keep any unforeseen obstacles from arising would be to take utmost care during the planning stage. It will probably be necessary to retain the services of a hydrologist, a geologist, and in the case of new construction, an archeologist so the correct choices are made before any money or construction effort is wasted and so that all regulatory agencies are satisfied.

TABLE 3

DESERT HOT SPRINGS

DISPOSAL AFTER USE - POTENTIAL ENVIRONMENTAL PROBLEMS

	<u>INDIRECT</u>	<u>AQUACULTURE</u>	<u>AGRIBUSINESS</u>	<u>MOBIL HOME PARK/ SPA</u>
IN-GROUND HEAT TRANSFER	NONE	-	-	-
REINJECTION	NONE	WASTE, TDS, NH_3	-	TDS (?)
PERCOLATION	TDS	WASTE, TDS, NH_3	TDS	TDS
EVAPORATION	SUBSIDENCE	SUBSIDENCE	-	SUBSIDENCE
SEWER SYSTEM	TDS, SUBSIDENCE	TDS, NH_3 , SUBSIDENCE, WASTE	-	TDS, SUBSIDENCE

APPENDIX 2

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.

A number of assumptions must be made before considering the four scenarios presented in detail below. The first assumption is that the City must operate within the structure of existing property rights. A number of cases are currently being adjudicated in California to define the exact nature of geothermal resources. The debates center around whether the geothermal resource is part of either the mineral estate or the water estate of any given parcel of land. Most theoretical work argues that the geothermal resource is uniquely heat, and therefore, the property rights scheme to be implemented should reflect its heat characteristics. Water is generally argued to be a transport mechanism for delivering the heat energy to the surface, regardless of whether the water is itself consumptively used. Recent theoretical work has demonstrated that the creation of a property rights scheme based on the enthalpy of the geothermal fluid would require state legislative action.⁸¹ In the near term it is doubtful that this type of legislative action will be forthcoming. Therefore, the City must make its policy and management decisions within the structure of existing property rights, however the resource may ultimately be defined. The main impact of this constraint is that the City cannot directly establish unattenuated public domain property rights over the resource. That is, 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).

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.

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.

The fifth assumption is that all regulations of other agencies outside the City, for example State of California and federal agencies, are assumed to be filled by the resource user at no cost to the City. In the discussion that follows the only costs to be evaluated are those to be born by the City or imposed by the City on the resource user. It should be noted that any discussion of costs encompasses difficult theoretic and policy issues which have not been examined here. The approach is one of attempting to sketch a framework for possible resource management systems. The analysis has not considered the effects of time delays due to permitting and other requirements.

Based on the above assumptions, four resource management scenarios are presented, each based on a different policy decision which may be made by the City Council. The four are titled: (1) Rapid Resource Utilization Scenario (RRUS), (2) Minimum Resource Information Scenario (MRIS), (3) Resource Monitoring Scenario (RMS), and (4) Maximum Resource Conservation Scenario (MRCS). These scenarios are conceptualized as being on a continuum, the Rapid Resource Utilization Scenario (RRUS) being the one with minimum City involvement in the resource allocation decision, the Maximum Resource Conservation Scenario (MRCS) being the one which would ultimately utilize sequential decision making and maximize City involvement in resource conservation. The other two scenarios fall in between, the Minimum Resource Information Scenario (MRIS) being nearer to the Rapid Resource Utilization Scenario (RRUS), and the Resource Monitoring Scenario (RMS) being nearer the Maximum Resource Conservation Scenario (MRCS). Each of these is discussed below.

2.0 Rapid Resource Utilization Scenario (RRUS)

The Rapid Resource Utilization Scenario (RRUS) assumes that the City would exercise minimal control over potential uses of the geothermal resource, and only through its existing general plan and zoning ordinance. The general plan and the zoning ordinance would be changed only where they conflict with residential areas. Once the individual user satisfies the general plan and zoning ordinance requirements, the only additional requirement would be to obtain a building permit. This scenario envisions the maximum individual user decision-making relative to potential uses, and does not provide for any overall control of the amount of the resource that is used in any given time period. The RRUS imposes the smallest procedural costs on City government since the procedures to be followed are those now in operation.

Since increased utilization of the geothermal resource would be a significant action within the City, the City must at a minimum prepare a generic geothermal environmental impact report (EIR) to address those anticipated impacts which may result from the increased utilization. Once this generic EIR is completed, all further projects would be subsumed under the scope of the original document as long as the proposed use fell within the scope of those evaluated at the time the generic EIR was prepared. The only additional information required of an individual developer would be a building permit application.

This scenario does not envision any City control over the large number of existing wells or the amount of resource extracted via those wells. Disposal of thermally spent geothermal brine would be the responsibility of the individual user, subject to a discharge permit from the Regional Water Quality Control Board. As a result most of the water would probably be percolated back to the ground water table via disposal ponds.

The Rapid Resource Utilization Scenario (RRUS) imposes virtually no costs upon the individual user of the resource beyond those normally associated with development. The developer, to proceed, obtains a building permit once he meets the requirements of the general plan and zoning ordinance. There is no City control over the amount of the resource extracted via the existing wells, nor is there control over the amount of the resource extracted by all future users. There is no guarantee that existing uses will be continued at their present level, nor that the resource will be conserved. The Rapid Resource Utilization Scenario (RRUS) is a rule of capture game where the first users extract the quantity of the resource they want and all subsequent users make use of the remainder, each later user possibly having a diminishing quantity available. Under this scenario there is no effective way to prevent degradation of the resource; this is not a policy issue to be decided by the City. The major elements of the Rapid Resource Utilization Scenario (RRUS) are summarized in Table 1.

3.0 Minimum Resource Information Scenario (MRIS)

The Minimum Resource Information Scenario (MRIS) is only a slight departure from the Rapid Resource Utilization Scenario (RRUS) described above. The intent of the Minimum Resource Information Scenario (MRIS) is to exercise minimal City control over the utilization of the resource, but to provide for some conservation measures which themselves do not require significant involvement by the City. The tactic proposed is control of well spacing, that is, requiring a minimum well spacing for geothermal wells throughout the reservoir as part of the zoning ordinance.

It may be argued that mandating a minimum well spacing will limit the quantity of the resource which can be extracted, and also will result in an allocation of the surface estate among a larger number of users. That is, for utilization of a significant number of wells a user would have to acquire the surface rights to a large area. Since acquisition of a larger area within an existing urban structure is considerably more difficult than acquiring a smaller tract, this may result in a larger number of users having access to the resource, each having smaller facilities. A presupposition is that all wells are of a given diameter and will

Table 1

Rapid Resource Utilization Scenario

Planning	Existing general plan (change GP only in residential areas)
Legal basis of implementation	Existing zoning ordinance (change zoning only in residential areas)
Permits required	Building permit
Environmental review	Generic Geothermal EIR
Information required	Building permit application
Existing wells	No action
Financing	No additional
Disposal	Individual
Manpower requirements	No additional

Table 2

Minimum Resource Information Scenario

Planning	Existing general plan
Legal basis for implementation	Revised zoning ordinance (well spacing)
Permits required	Building permit
Environmental review	Generic Geothermal EIR
Information required	Application showing well spacing
Existing wells	No action
Financing	No additional
Disposal	Individual
Manpower requirements	No additional

provide a uniform flow rate. This, however, is still a rule of capture game. Although the wells are spaced, there is no control over the size of the well or the maximum fluid extraction rate which can be obtained. Therefore, even though the user would perhaps require a larger surface estate to sink the required number of wells for his use, there is no constraint on the amount of the resource he may utilize. The results are essentially the same as presented for the Rapid Resource Utilization Scenario (RRUS).

The only added information required of a developer is an application showing the proposed well spacing. All other requirements are the same as those for the Rapid Resource Utilization Scenario (RRUS). See Table 2.

4.0 Resource Monitoring Scenario (RMS)

The Resource Monitoring Scenario (RMS) is a considerable jump along the continuum towards a management scheme wherein the primary concern is conservation of the resource. This scenario is less restrictive than the conservation perspective to be presented in the next scenario, however, it does require obtaining and using information about the extent and quality of the reservoir in decision-making.

The Resource Monitoring Scenario (RMS) uses the existing zoning ordinance procedures for conditional use permit (CUP) applications. Conditional use permits normally require Planning Commission and City Council review prior to issuance. The details of the permit application procedures are not discussed here.

The major addition to the management scenario contained herein is the requirement for monitoring well output by the individual user and reporting of this information to the City. The City would randomly sample users to ensure compliance with the self reporting requirements. The zoning ordinance would be revised to contain penalties for non-compliance with the self reporting requirements. Since this information is crucial to effective management of the reservoir, the penalty will have to be significant to ensure that the information is forthcoming from the individual user.

This scenario also requires monitoring and reporting of the geothermal fluid extracted through existing wells. The same penalty would be imposed for non-reporting by existing well owners as that for new wells. All of the monitoring data would be collected by the City and be used for ascertaining the condition of the overall reservoir. Disposal would still be an individual option.

Under its police power, the City may charge a fee for issuing permits to use the geothermal resource. The revenues generated by the permit fees should compensate for the additional work associated with collecting and compiling the data on the condition of the reservoir. There may be an additional desire to collect fees to be used to compensate non-users of the resource, a redistribution of income concept not to be discussed here. See Table 3.

Table 3

Resource Monitoring Scenario

Planning	Existing general plan
Legal basis for implementation	Revised zoning ordinance Penalties for noncompliance
Permits required	Conditional Use Permit (CUP) building permit
Environmental review	Generic Geothermal EIR
Information required	Application specifying use well output monitoring Self reporting Random sampling
Existing wells	Require monitoring and reporting
Financing	Charges for permits
Disposal	Individual
Manpower requirements	Existing procedures

Table 4

Maximum Resource Conservation Scenario

Planning	Geothermal element
Legal basis of implementation	Revised zoning ordinance penalties for noncompliance
Permits required	Conditional Use Permit (CUP) building permit
Environmental review	Generic Geothermal EIR Individual project assessment as part of CUP monitoring (subsidence, water quality, etc.)
Information required	Application specifying use Well output monitoring (T, W)* Self reporting Random sampling Development of city-wide/reservoir data/base
Existing wells	Require monitoring and reporting
Financing	Charges for permits Disposal fee based on W
Disposal	Require central disposal bond removal of mud, sludge, etc.
Manpower requirements	Designated responsibility integration of permit processing into existing procedures

W = mass flow rate

This scenario would begin to give the City information necessary to make decisions on permitting additional uses which might significantly impact the geothermal resource. It does not impose disposal requirements on any of the users by continuing to allow individual disposal, but it does provide a data base for ascertaining the condition of the resource. The Resource Monitoring Scenario (RMS) is still a rule of capture game, but the City would have information about how much of the resource is being used. By observing trends over time, more control may be exercised over later users. Under this scenario early users of the resource establish claims relatively easily but later users may find it harder to obtain permission to proceed with development. Even with the information available, this scenario does not guarantee reservoir preservation or continuation of existing uses.

5.0 Maximum Resource Conservation Scenario (MRCS)

The Maximum Resource Conservation Scenario (MRCS) is the most stringent scenario presented 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 as in the previous scenario to require a conditional use permit (CUP) for all potential users of the resource.

Here too 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. See Table 4.

Implementation of the Maximum Resource Conservation Scenario (MRCS) 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 (MRCs) will ensure the continuance of existing uses and nondegradation of the reservoir.

6.0

Conclusion

The objective of this analysis has been to examine possible resource management systems which are both legally feasible and economically efficient. A number of theoretical and practical problems must be solved before any management scenario can be implemented. The four scenarios are summarized in Table 5,

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 including the Rapid Resource Utilization Scenario (RRUS), and the Minimum Resource Information Scenario (MRIS). 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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SCENARIO	PLANNING	LEGAL BASIS	PERMITS	ENVIRONMENTAL REVIEW	INFORMATION	EXISTING WELLS	FINANCING	DISPOSAL	MANPOWER
RAPID RESOURCE UTILIZATION	EXISTING GENERAL PLAN	EXISTING ZONING	BUILDING	GENERIC GEOTHERMAL EIR	BUILDING PERMIT APPLICATION		NO ADDITIONAL	INDIVIDUAL	NO ADDITIONAL
MINIMUM RESOURCE INFORMATION		WELL SPACE ZONING			WELL SPACE APPLICATION				
RESOURCE MONITORING		MONITORING	CONDITIONAL USE PERMIT		SPECIFIC USE APPLICATION RESOURCE MONITORING	REQUIRE MONITORING AND REPORTING	CHARGE FOR PERMIT		
RESOURCE CONSERVATION	GEOTHERMAL ELEMENTS	MONITORING		INDIVIDUAL PROJECT ASSESSMENT CITY WIDE MONITORING	CITY-WIDE DATABASE		DISPOSAL FEE	CENTRAL DISPOSAL	DESIGNATED RESPONSIBILITY

TABLE 5

SUMMARY OF RESOURCE MANAGEMENT SCENARIOS

If the object of the City is to control the resource itself, the most efficient method is to obtain absolute control of the resource, that is, to have in the City's purview unattenuated property rights to the geothermal resource. Although this is theoretically desirable, given the unsettled nature of laws defining exactly who owns geothermal resources, that is, whether they accrue to the mineral estate or to the water estate, it is highly unlikely that the City can acquire such broad rights to the resource.

It is clear that the City has the power to control the drilling of geothermal wells. It has not been judicially established that any local government has the right to control operation of the wells, nor that they do not have the right. The question has not been adjudicated. Regardless, through its power to control well drilling, both the number of wells and their location, the City may, in fact, acquire control over the resource. This may be accomplished by requiring that a permit be obtained for drilling wells, and that information be provided to the local government on the mass flow rate and the temperature profile of the brine extracted. The developer makes application to the local government to drill a number of wells and extract a given quantity of fluid sufficient to implement his proposed use. The quantity restriction is a condition imposed on the granting of the permit to drill. With each succeeding application, the City must make a judgment whether or not that additional use will impact the overall characteristics of the reservoir. If it does not, then the permit may be granted as long as any other conditions are met; if it does, then the City has the power to deny the permit to drill. Thus, the City uses its right to control development on the surface of the land to effectively exercise control over the geothermal reservoir. This process is known as sequential allocation, that is, with each subsequent application, the City evaluates the probability that the reservoir will be degraded versus the benefit to be achieved from its further utilization.

To implement a regulatory scheme such as has been described above requires the City to collect data on all existing uses, monitor closely, and carefully evaluate proposed uses to assess potential impacts on the reservoir areas of great uncertainty. Geothermal reservoirs may, and often do, change from well to well. Even with careful data collection, monitoring and evaluation there is no guarantee that the reservoir will not degrade. These actions should, however, provide forewarning of changes taking place within the reservoir. The cost of monitoring and information reporting may be passed directly to the developer through a permit and use fee tied to the volumetric extraction of the geothermal resource. The only management scenario having these characteristics is the Maximum Resource Conservation Scenario (MRCS).

This regulatory scheme insures that claims to the value of the resource by non-participants in its development are protected. That is, current users will not degrade the resource such that subsequent users are precluded from making application. This does not mean, however, that all potential users will have the right to make use of the resource. The resource is finite and use is permitted only to the extent that the reservoir is not degraded.

APPENDIX 13

Geothermal Resources Property Rights and Powers of Cities
to Regulate Indigenous Geothermal Resources and to Finance
Construction of Facilities for Utilization of Such Resources

GEOTHERMAL RESOURCES PROPERTY RIGHTS
AND POWERS OF CITIES TO REGULATE
INDIGENOUS GEOTHERMAL RESOURCES
AND TO FINANCE CONSTRUCTION OF
FACILITIES FOR UTILIZATION OF
SUCH RESOURCES

PREPARED FOR
THE CITY OF DESERT HOT SPRINGS, CALIFORNIA

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This paper discusses the current state of the law with respect to property rights in geothermal resources in the State of California 1/ (i.e., whether geothermal resources are classified as mineral, water or otherwise and how one acquires rights in or to produce and use geothermal resources). It further discusses the role of cities in regulating indigenous geothermal resources, ways in which a city might finance construction of municipal facilities for utilization of geothermal resources (e.g., a municipal heating system), and whether a city may provide financial assistance for construction of private commercial and industrial facilities which would utilize geothermal resources.

1/ Accompanying this paper as Appendix 13A is a summary of geothermal resource statutes and regulations in California, Nevada, Arizona and New Mexico, which in part discusses matters related to property rights in these four states.

A. Geothermal Property Rights

In areas such as the City of Desert Hot Springs where the geothermal resources are geothermally heated ground water, controversies may arise (1) between owners of the mineral and surface estates on land overlying the geothermal resources, where there has been a reservation of the mineral estate, (2) between competing producers of geothermal water and producers of ground water from the same aquifer or inter-related aquifers, and (3) between competing producers of geothermal water from the same aquifer. The classification of the geothermal resources (i.e., as mineral or water) will have a substantial bearing on the resolution of these disputes.

Disputes Between Owners of Surface and Mineral Estates

In situations where there has been a reservation of the mineral estate, and ownership of the mineral estate is thus separate and distinct from the surface estate, courts have recently held that geothermal resources (i.e., steam or hot water) are mineral rather than water, and that the owner of the mineral estate controls the resources and is entitled to develop, sell or lease them. 2/

In United States v. Union Oil Co. of California, the U. S. Court of Appeal for the Ninth Circuit held that the mineral reservation in patents issued under the Stock-Raising Homestead Act of 1916 3/ reserved to the United States geothermal resources underlying the patented lands. Union Oil Company was the lessee of land in "the Geysers" area of Sonoma County beneath which are sources of geothermal steam. The land was patented under the Stock-Raising Homestead Act of 1916. The court concluded that geothermal resources "are depletable subsurface reservoirs of energy, akin to deposits of coal and oil, which it was the particular object of the reservation clause to retain in public ownership..." 4/

2/ United States v. Union Oil Co. of California (N.D. Cal. 1973) 369 F.Supp. 1289, reversed (9th Cir. 1977) 549 F.2d 1271, cert. denied in Ottobani v. U.S., ____ U.S. ____, 54 L.Ed.2d 291 (1978); Geothermal Kinetics, Inc. v. Union Oil Co. 75 C.A.3d 56 (1977), hearing denied Jan. 26, 1978; Pariani v. State of California, Superior Court of the City and County of San Francisco, No. 657-291 (Memorandum of Intended Decision).

3/ 43 U.S.C. Sec. 291 et seq.

4/ Id., 549 F.2d at 1279.

In Geothermal Kinetics, Inc. v. Union Oil Co., 5/ a California Court of Appeal also ruled that geothermal resources belong to the owner of the mineral estate rather than the owner of the surface estate. In making this ruling, the court found that geothermal resources are part of the mineral estate and that geothermal water is a mineral.

This case also involved geothermal resources consisting of hot steam existing beneath the surface of land located in "the Geysers" area of Sonoma County. In this area, the geothermal steam reservoir is separated from the overlying ground water system by a 1000 foot thick silicarbonate seal. Geothermal Kinetics, as the holder of the leasehold of the mineral estate, drilled a geothermal well some 7,200 feet deep at a cost of approximately \$400,000.

The court found that the minerals in the condensed steam from this well are generally toxic, requiring their reinjection back below the silicarbonate seal, and that purification of this condensed steam so as to render it safe for agricultural or domestic purposes is not economically feasible.

The reservation of the mineral estate was silent with respect to geothermal resources. The court held: "In the absence of any expressed specific intent to the contrary, the scope of the mineral estate, as indicated by the parties' general intentions and expectations, includes the geothermal resources underlying the property." 6/

It can be concluded from the court's opinion in Geothermal Kinetics that where the geothermal resources are steam or water which contain minerals which are toxic or otherwise render the condensed steam or water unfit for surface agricultural or domestic use, the California courts will treat the resources as mineral. The decision does not, however, speak to the situation where the geothermal resources, steam or water, are fit for agricultural or domestic use and can be produced for such use in an economically feasible manner. The court's decision in Geothermal Kinetics is based in large part on the fact that the geothermal resources were not necessary for the enjoyment of the surface estate.

More importantly, insofar as the City of Desert Hot Springs geothermal resources are concerned, the opinion does not shed much light, if any, on how geothermal resources will be characterized when the resources and ground water are inter-

5/ Supra, 75 C.A.3d 56.

6/ Supra, 75 C.A.3d at 62.

mingled rather than separate. The decision in Geothermal Kinetics was also based on the court's finding that:

"(T)he water and steam components of geothermal resources are part of a separate water system cut off from...surface and subsurface waters by a thick mineral cap. Only insignificant amounts of ground water enter the geothermal water system. Unlike the surface and subsurface waters, the origin of geothermal water is not rainfall, but water present at the time of the formation of the geologic structure. Because rainfall does not replenish geothermal water, it is a depletable deposit." 7/

For two reasons then, Geothermal Kinetics would probably not be controlling in a controversy between the owners of the mineral and surface estates regarding the Desert Hot Springs resources. First, unlike the situation in Geothermal Kinetics, the geothermal resources underlying the City of Desert Hot Springs area are not separate from the ground water system. Rather, the City of Desert Hot Springs' resources are ground water which has been geothermally heated. 8/ Second, the mineral composition of the geothermal water does not render it unfit for agricultural or domestic use. 9/

Under circumstances such as these, it is unlikely that a court would treat the geothermal resources as mineral in a controversy between the owners of the mineral and surface estates over control of the resources. Most likely, the court would conclude that since the geothermal resources are part of the ground water supply and usable for agricultural and domestic purposes, they would not pass with the mineral estate.

7/ Supra, 75 C.A.3d at 63.

8/ Russell, Desert Hot Springs Resource Assessment and Characterization, Appendix 1 to Nonelectric Applications of Geothermal Resources at Desert Hot Springs, California, Quarterly Report for period August 12, 1977 - November 11, 1977.

9/ The mineral constituency or quality of water from the geothermal aquifer is such that the water could be used for some agricultural uses without treatment.

Disputes Between Geothermal and Ground Water Producers

It is also unlikely that Geothermal Kinetics would be applied in an action brought by producers of ground water for agricultural or domestic use with respect to potential interference with such production by wells drilled for the purpose of producing geothermally heated ground water for energy purposes. It is more likely that in such an action the court would characterize the geothermal resources as water rather than mineral and resolve the action through application of principles of ground water law.

Section 3742.2 of the California Public Resources Code could have a bearing on the resolution of such an action. Under this section, a person who has drilled a well which is producing or capable of producing geothermal resources may apply to the Geothermal Resources Board for a "certificate of primary purpose," the issuance of which establishes a rebuttable presumption that such person has absolute title to the geothermal resources reduced to his possession from such well. This presumption may be rebutted only upon a showing that the water content of the geothermal resources is useful for domestic or irrigation purposes without further treatment.

If geothermal water reduced to possession is capable of being used for domestic or irrigation purposes without further treatment, the presumption of ownership would appear to be rebutted, and, if rebutted, presumably the established law with respect to ground water rights would apply and the certificated party would be subject to suit by the holder of a superior overlying or appropriative ground water right to enjoin production or for damages.

Section 3742.2 further provides that even if the water is of a quality suitable for domestic or irrigation purposes, the presumption of ownership is not rebutted if the water is a "by-product" of the production of geothermal resources. It has been suggested that if the certificated party's objective is to extract energy from water, the water would be a "by-product" of the production of geothermal resources and the presumption of ownership would apply. 10/

10/ Sato & Crocker, Property Rights to Geothermal Resources, (Part Two) 6 Ecology L.Q. 484, 488 (1977).

Nevertheless, the "certificate of primary purpose" probably deals only with title to resources reduced to possession and does not establish a continuing right to produce a specific quantity of water. Thus, in situations where it is clear that producers of geothermal water and ground water producers are pumping from the same basin or aquifer, controversies between such competing geothermal producers and ground water producers will most likely be governed by the established law of ground water rights. 11/

Under California law, if both a competing geothermal producer and a competing ground water producer would be considered to be overlying users (i.e., owners of land overlying a ground water basin who make use of ground water on or in connection with their overlying land), the correlative rights doctrine would apply. Under this doctrine, the rights of overlying users are equal and correlative, 12/ and if the quantity of water in a ground water basin is insufficient to satisfy the reasonable needs of all overlying users, each overlying user is limited to his proportionate fair share of the total amount available based upon his reasonable need. 13/

11/ We are advised by the State Superintendent of Oil and Gas that the Geothermal Resources Board has yet to issue a "certificate of primary purpose."

12 Hutchins, The California Law of Water Rights, n. 20, p. 438; Hudson v. Dailey 156 Cal. 617, 628 (1909); Burr v. Maclay Rancho Water Co. 160 Cal. 268, 273 (1911); Katz v. Walkinshaw 141 Cal. 116, 136 (1903).

13/ Tehachapi-Cummings County Water Dist. v. Armstrong 49 C.A.3d 992, 1001 (1975).

A detailed discussion of California ground water law is beyond the scope of this paper. It should be mentioned, however, that in addition to the rights of overlying users, the courts recognize appropriative rights (i.e., rights obtained by non-overlying producers of surplus waters of a ground water basin) and prescriptive rights (i.e., rights obtained by appropriators in an overdrafted ground water basin by continuous use during a 5-year prescriptive period). See City of Pasadena v. City of Alhambra 33 Cal.2d 908, 925-933 (1949); City of Los Angeles v. City of San Fernando 14 Cal.3d 199, 277-284; Hutchins, supra, 426-465 (1975). It should also be noted that the laws of Arizona, Nevada and New Mexico differ substantially from California law.

Disputes Between Geothermal Producers

Since the geothermal resources underlying the City of Desert Hot Springs are geothermally heated ground water, it is unlikely that, in resolving a dispute between competing producers of the resources for energy purposes, a court would follow Geothermal Kinetics and characterize the resources as a mineral. Rather, the court would probably settle such a controversy in the same manner as it would a controversy between a geothermal producer and a ground water producer: through application of existing principles of ground water law. However, if Geothermal Kinetics were followed and the Desert Hot Springs geothermal resources were characterized as mineral, it is possible that a court would look to oil and gas law in resolving such a controversy. In California, the land owner or holder of the mineral estate does not have absolute title to the oil and gas beneath the surface; rather, he has an exclusive right to drill on his property for those substances. An unqualified and absolute title attaches to the resource only after the substance has been reduced to possession. ^{14/} However, once the resource escapes from under the land and enters the land of another, the right of dominion of the land owner or the holder of the mineral estate over the substance is gone. ^{15/} Thus, a rule of capture applies and the producer who operates his well most diligently obtains the greatest benefit. ^{16/}

If this rule of capture were applied in a controversy between competing producers of the Desert Hot Springs geothermal resources, each producer would have the exclusive right to explore for, capture and bring to the surface any of the geothermal resources that might be found within the bounds of his property, as measured by the property lines extended vertically downward. ^{17/} This would be the case even though the aquifer from which the resources are being drawn extends under neighboring property. The only limitation (absent pooling or unitization) is that the land owner may not sink a well by slant drilling so as to intercept the resources from

^{14/} Bernstein v. Bush 29 C.2d 773, 778 (1947); Gerhard v. Stephens 68 C.2d 864, 877-879 (1968).

^{15/} People v. Associated Oil Co. 211 Cal. 93, 101 (1930).

^{16/} Bandini Petroleum Co. v. Superior Court 284 U.S. 8, 20 (1931).

^{17/} A. E. Bell Corp. v. Bell View Oil Synd. 24 C.A.2d 587, 595 (1938). See generally, 36 Cal.Jur.2d, Oil & Gas, p. 617.

resources from beneath the surface of a neighboring owner's land. 18/

B. Powers of Cities to Regulate Geothermal Resources

In this part, we discuss the powers of cities to regulate the drilling for and the production and use of indigenous geothermal resources.

As a general rule, cities, as political subdivisions of the state, can only exercise those powers which are expressly granted to them by charter or statute, or which are necessarily or fairly implied as incident to such express powers. 19/

A city cannot alter basic property rights as defined by the state. 20/ Thus, a city could not legislate a system for acquiring rights in geothermal resources within the city limits or for allocating such resources among competing producers, nor could a city exercise dominion over the resources to the exclusion of other would-be producers.

18 A. E. Bell Corp. v. Bell View Oil Synd., Id.

19/ 35 Cal.Jur.2d, Municipal Corporations, Sec. 194; 2 McQuillan, Municipal Corporations, Sec. 10.09.

20/ Sato & Crocker, supra, p. 489, n. 323. As hereinafter discussed, a city, in the exercise of its police power, can enact zoning and other ordinances which will indirectly affect the allocation of geothermal resources.

It has been suggested that the City could exercise its power of eminent domain to condemn the entire aquifer from which the geothermal resources are produced, thereby enabling it to directly control the allocation and use of the resources. The legislative body of a city has the power to "acquire by eminent domain any property necessary to carry out any of its powers or functions." Government Code Sec. 37350.5; City of Sierra Madre v. Superior Court of Los Angeles County 191 C.A.2d 587, 590 (1961). The California courts have held that the power of eminent domain may be exercised for the purpose of obtaining oil, gas and mineral rights and water rights. County of Kern v. Galatas 200 C.A.2d 353, 356-357 (1962); Northern Light, Etc. Co. v. Stacher 13 C.A. 404, 410-412 (1910); and see Code of Civil Procedure Sec. 1240.110. No authority can be found which holds that a city may condemn an entire ground water aquifer. However, assuming that a city could show that such a condemnation was

The California Constitution, Section 7, Article 6 provides that: "A city may make and enforce within its limits all local, police, sanitary, and other ordinances and regulations not in conflict with general laws." Government Code Sec. 37100 provides that in carrying out this constitutional provision, the legislative body of a city "may pass ordinances not in conflict with the constitution and laws of the State or the United States."

The California courts have held that cities have the inherent right to control or prohibit oil and gas production, provided it is done reasonably and not arbitrarily. 21/ Based on such court decisions, the California Attorney General has concluded that this authority extends to geothermal resources. 22/

The Attorney General went on to conclude that the state has exclusively occupied or preempted the regulation of down-hole or subsurface geothermal well operations, but that cities may regulate the drilling, operation, maintenance and abandonment of geothermal wells with respect to phases of such activities not covered by state statute or regulation so long as such city regulation does not conflict with state regulation concerning other phases of such activities.

Whether and to what extent the City of Desert Hot Springs should regulate drilling for or development or production of geothermal resources underlying the City are policy questions to be answered by the City Council, and it is not the purpose of this paper to suggest that the City should or should not engage in such regulation. At present the drilling of geothermal wells and production therefrom is not specifically regulated by the City. Most likely the City has not seen fit to regulate geothermal resources because to date production and use of geothermal resources in and around the City is

a legitimate object of government which would promote the general interest (Bauer v. County of Ventura 45 C.2d 276, 284 (1955); Code of Civil Procedure Sec. 1240.010), the City would be faced with the substantial if not overwhelming problem of providing "just compensation" to the owners of property overlying the aquifer and to producers of the geothermal resources. Code of Civil Procedure Sec. 1263.010 et seq.

21/ Pacific Assn. v. Huntington Beach 196 Cal. 211 (1925); Beverly Oil Co. v. City of Los Angeles 50 Cal.2d 552, 558 (1953); Marblehead Land Co. v. City of Los Angeles 47 F.2d 528, 532 (1931) cert. denied 284 U.S. 634 (1931).

22/ 59 Ops.Atty.Gen. 461, 468-469.

relatively insignificant. However, as energy costs escalate, as additional uses of geothermal resources are identified, and as the demand on the resources underlying the City increases, the City Council may find it desirable if not necessary to regulate the drilling of geothermal wells and the production of geothermal resources in order to promote the efficient and economical utilization of the resources as well as the general public welfare.

Some public welfare goals which might be promoted by regulating the drilling of geothermal wells and the production of geothermal resources are:

(1) Maintenance of temperatures adequate for economically feasible utilization of the resources.

(2) Protection of property values within the City from depreciation associated with surface subsidence resulting from excessive extraction of geothermal water.

(3) Preservation of adequate water levels within the aquifer or aquifers from which geothermal water is produced so as to minimize the effect of the production of geothermal water on production of ground water for domestic and agricultural uses.

(4) Insuring that the drilling for and production of geothermal resources are conducted in a safe manner with as little adverse impact on the ambient environment as possible.

The City Council could regulate the drilling for and production of geothermal resources to promote these social goals by adopting an ordinance which might have the features hereinafter mentioned. These features would not be in conflict with regulations of the State Supervisor of Oil and Gas. 23/

23/ Authority for the adoption of such an ordinance is found in Government Code Sec. 65850 which provides: "(T)he legislative body of any...city by ordinance may...(r)egulate the use of buildings, structures and land as between industry, business, residents, open space, including...use of natural resources, and other purposes." See also Beverly Oil Co. v. City of Los Angeles 40 C.2d 552, 558 (1953); Wood v. City Planning Commission 130 C.A.2d 356, 364 (1955); and 8 McQuillan, Municipal Corporations, Secs. 25.131d and 25.150a.

Well Spacing

The ordinance could provide for the location, spacing and size of drilling sites. 24/ The ordinance could also prohibit drilling on any site or at any location other than those approved by the Council or a City employee designated in the ordinance. Such prohibition might also apply to slant wells drilled from locations outside the city but which will bottom within the city limits. The ordinance should include a "grandfather" provision exempting existing wells from compliance with these and other requirements of the ordinance, at least insofar as present levels of production are concerned.

Permit and Conditions of Issuance

The ordinance could require the issuance of a City license or permit (e.g., conditional use permit or building permit) before drilling could commence. 25/ This provision could also be made applicable to wells drilled outside the city limits but which would bottom within the City. As a condition of the issuance of a permit the City might require the submission of an appropriate application and payment of a fee to defray the City's cost of investigating the proposed well, and ensuring that the permittee or applicant complies with the requirements of the ordinance.

The applicant might be required to specify in his application the intended use of the geothermal resources and the average and peak quantities to be extracted. The applicant might also be required to post a bond to insure completion of the well or its abandonment and restoration of the well site to its original condition.

If the City determines -- either because of the existing order of the California Regional Water Quality Control Board,

24/ Under Section 3757 of the California Public Resources Code, a new well may not be located within 100 feet of the outer boundary of the parcel or within 100 feet of a public road. However, under Section 3757.2 the State Oil and Gas Supervisor may permit the location of wells producing from low temperature geothermal resources (i.e., fluids having a temperature no more than the boiling point of water at the altitude of occurrence (Sec. 3703.1)) to be located within 15 feet of the outer boundary or a public road.

25/ Government Code Sec. 37101 provides: "The legislative body (of a city) may license, for revenue and regulation, and fix a license tax upon, every kind of lawful business transacted in the city..."

Colorado Region, prohibiting discharge of geothermal effluent into the sanitary sewer system, or for the purpose of insuring proper recharge of the aquifer from which geothermal resources are produced -- to construct and operate a municipal geothermal effluent disposal or recharge system, the applicant or ultimate user of the geothermal resources could be required to connect to and discharge all geothermal effluent into this system.

As a condition to the issuance of a permit the applicant could be required to assume the risk of reduction in the temperature of the geothermal resources, as a result of production by others, and to hold the City harmless from any claim by the applicant or others as a result of any such temperature reduction. The applicant could also be required to hold the City harmless from liability for damages resulting from the applicant's operations and to provide the City with proof of adequate insurance coverage to effectuate the hold harmless agreement.

The city could also require as a condition for the issuance of a permit that the applicant make some provision for monitoring both the temperature and flow rate of the resources produced from the well. Monitoring could be implemented in several ways. It could take the form of a self-reporting requirement, with the city insuring compliance by conducting a program of random sampling. Alternatively, the city could avoid the problems of enforcing compliance by simply requiring the applicant to install the appropriate monitoring equipment and to grant the city access to the well so that designated city employees could periodically monitor the temperature and flow rate.

Other conditions for the issuance of a permit might be: (1) the establishment of deadlines for the commencement and completion of drilling; (2) compliance with requirements regarding type of drilling equipment, measures to minimize noise and odor, and removal of drilling waste material; (3) compliance with requirements regarding cleanup after completion of drilling and landscaping, screening, housing and fencing of wells and production equipment for attractiveness and safety, and requirements with regard to production equipment necessary to eliminate noise, odor, etc.

Abandonment

The City could also provide in the ordinance that the abandonment of non-producing wells would be pursuant to the rules and regulations of the State Supervisor of Oil and Gas. Down-hole abandonment probably has been exclusively preempted by the State. However, the City could probably regulate surface

abandonment practices. 26/

Subsidence and Temperature Reduction

The ordinance could also provide for the monitoring of subsidence by the City and the suspension of production of wells if a danger of subsidence is detected. Similar provisions could be included in the ordinance with regard to measures to protect against an adverse reduction in fluid temperature.

Environmental Assessment

The ordinance should require compliance with the City's procedures for compliance with the California Environmental Quality Act 27/ or for assessing environmental impacts associated with the drilling of or production from the proposed well.

Violations

The ordinance could also contain provisions with regard to criminal penalties for each violation and with regard to enforcement.

Compliance with State Regulations

The ordinance should probably require that all geothermal drilling and production be in conformance with the regulations of the State Supervisor of Oil and Gas.

C. Financing of Geothermal Resources Utilization Facilities

Potential uses for the Desert Hot Springs geothermal resources which have thus far been identified are: (1) space heating and/or water heating, (2) heating of a greenhouse complex where agricultural or horticultural operations would be conducted, and (3) maintenance of adequate water temperature in an aquaculture pond where fresh water prawn or other fish varieties would be raised for market. 28/ With regard to space heating and water heating, it has been suggested that

26/ 59 Ops. Atty. Gen., supra, 461-462.

27/ Public Resources Code Sec. 21000 et seq.

28/ Non-electric Applications of Geothermal Resources at Desert Hot Springs, California, quarterly report for period August 12, 1977 - November 11, 1977. It has been determined that temperatures of water from existing geothermal wells in the Desert Hot Springs area are not adequate to be used for air conditioning.

the City of Desert Hot Springs might construct and operate a municipal heating system which would utilize the City's indigenous geothermal resources. 29/ Thus, in this part we explore ways in which the City might finance construction of such a system.

Cities generally finance public improvements which are of general benefit to the residents and taxpayers of the city -- rather than of special benefit only to residents and property owners in a part of the city -- through the issuance of general obligation or revenue bonds.

General obligation bonds are a bonded indebtedness of the city payable from the proceeds of taxes levied upon taxable property in the city. 30/ Annually at the time of making the general tax levy, the city must levy and collect a tax sufficient to pay annual interest and principal on the bonds. 31/ The issuance of general obligation bonds requires the two-thirds affirmative vote of the electors voting on the bond proposition. 32/

29/ A city is empowered to construct, own, operate or lease a public utility to supply its inhabitants or any portion thereof with heat, among other things. Public Utilities Code Sec. 10001.

30/ Government Code Sec. 43605.

31/ Government Code Sec. 43632. The status of general obligation bonds is in doubt as a result of the approval by California voters of Proposition 13 (the "Jarvis-Gann Initiative") on the June 6, 1978 ballot. Effective July 1, 1978, this measure adds Article XIII A to the California Constitution. It limits the amount of any ad valorem tax on real property to one percent of the full cash value of such property and sets the "full cash value" at the 1975-76 county assessor's valuation of real property. This base may be increased annually by the change in the consumer price index, but no greater than a two percent increase is permitted in any year. Real property may be reassessed to current value when it is newly purchased, when it is newly constructed, or when there is a change in ownership.

Because of the stringent limitations imposed by this measure upon the municipality's ability to levy taxes, it appears that it will be virtually impossible in the future for a city to guarantee that it can levy taxes sufficient to meet principal and interest payments on general obligation bonds, as is now required. Assuming that the Jarvis-Gann Initiative ultimately is implemented as enacted, it seems likely to eliminate the general obligation bond as an effective means of financing the projects discussed in the body of this paper.

32/ California Constitution, Sec. 18, Article 16;
Government Code Sec. 43614.

Although the code sections which authorize cities to issue general obligation bonds for municipal improvements do not specifically authorize the issuance of such bonds for the acquisition and construction of a municipal heating system, such authorization is probably broad enough to empower cities to issue general obligation bonds for this purpose. 33/

Revenue bonds are not a charge against general tax revenues of the city but are special obligations secured by a pledge of the revenues of the enterprise constructed with the proceeds from the sale of the bonds, and are payable as to principal and interest solely from the gross revenues of the enterprise. 34/

The issuance of revenue bonds requires the affirmative vote of a majority of the voters voting on the bond proposition. 35/ General law cities are empowered to sell revenue bonds for construction of almost any type of public improvement, including construction of facilities useful for the generation, production or transmission of electric energy for lighting, heating and power for public or private uses. 36/ However, the revenue bond powers of cities will not permit a city to issue revenue bonds to fund construction of a municipal heating system.

It has been suggested that the safe yield of the Desert Hot Springs geothermal aquifer may only be adequate to supply a heating system for a portion of the City. 37/ The portion to be benefited would apparently be determined based upon the receptiveness of the citizenry and the location of wells capable of producing a sufficient volume of water at an adequate temperature.

If only a portion of the City would benefit from the construction of a heating system, it would not be appropriate for the City to finance such construction through the issuance of general obligation bonds which would be secured and serviced by city-wide ad valorem property taxes.

33/ Government Code Sec. 43601 defines "municipal improvement" as including, inter alia, water works, light and power works or plants, buildings for municipal uses, "and other works, property, or structures necessary or convenient to carry out the objects, purposes and powers of the city..." (Emphasis added.) As previously mentioned, a city may construct, own and operate a public utility to supply its inhabitants or any portion thereof with heat. Public Utilities Code Sec. 10001.

34/ Government Code Secs. 54420-54424.

35/ Government Code Sec. 54386.

36/ Government Code Sec. 54309.

37/ The term "aquifer" is defined as a water-bearing formation yielding water in an economic manner. The term "geothermal aquifer" indicates a hot water system given a minimum temperature. Russell, supra, p. 103. The "safe yield" of an aquifer or ground water basin in a natural state is considered to be the average annual amount contributed to the aquifer by rainfall. City of Pasadena v. City of Alhambra 33 C.2d 908, 929 (1949). The safe yield of the Desert Hot Springs geothermal aquifer is considered to include precipitation, surface inflow and subsurface inflow. Russell, Id., p. 112-118.

The construction of such facilities could, however, be financed through the sale of revenue bonds, the principal and interest of which would be paid from revenues of the system. As mentioned, the issuance and sale of such revenue bonds would require approval by a majority vote at a city-wide election. 38/

The Improvement Act of 1911 39/ and the Municipal Improvement Act of 1913 40/, are utilized by municipalities in California to finance the construction and installation of municipal improvements which benefit only a portion of the municipality. Generally, under both of these acts, municipal improvements are financed through assessments on properties which are benefited by the improvement and the sale of improvement bonds which are issued to represent assessments which are not paid during the "cash payment period" prior to the sale of bonds. Principal and interest on such bonds are paid out of annual installments on the unpaid assessments which are a lien on the benefited properties. 41/

Proceedings may be conducted under these improvement acts and bonds issued without an election. Such proceedings may be stopped, however, by the filing of a majority protest signed by the owners of 51% of the area of the property to be assessed. 42/

Although neither of these improvement acts contains specific authorization for the construction of pipelines and other facilities which would be used for heating of residences and commercial establishments, the general language of the authorization sections of both acts is probably broad enough to

38/ As previously mentioned, legislation would be required to authorize the issuance of revenue bonds for the construction of such facilities.

39/ Division 7 (commencing with Sec. 5000) of the Streets and Highways Code.

40/ Division 12 (commencing with Sec. 10000) of the Streets and Highways Code.

41/ Streets and Highways Code Secs. 6400-6427, 10600-10609. In the case of the 1911 Act, each bond is secured by a lien on a specific property which is described in the bond. (Sec. 6460).

42/ Streets and Highways Code Secs. 5220-5227, 10310-10311.

include the construction of such facilities. 43/ Moreover, in view of the intensity of current interest in the development of new energy sources, it should not be difficult to obtain passage of legislation which would specifically provide such authorization. 44/

A device which is sometimes utilized by California cities to finance construction of municipal facilities, particularly, where the requisite voter approval for issuance of the city's bonds cannot be obtained, is the "public leaseback" arrangement. Under this arrangement revenue bonds of a joint powers agency created by the city and one or more other public agencies are sold to finance construction of the facilities which are then leased back to the city. The principal and interest on these bonds are paid from rental revenues. Existing code provisions do not authorize joint powers agencies to issue revenue bonds for construction of a municipal heating system. 45/

43/ See Streets and Highways Code Secs. 5101 and 10100, the latter of which provides: "Whenever the public interest or convenience requires, the legislative body of any municipality may install in or along its streets...any works, utility, or appliances necessary or convenient for providing any...public service."

44/ Municipalities are authorized to utilize these improvement acts for installation of pipes and other necessary works and appliances for providing gas service and poles, posts, wires and other necessary works and appliances for street lighting and for furnishing electricity and electric service or telephone service. (Streets and Highways Code Secs. 6101 and 10100.)

45/ In California two or more public agencies may by agreement jointly exercise any power common to them. Such an agreement is commonly referred to as a "joint powers agreement." Government Code Secs. 6500-6515. A joint powers agency may sell revenue bonds to finance construction of an exhibition building, coliseum, stadium, sports arena and any other public building. Government Code Sec. 6546. A joint powers agency may sell revenue bonds without an election; however, issuance of such bonds is subject to referendum. Government Code Secs. 6547-6547.3. Joint powers agencies may also issue revenue bonds pursuant to the provisions of the Revenue Bond Law of 1941, Chapter 6 (commencing with Sec. 54300) of Part 1 of Division 2 of Title 5 of the Government Code, for the construction of facilities for the generation, production or transmission of electric power for lighting, heating and power for public or private uses. Government Code Secs. 6579, 54307.1 and 54307.2. As previously mentioned, issuance

A variation of the public leaseback arrangement which has been utilized by some municipalities involves the formation of a private, nonprofit corporation which sells its bonds for the construction of facilities which are then leased back to the city. Such a corporation is referred to as a "public leaseback corporation". 46/ The City of Burbank, California has apparently formed a private, nonprofit corporation which will issue bonds to finance the exploration and development of geothermal resources for electric power generating purposes. 47/

As previously discussed, a city is empowered to lease a public utility to supply its inhabitants or any portion thereof with heat. 48/ Thus, a city could probably lease a municipal heating system which was constructed through the sale of the bonds of a non-profit corporation. Moreover, since the nonprofit corporation's bonds would be issued to finance a project which is public in nature the interest on the bonds would most likely be tax exempt. 49/

It has been suggested that in order to promote the commercial and industrial use of geothermal resources, it would be desirable if the City could finance facilities which would be made available to commercial and industrial firms or to in some way

of revenue bonds under the Revenue Bond Law of 1941 requires the affirmative vote of a majority of all voters voting on the bond proposition. Government Code Sec. 54386.

For a more detailed analysis of this type of municipal financing, see: Beebe, Hodgman & Sutherland, Joint Powers Authority Revenue Bonds, 415 Cal. L. Rev. 19 (1958), and Taber & Whittaker, Joint Powers Revenue Bonds: A Tool for Intergovernmental Cooperation in California, 23 Hastings L.J. 791 (1972).

46/ Government Code Secs. 4220-4224, 54240-54245.

47/ Kramer & Hammer, The Role of Municipalities in Geothermal Resource Development, Geothermal Resources Development Institute - Paper 5, pp. 5-16-5-17 (Rocky Mt. Min. L. Fdn., 1977).

48/ Public Utilities Code Sec. 10001.

49/ Where the requirements of Internal Revenue Code Sec. 103 are met, such bonds are deemed to be issued "on behalf of" the municipality and the interest is tax exempt. Revenue Ruling 63-20 requires that the nonprofit corporate bond issuer engage in activities which are essentially public in nature.

lend the City's credit to assist such firms in raising capital for such facilities. Unfortunately, the California Constitution forbids the Legislature to give or lend the credit of any city for the payment of liabilities of any individual, association or corporation. The Constitution further precludes the Legislature from making any gift or authorizing the making of a gift of any public money. 50/

Thus, unlike municipalities in some other states, cities in California are not empowered to issue bonds for the acquisition of real property and the construction of industrial buildings and facilities to be leased or conveyed under a lease-purchase agreement to private interests. 51/

Although a private, nonprofit corporation could be organized to finance construction of such facilities, which could then be leased or sold to a private commercial or industrial firm, since the nonprofit corporation would not be engaged in activities which are essentially public in nature, the corporation's bonds would not be deemed to have been issued "on behalf of" the city and the interest on the bonds would most likely be taxable. 52/

50/ California Constitution, Section 6, Article 16. In San Diego W.Co. v. City of San Diego, 59 Cal. 517, 521 (1881), the court held that the city could not contract to pay money, or to appropriate the revenues of the city to aid in constructing the works of a private corporation.

51/ Among states where cities have such power are Alabama, Kentucky, Maryland, Michigan, Minnesota, Missouri, New Hampshire, New Mexico, North Dakota, Oklahoma, Tennessee and Wyoming. In these states the acquisition of property and the construction of industrial buildings to be leased to or conveyed under a lease-purchase contract to private interests for the purpose of attracting industry or trade to the city are considered to be proper municipal purposes for which bonds may be issued. 15 McQuillan, Municipal Corporations, Sec. 43.32a, p. 531. An example of the breadth of such powers is found in Kennecott Copper Corp. v. Town of Hurley, 84 N.M. 743, 507 P.2d 1074 (1973), where the New Mexico Supreme Court held that the issuance of revenue bonds pursuant to the New Mexico Industrial Revenue Bond Act to finance the cost of pollution control equipment for a privately owned factory was a proper public purpose for which such revenue bonds could be issued.

52/ Internal Revenue Code Sec. 103; Revenue Ruling 63-20.

If an area within the City where commercial establishments or industries which would utilize the geothermal resources would be located could be considered a "blighted area" as defined in the Community Redevelopment Law 53/, the City may want to consider the possibility of providing a limited subsidy for such commercial and industrial establishments through the creation of a redevelopment agency. A redevelopment agency may acquire and clear land for redevelopment purposes and may also develop a building site on any such real property. Such development may include the installation or construction of utilities necessary for carrying out the redevelopment plan 54/. A redevelopment agency may sell or lease land acquired by it for redevelopment purposes 55/, and after compliance with requirements for hearing and notice, may sell such property for less than its fair market value. 56/ A redevelopment agency may not, however, construct buildings for commercial or industrial use. 57/

D. Conclusions

The law with respect to property rights in geothermal resources is in the early stages of its development. Based upon the court's decision in Geothermal Kinetics, Inc. v. Union Oil Co., supra, it can be assumed that in controversies between the owners of the surface estate and the mineral estate, where there has been a reservation of the mineral estate, on land overlying geothermal resources which consist of steam or water which contains toxic minerals, the resources will be characterized as mineral, thus allowing the owner of the mineral estate to control the drilling for and use of the resources. However, because of the nature of the resources involved in Geothermal Kinetics, the case cannot be relied upon with regard to disputes between the owners of severed surface and mineral estates with regard to geothermal resources which consist of water which is of suitable quality for agricultural or domestic

53/ Part 1 (commencing with Sec. 33000), Division 24, Health and Safety Code.

54/ Health and Safety Code Secs. 33390-33398, 33420-33421. It is doubtful, however, that such necessary utilities would include a public utility for supplying heat to commercial or industrial firms.

55/ Health and Safety Code Secs. 33430-33432.

56/ Health and Safety Code Secs. 33433.

57/ Health and Safety Code Secs. 33440.

use, or with respect to controversies between competing producers of geothermal water and producers of ground water from the same aquifer or interrelated aquifers, or in controversies between competing producers of geothermal water from the same aquifer. Such disputes will probably be settled through application of principles of ground water law, although oil and gas law may also play a part in the resolution of such disputes.

Although the State of California has probably preempted regulation of subsurface geothermal well operations, cities may in exercise of their zoning powers regulate many phases of the drilling of geothermal wells and production of geothermal resources, as long as such regulation does not conflict with state regulation concerning other phases of such activities.

California cities can finance municipal heating systems through the sale of general obligation and revenue bonds, and where such a system will benefit only part of the city, by utilization of assessment district proceedings under either the Improvement Act of 1911 or the Municipal Improvement Act of 1913. Further, the City of Desert Hot Springs has the authority to make use of geothermal resources and to install facilities to provide space heating and water heating for city buildings.

However, unlike cities in some other states, cities in California are not empowered to issue bonds or to otherwise finance the construction of buildings and other facilities to be made available to commercial and industrial firms.

APPENDIX L3A

SUMMARY OF PROPERTY RIGHTS AND
REGULATION OF GEOTHERMAL RESOURCES IN CALIFORNIA,
NEVADA, ARIZONA AND NEW MEXICO

By

Richard T. Anderson

and

Stephen C. Jones

of

Best, Best & Krieger

I. RESPONSIBLE STATE AGENCIES

A. California.

Division of Oil and Gas
Room 1316-35, Resources Building
1416 Ninth Street
Sacramento, California 95814
Phone: (916) 445-9686

The following terminology will be used:

- (1) Supervisor. State Oil and Gas Supervisor.
- (2) Division. Division of Oil and Gas in the Department of Conservation.
- (3) Board. Geothermal Resources Board.
- (4) Regulations. Regulations pertaining to Geothermal Resources promulgated by the Division of Oil and Gas. (14 Cal.Admin.Code Sec. 1900 et seq.)

B. Nevada.

Division of Water Resources
201 South Fall Street
Carson City, Nevada 89701
Phone: (702) 885-4380

The following terminology will be used:

(1) State Engineer. State Engineer appointed by the Director of the State Department of Conservation and Natural Resources, or his designee.

(2) Regulations. Regulations pertaining to Exploration Drilling for the purpose of obtaining geochemical, geological or geophysical data, promulgated by the Division of Water Resources.

C. Arizona.

Oil and Gas Conservation Commission
4515 North Seventh Avenue
Phoenix, Arizona 85013
Phone: (602) 271-5161

The following terminology will be used:

(1) Commission. Oil and Gas Conservation Commission.

(2) Regulations. General Rules and Regulations Governing the Conservation of Geothermal Resources, promulgated by the Oil and Gas Conservation Commission.

D. New Mexico.

Oil Conservation Commission
P. O. Box 2088
Santa Fe, New Mexico 87501
Phone: (505) 827-2434

The following terminology will be used:

(1) Commission. Oil Conservation Commission.

(2) Regulations. Rules and Regulations pertaining to Geothermal Resources, promulgated by the Oil Conservation Commission.

II. DEFINITION OF THE RESOURCE

A. California. Section 3701 of the California Public Resources Code (PRC) defines "geothermal resources" as follows:

"(T)he natural heat of the earth, the energy, in whatever form, below the surface

of the earth present in, resulting from, or created by, or which may be extracted from, such natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases and steam, in whatever form, found below the surface of the earth, but excluding oil, hydrocarbon gas or other hydrocarbon substances." (See also PRC Sec. 6903.)

B. Nevada. Section 534A.010 of the Nevada Revised Statutes (NRS) defines "geothermal resources" as follows:

"(H)eat or other associated geothermal energy found beneath the surface of the earth." (See also NRS Sec. 322.005.)

The Regulations vary this definition slightly:

"(H)eated water, steam, heat or other associated geothermal energy found beneath the surface of the earth." (Regulations, Rule I.)

C. Arizona. Section 27-651(5) of the Arizona Revised Statutes (ARS) defines "geothermal resources" as follows:

"(a) All products of geothermal processes embracing indigenous steam, hot water and hot brines.

(b) Steam and other gases, hot water and hot brines resulting from water, other fluids or gas artificially introduced into geothermal formations.

(c) Heat or other associated energy found in geothermal formations, including any artificial stimulation or induction thereof.

(d) Any mineral or minerals, exclusive of fossil fuels and helium gas, which may be present in solution or in association with geothermal steam, water or brines."

D. New Mexico. Section 65-11-3 of New Mexico Statutes (NMS) defines "geothermal resources" as follows:

"(T)he natural heat of the earth, or the energy, in whatever form, below the surface of the earth present in, resulting from, created by, or which may be extracted from, this natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases and steam, in whatever form, found below the surface of the earth, but excluding oil, hydrocarbon gas and other hydrocarbon substances."

III. CHARACTERIZATION AND RESOURCE MANAGEMENT

A. California. Any person having drilled a well or wells on state, federal or private lands which are producing or, according to the Geothermal Resources Board, are capable of producing geothermal resources, may, at any time, apply to the Board for a Certificate of Primary Purpose. The Board will issue the Certificate upon a determination that the well or wells are primarily for the purpose of producing geothermal resources, and not for the purpose of producing water usable for domestic or irrigation purposes.

The Certificate creates a rebuttable presumption that the person has absolute title to the geothermal resources reduced to his possession from such well or wells. The presumption is rebuttable only upon a showing that the water content of the geothermal resources is useful for domestic or irrigation purposes without further treatment thereof, but not by virtue of any production of such water as a by-product incident to the production of geothermal resources. (PRC Sec. 3742.2.)

The Supervisor is directed to so supervise the drilling, operation, maintenance and abandonment of geothermal resource wells as (1) to encourage the greatest ultimate economic recovery of geothermal resources, (2) to prevent damage to life, health, property and natural resources, (3) to prevent damage to, and waste from, the underground geothermal deposits, and (4) to prevent damage to underground and surface waters suitable for irrigation or domestic purposes by reason of the drilling, operation, maintenance and abandonment of geothermal resource wells. (PRC Sec. 3714. See also PRC Sec. 3700; 14 Cal.Admin.Code Sec. 1930.)

B. Nevada. Any water and steam encountered during geothermal exploration is subject to the appropriation pro-

cedures of Chapter 533 (Adjudication of Vested Water Rights; Appropriation of Public Waters) and Chapter 534 (Underground Water and Wells) of Nevada Revised Statutes. (NRS Sec. 534A.040.) Rights to geothermal water and steam are thus determined in the same manner as are rights to other groundwater.

All underground waters belong to the public, and, subject to all existing rights to the use thereof, are subject to appropriation for beneficial use. (NRS Sec. 534.020.) A legal right to appropriate underground water or steam for beneficial use can only be acquired by complying with the permitting provisions of NRS Sec. 533.25 et seq. (NRS Sec. 534.080.) If the drilling occurs in a designated groundwater basin, a permit to appropriate water is required before sinking a well. In undesignated areas, no appropriation permit is required until after the well is sunk or bored and the resource is developed. (NRS Sec. 534.050.)

"Waste" of the resource, or unauthorized use of water or steam to which another person is entitled, is punishable as a misdemeanor. The possession or use of such water without legal right is prima facie evidence of the guilt of the person using it. (NRS Sec. 533.460 et seq.; NRS Sec. 534.070; NRS Sec. 534.020.) "Waste" is defined as follows:

"(C)ausing, suffering or permitting any artesian well to discharge water unnecessarily above or below the surface of the ground so that the waters thereof are lost for beneficial use or in any canal or ditch conveying water from a well where the loss of water in transit is more than 20 percent of the amount of the water discharged from the well."
(NRS Sec. 534.010.)

Within an area designated by the State Engineer where, in his judgment, the groundwater basin is being depleted, the State Engineer may make such rules, regulations and orders as are deemed essential for the welfare of the area involved. In the interest of public welfare, the State Engineer is authorized and directed to designate preferred uses of water within the respective areas so designated by him and from which the groundwater is being depleted, and in acting on applications to appropriate groundwater he may designate, within specified limits, such preferred uses in different categories. (NRS Sec. 534.120.)

C. Arizona. Geothermal resources and their development are deemed exempt from the water laws unless (1) such resources

are commingled with surface or ground waters or (2) such development causes impairment of or damage to the groundwater supply. In the development of geothermal resources, any well drilled to obtain and use groundwater is subject to the water laws. (ARS 27-667.) "Groundwater" is defined as "water under the surface of the earth regardless of the geologic structure in which it is standing or moving. It does not include water flowing in underground streams with ascertainable beds and banks." (ARS 45-301.) Administrative regulations implementing this statute are being drafted.

The Commission is directed to supervise the drilling, operation, maintenance and abandonment of geothermal resource wells as (1) to encourage the greatest ultimate economic recovery of geothermal resources, (2) to prevent damage to and waste from underground geothermal reservoirs, (3) to prevent damage to or contamination of any water of the state or any formation productive or potentially productive of fossil fuels or helium gas, and (4) to prevent the discharge of any fluids or gases or disposition of substances harmful to the environment by reason of drilling, operation, maintenance or abandonment of geothermal resource wells. (ARS 27-652.)

The waste of geothermal resources is specifically prohibited. (Regulations, Rule B-3.) "Waste" is defined as follows:

"(A)ny physical waste including, but not limited to, underground waste resulting from the inefficient, excessive or improper use or dissipation of reservoir energy or resulting from the location, spacing, drilling, equipping, operation or production of a geothermal resources well in such a manner that reduces or tends to reduce the ultimate economic recovery of the geothermal resources within a reservoir, and surface waste resulting from the inefficient storage or utilization of geothermal resources and the location, spacing, drilling, equipping, operation or production of a geothermal resources well in such a manner that causes or tends to cause the unnecessary or excessive surface loss or destruction of geothermal resources obtained or released from the reservoir." (ARS 27-651(9); Regulations, Rule A-10.)

Upon a determination by the Commission that geothermal resources production in the state, or in a particular geothermal area, is causing waste, the Commission is required to limit the total amount of geothermal resources which may be produced in the state or in a particular geothermal area. (Regulations, Rule G-401.)

D. New Mexico. The Commission is empowered to prevent waste of the resource in handling or production and to protect correlative rights. (NMS 65-11-7, 65-11-4; Regulations, Rule 3.) "Correlative rights" is defined as follows:

"(T)he opportunity afforded, in so far as is practicable to do so, to the owner of each property in a geothermal reservoir to produce his just and equitable share of the geothermal resources within such reservoir, being an amount, so far as can be practicably determined, and so far as can be practicably obtained without waste, substantially in the proportion that the recoverable geothermal resources under such property bears to the total recoverable geothermal resources in the reservoir, and for such purpose to use his just and equitable share of the natural heat or energy in the reservoir." (NMS 65-11-3.)

The term "waste" includes (1) underground waste resulting from the inefficient, excessive or improper use or dissipation of the resource and from the improper or inefficient locating, spacing, equipping, operating or producing of any well or wells, (2) surface waste resulting from the unnecessary or excessive surface loss of the resource without beneficial use, however caused, (3) production of the resource in excess of the reasonable market demand therefor, in excess of the capacity of the connected geothermal transportation facility to efficiently receive and transport the resource, or in excess of the capacity of a geothermal utilization facility to efficiently receive and utilize the resource, (4) the nonratable purchase or taking of the resource within a geothermal reservoir, and (5) drilling or producing operations for the resource within an area containing commercial deposits of potash (naturally occurring bedded deposits of the salts of the element potassium) where this would adversely affect the development of such potash deposits. (NMS 65-11-5; Regulations, Definitions at p. A-3.)

The sale, purchase or acquisition, transportation, utilization, processing or handling in any other way (1) of

geothermal resources in whole or in part produced in excess of the amount allowed by statute or by rule or regulation or (2) of any product of any geothermal resources, which product is derived in whole or part from geothermal resources produced in whole or in part in excess of the amount allowed, is prohibited. Such geothermal resources are termed "illegal geothermal resources" and such commodity or product is termed an "illegal geothermal resources product." (NMS 65-11-16.) Detailed rules effectuating the prohibitions against "illegal geothermal resources" and "illegal geothermal resources products" provide for the imposition of penalties by the Commission (NMS 65-11-16), the commencement of legal actions by the Commission for penalties or an injunction, or both (NMS 65-11-20), for the commencement of actions by private parties (NMS 65-11-21), and for the seizure and sale of "illegal" resources or products (NMS 65-11-24). (See generally, NMS 65-11-15 et seq.)

Upon a determination by the Commission that the production of geothermal resources from a particular reservoir is causing waste or is about to result in waste, the Commission is required to limit, allocate and distribute the total amount of geothermal resources which may be produced from that reservoir. (NMS 65-11-9.) When geothermal production is so limited, the Commission must allocate and distribute allowable production among geothermal resource wells in the reservoir on a reasonable basis, recognizing correlative rights. (NMS 65-11-10.)

Under the "ratable taking" provisions, adopted from oil and gas law, any person engaged in purchasing geothermal resources from one or more producers within a single geothermal resource is designated a "common purchaser" within that reservoir. The "common purchaser" is required to purchase geothermal resources lawfully produced from that reservoir (of like quality, quantity and pressure and tendered to such common purchaser at a reasonable point) without unreasonable discrimination in favor of one producer against another in price paid, quantities taken, bases of measurement, or facilities offered. If the purchaser is also a producer, he is prohibited to the same extent from discriminating in favor of himself with respect to geothermal resource wells in which he has an interest, direct or indirect, as against other wells in the same reservoir. (Regulations, Rule 402; NMS 65-11-14.)

IV. DESIGNATION OF AN AGENT

A. California. Every operator must designate an agent who resides in California and upon whom all orders, notices

and processes of the Supervisor or any court may be served. (PRC Sec. 3721.) The Designation of Agent form must be on file with the Division before a Notice of Intention to Drill may be submitted. (Drilling and Operating Geothermal Wells in California, Division of Oil and Gas, Draft, p. 2.)

B. Nevada. No provision.

C. Arizona. Every owner or operator of any well must designate an agent who resides in the state and upon whom may be served all orders, notices and processes of the Commission or a court. (ARS Sec. 27-657.)

D. New Mexico. Any person who has drilled, is drilling, or proposes to drill any geothermal well must file a Designation of Agent form with the Commission. (Regulations, Rule 100.)

V. DRILLING PERMITS

A. California. Before an owner or operator can drill a new well or redrill an abandoned well, (1) a written Notice of Intention to Drill New Well, (2) a fee, and (3) a bond must be filed with the Supervisor or District Deputy. Work may not commence until approval is received from the Division. If a written response is not received from the Division within ten (10) working days, approval is deemed granted. If operations have not commenced within one (1) year of receipt of notice of approval from the Division, the notice will be cancelled. (PRC Sec. 3724; 14 Cal.Admin.Code Sec. 1931.) The application fee is based upon the depth and extent of the proposed drilling activity. (PRC Sec. 3724; 14 Cal.Admin.Code Sec. 1932.) For purposes of determining the amount of the bond, wells are categorized as high temperature wells (temperature is greater than the boiling point of water at the altitude of occurrence) or low temperature wells (temperature is no more than the boiling point of water at the altitude of occurrence). (See PRC Sec. 3703.1.) Provision is made for single-well (individual) and multiple-well (blanket) bonds. (PRC Sec. 3725-29.) The blanket bond may be utilized when one or more wells are being drilled and will cover all drilling operations in the state. (PRC Sec. 3726.) Bonds will be released when wells are properly abandoned or another bond is substituted for the original bond. (PRC Sec. 3728-29.)

Before an owner or operator may deepen, redrill, plug or perform any operation that will in any manner permanently alter the well casing, a Notice of Intention to Deepen, Redrill, Plug or Alter Casing form must be filed with the Division. Written approval must be received before

work may commence. A fee and/or bond may be required in certain circumstances. (14 Cal.Admin.Code Sec. 1931.1.)

Before an owner or operator may convert an existing well into an injection or disposal well, a written Notice of Intention must be filed with the Division and written approval must be received before work is commenced. (14 Cal.Admin.Code Sec. 1931.2.)

An owner or operator may submit to the Supervisor for approval a written program to drill shallow wells or wells for geothermal observation purposes. (PRC Sec. 3724.1-3724.4; 14 Cal.Admin.Code Sec. 1931.4.)

If construction of drilling sites, roads, sumps, steam transmission lines, and other construction attendant to geothermal operations could cause or be affected by slumping, landslides, or unstable earth conditions, the Supervisor will require the operator to submit a written analysis of the proposed work prior to commencement of any construction and prior to approving any permit to drill. (14 Cal.Admin.Code Sec. 1931.5.)

After Division approval of a Notice of Intention, the Division will issue a permit (P-Report). If the Division does not process the P-Report within ten (10) working days, the proposed activity is deemed approved. The P-Report will automatically be cancelled in one (1) year from the date of issuance unless renewed by the filing of a Supplementary Notice. In the P-Report, or at any time, the Supervisor may order any tests or remedial work necessary to prevent damage to life, health, property and natural resources. Within thirty (30) days after a written order is issued, the owner or operator must commence the work ordered and continue work until completion. If the operator fails to complete the work, the Supervisor is empowered to complete the work and charge expenses to the operator or bonding company. (Drilling and Operating Geothermal Wells in California, Division of Oil and Gas, Draft, p. 5-6; PRC Sec. 3743-44.)

B. Nevada. A person licensed as a well driller is not required to possess a license to drill exploration holes. If the person is not a licensed well driller, two licenses are required: (1) An exploration driller's license which is obtained by applying to the State Engineer and paying a \$25 fee (unless renewed, this license expires June 30 of the following year); and (2) a state contractor's license which is obtained by applying to the State Contractor's Board. (If the driller is (a) the owner of a drilling rig, (b) has a drilling rig under lease or rental, or (c) has a contract

to purchase a drilling rig, he must additionally obtain a license as a driller from the State Contractor's Board.) (Regulations, Rule II.)

Before commencing the drilling of a hole, a driller is required to file with the Division a Notice of Intention to Drill. (Regulations, Rule III.)

C. Arizona. A person must notify the Commission of intent to drill by (1) filing an application for a Permit to Drill, Reopen, Plugback, or Re-enter; (2) paying a fee of \$25 for each proposed well; (3) filing a plat (after the well location is surveyed and the plat is certified by a registered surveyor); and (4) filing an approved individual or blanket bond with the Commission. (Regulations, Rules G-101, 102, 105; ARS 27-654 through 659.) Except in certain specified situations the Commission "will promptly issue such person a permit to drill...." (Regulations, Rule G-102.) The permit to drill becomes null and void unless operations are commenced within ninety (90) days after the date of approval (unless the Commission grants an extension in writing).

Once a well is completed, it cannot be deepened, plugged-back or reworked without first giving ten (10) days written notice to the Commission of the character of the work proposed and the time when it will begin. The Commission will notify the applicant in writing of approval or disapproval. (Regulations, Rule G-119.)

D. New Mexico. Prior to commencement of drilling, deepening or plugging operations, the owner or operator of a proposed well for exploration, production, observation, injection or disposal purposes must file (1) an application for Permit to Drill, Deepen or Plugback -- Geothermal Resources Well, (2) a Geothermal Resources Well Location and Acreage Dedication Plat and (3) an individual or blanket bond. Approval must be obtained before work may commence. The applicant must submit proof that a Notice of Intention to Drill has been filed with the appropriate local governing body. (Regulations, Rules 102, 201, 203.) For purposes of determining the amount of the bond, wells are categorized as (1) geothermal exploratory, development, injection or disposal wells, and (2) low temperature thermal or geothermal observation wells. The bond endures until the well is properly plugged and abandoned. (Regulations, Rule 101.)

VI. DRILLING AND WELL CONSTRUCTION REQUIREMENTS

A. California. Any person operating any wells in an area where high pressures are known to exist, or where

the pressures are unknown, must equip the well with casings of sufficient strength and with such other safety devices as may be necessary to prevent blowouts, explosions and fires. (PRC Sec. 3739; 14 Cal.Admin.Code Sec. 1940.) The Regulations establish classifications of areas and requirements for the installation of blowout protection equipment. (14 Cal.Admin.Code Sec. 1940-1942.2.)

The owner or operator of any well on lands producing or reasonably presumed to contain geothermal resources must properly case it with water-tight, adequate casing. (PRC Sec. 3740; 14 Cal.Admin.Code Sec. 1935.)

B. Nevada. All holes must be sealed at the surface with natural soil or concrete regardless of diameter or depth. (Regulations, Rule IV.)

C. Arizona. Any person drilling a well in an area where high pressures are known to exist or where the pressures are unknown must (1) case in a water-tight manner, with pipe of an adequate strength, the bore hole to a depth sufficient to protect against surface cratering in the event of a blowout, (2) equip the well with a blowout preventer and other safety devices and (3) exercise due caution in all drilling operations to prevent blowouts, explosions or fires. (Regulations, Rules G-110, 111; ARS 27-660.) The Regulations also require an adequate pit for mud laden fluid or accumulation of drill cuttings in order to confine oil, gas, water or other fluids to their native strata (Regulations, Rule G-106); that all oil, gas and water above the producing horizon must be confined to their respective strata and be sealed or separated in order to prevent their contents from passing into another strata (Regulations, Rule G-107); and that casing requirements be met (Regulations, Rules G-108, 109; ARS 27-652(b); see Regulations, Rule G-110).

D. New Mexico. In areas where high subsurface pressures are known to exist, where there is a history of lost circulation and/or blowouts, or where subsurface pressures are not known, all proper and usual precautions must be taken for keeping the well under control, including the use of blowout preventers and high pressure fittings attached to properly cemented casing strings. Blowout preventers are not required for drilling low temperature thermal wells, geothermal observation wells or seismic, core or other exploratory wells less than five hundred (500) feet deep. (Regulations, Rules 601, 602.)

Adequately equipped rotary drilling equipment must be used on all wells except geothermal observation wells, low temperature thermal wells and disposal wells. A pit

of adequate size to hold drilling fluids and to receive drilling cuttings must be provided prior to drilling in order to prevent the overflow of contaminants. (Regulations, Rule 106.) During drilling, all fresh water and salt water strata overlaying the geothermal resources strata must be sealed or separated to prevent migration of fluids from one stratum to the other. (Regulations, Rule 197.) Casing and cementing requirements must be met for all wells. (Regulations, Rules 108, 117.)

VII. WELL-SPACING REQUIREMENTS

A. California. Any well drilled for the discovery or production of geothermal resources or as an injection well must be located at least one hundred (100) feet from and within the outer boundary of the parcel of land on which the well is situated, and at least one hundred (100) feet from a public road, street or highway dedicated prior to commencement of drilling. (PRC Sec. 3757; 14 Cal.Admin. Code Sec. 1934.) The requirement may be waived by the Supervisor in certain cases, such as in the case of low temperature thermal wells in residential or industrial areas. (PRC Sec. 3757.2; 14 Cal.Admin.Code Sec. 1934.) Provision is made for directional drilling under certain circumstances (PRC Sec. 3757.1; 14 Cal.Admin.Code Sec. 1934.)

B. Nevada. No provision.

C. Arizona. On an individual basis the Commission will administratively approve a proposed well-spacing program or administratively prescribe such modifications to the programs as it determines are necessary for proper development. (Regulations, Rule G-105.)

D. New Mexico. For purposes of establishing well-spacing requirements, wells are categorized as (1) exploratory wells, (2) development wells, (3) injection wells, (4) disposal wells, (5) geothermal observation wells and (6) low temperature thermal wells. No well-spacing restrictions are placed on the latter three categories; varying requirements are placed on the first three categories of wells. (Regulations, Rule 104; NMS 65-11-11.) Provision is made for exceptions under certain circumstances. (Regulations, Rule 104(c)-(e).)

VIII. UNITIZATION AND POOLING AGREEMENTS

A. California. When the Geothermal Resources Board determines that it is in the interest of the protection of the resource from unreasonable waste -- lessors, lessees, operators or other persons owning or controlling a royalty or other interest in separate properties of the same producing or prospective geothermal resources area may, with the approval of the Board, enter into agreements for the purpose of (a) bringing about cooperative development and operation of all parts of the area, (b) bringing about the development or operation of all or a part or parts of such area as a unit or (c) fixing the time, location and manner of drilling and operating wells for the production of geothermal resources. (PRC Sec. 3756.)

B. Nevada. No provision.

C. Arizona.

(1) Pooling Agreements. When two or more separately owned tracts of land are embraced within an established drilling unit, persons owning the drilling rights therein and the right to share in the production therefrom may agree to pool their interests and develop their lands as a drilling unit. If the parties do not agree to pool, the Commission may for the prevention of waste, for the protection of correlative rights or to avoid the drilling of unnecessary wells, order the pooling and integrating of their interests. (Regulations, Rule G-105; ARS 27-666.)

(2) Unitization. When the Commission determines that it is in the interest of the protection of the resource from unreasonable waste -- lessors, lessees, operators, owners or other persons holding or controlling royalty or other interest in separate properties within the same productive or prospectively productive geothermal area may, with the approval of the Commission, enter into an agreement for the purpose of (a) bringing about the cooperation, development and operation of all or a portion of the geothermal resources area as a unit or (b) fixing the time, location and manner of drilling and operating of the wells for the production of geothermal resources within such area or portion thereof. (ARS 27-664 through 665.)

D. New Mexico. When (1) two or more separately owned tracts of land are embraced within a spacing unit or (2) where there are owners of royalty interests or undivided interests in geothermal resources which are separately owned, or any combination thereof, embraced within a spacing unit -- the owner or owners thereof may validly pool their

interests and develop their lands as a unit. To avoid the drilling of unnecessary wells, protect correlative rights, or prevent waste, the Commission is empowered to require and enforce pooling agreements where the parties do not agree. (NMS 65-11-12, 65-11-13.)

IX. REPORTING AND RECORD KEEPING REQUIREMENTS

A. California. The owner or operator must keep a careful and accurate log, core record, and history of the drilling of the well. (PRC Sec. 3733; 14 Cal.Admin.Code Sec. 1937.) The following records must be filed with the Division (PRC Sec. 3736; 14 Cal.Admin.Code Sec. 1937.1):

- (1) Drilling Log. (See PRC Sec. 3731, 3734.)
- (2) Core Record. (See PRC Sec. 3732.)
- (3) Well History. (See PRC Sec. 3733.)
- (4) Well Summary Report.
- (5) Monthly Geothermal Resources Report (Production Report). (PRC Sec. 3745.)
- (6) Monthly Geothermal Injection Report.
- (7) Electric logs (see 14 Cal.Admin.Code Sec. 1936), physical or chemical logs, tests, water analyses and surveys must be filed if run.

The Geothermal Resources Board requires the filing with it of (1) drilling logs, (2) descriptions of cores and samples and (3) drilling histories. (PRC Sec. 3742.1.)

Upon the operator's written request, records and reports will be kept confidential for a period not to exceed five (5) years from the date of (1) production or injection for other than testing purposes or (2) abandonment, whichever occurs first. Provision is made for extensions under certain circumstances. All such records and reports are otherwise public records. (PRC Sec. 3752.)

B. Nevada. Hole logs must be filed with the State Engineer. (Regulations, Rule V.) Exploration and subsurface information obtained as a result of a geothermal project must be filed with the State Engineer within thirty (30) days after it is accumulated. (NRS 534A.031; Regulations, Rule VIII.)

The information obtained as a result of a geothermal project is confidential for a period of five (5) years from the date of filing and shall not be disclosed before that time without the express written consent of the operator of the project. (NRS 534A.031; Regulations, Rule VIII.)

C. Arizona.

(1) Monthly Producers Report. The owner or operator of any well producing geothermal resources must file with the Commission a report setting forth each well's total production. (Regulations, Rules G-302, 402; ARS 27-662.)

(2) Geothermal Resource Purchaser's Monthly Report. Each purchaser or taker of a geothermal resource from a well, lease, reservoir or proration unit must file a report detailing the acquisition of geothermal resources. (Regulations, Rule G-602.)

(3) Monthly Injection Report. An injection project operator must keep accurate records of the amount of geothermal resources produced and the volumes of the substances injected, to be submitted monthly to the Commission. (Regulations, Rule G-504.)

(4) The owner, or one who has control or management of any geothermal generating or processing plant, must keep specified daily records, and unless directed otherwise by the Commission, must file a Geothermal Resources Purchaser's Monthly Report. (Regulations, Rule G-701.)

Upon the request of the operator, all information regarding the drilling of wells shall be kept confidential for a period not to exceed two (2) years following the date of completion of the well. (ARS Sec. 27-661.)

D. New Mexico. The owner or operator of any well must keep a careful and accurate well log and history of the drilling of the well. (Regulations, Rule 200.) All production from a completed well must be accounted for by continuous metering or by other Commission-approved method. (Regulations, Rule 118.) The following records must be filed with the Commission:

(1) Geothermal Resources Well Log. (See Regulations, Rule 205.)

(2) Geothermal Resources Well Summary Report. (See Regulations, Rule 206.)

(3) Geothermal Resources Well History. (See Regulations, Rule 207.)

(4) Monthly Geothermal Production Report. After placing a geothermal well in production, the owner or operator must file a monthly production report. (Regulations, Rule 208.)

(5) Monthly Geothermal Purchaser's Report. The purchaser of production from any geothermal resource must file a monthly purchaser's report. (Regulations, Rule 209.)

(6) Monthly Geothermal Injection Report. After placing any well on injection or disposal, the owner or operator thereof must file a monthly injection report. (Regulations, Rule 210.)

(7) Annual Geothermal Temperature and Pressure Test. (Rule 211.)

Neither the Statutes nor the Regulations provide for the confidentiality of records.

X. WELL COMPLETION AND ABANDONMENT REQUIREMENTS

A. California. Within sixty (60) days after a well has been completed, recompleted, abandoned or had operations suspended, the owner or operator must submit (1) a Well Summary Report -- Geothermal, (2) a Well Log and Core Record -- Geothermal, (3) a Well History -- Geothermal, and true copies of the (4) log, (5) core records, (6) well history and (7) copies, if made, of all electrical, physical or chemical logs, tests or surveys. (PRC Sec. 3735; 14 Cal. Admin.Code Sec. 1950, 1981; Drilling and Operating Geothermal Wells in California, Division of Oil and Gas, Draft, p. 8.)

At least five (5) days before any work is commenced to abandon any well, the owner or operator must file a Notice of Intention to Abandon Geothermal Resources Well with the Supervisor or District Deputy. If the Division fails to reply within the specified time, the proposed abandonment may be deemed approved. (PRC Sec. 3747-3749; 14 Cal.Admin. Code Sec. 1981.) Within five (5) days after completion of well abandonment, the owner or operator must submit a written report describing all work done in connection with the abandonment. The Supervisor or District Deputy must approve or disapprove of the abandonment procedures within ten (10) days. (PRC Sec. 3750, 3746; 14 Cal.Admin.Code Sec. 1981-1981.2.) The Division will issue its Report of Well

Abandonment only when all records are filed and the site is inspected for final cleanup. (14 Cal.Admin.Code Sec. 1981.)

No one is permitted to remove any casing or any portion thereof from any well without first giving written notice to the Supervisor or District Deputy of such intention at least five (5) days prior to the proposed removal. If the Supervisor or District Deputy does not approve or disapprove within the specified time, the proposed removal is deemed approved. The person removing the casing or portion thereof must submit a written report of the work done in connection with the removal within five (5) days after its completion. (PRC Sec. 3751.)

The Supervisor or District Deputy may order abandonment of any well that has been deserted whether or not any damage is occurring or threatened. (PRC Sec. 3755.)

B. Nevada. Holes drilled into or through artesian aquifers must be sealed to prevent upward leakage after the drilling pipe is withdrawn at the conclusion of drilling operations. (Regulations, Rule VII.)

C. Arizona. Any drilling well completed as a dry hole must be mudded and cemented unless authorization to the contrary has been given by the Commission. (Regulations, Rule G-201(b).)

Within thirty (30) days after completing a well, the owner or operator must file with the Commission (1) a Well Completion or Recompletion Report and Well Log, (2) all logs and surveys of any description, (3) a driller's log, (4) a core record and (5) a drilling history. (ARS 27-661; Regulations, Rule G-118.) Within twenty (20) days of well completion or abandonment, samples of all cores and cuttings must be furnished to the Commission. (Regulations, Rule G-118.)

Before any work is commenced to abandon any well, the owner and operator must file with the Commission an Application To Abandon And Plug. Work may not be commenced until permission is received from the Commission. (Regulations, Rules G-201, 202.)

D. New Mexico. Before placing any well on production, injection or disposal, the owner or operator must file with the Commission a Certificate of Compliance and Authorization to Produce Geothermal Resources. Approval must be obtained before commencing production, injection or disposal operations. (Regulations, Rule 204.) Additional approval for injection

or disposal wells must be obtained pursuant to Rules 501 through 505 of the Regulations.

The owner of any well is responsible for plugging the well upon abandonment. (Regulations, Rule 301.) Prior to commencing plugging operations, the owner or operator of the well must file with the Commission a Notice of Intention To Plug. Approval must be obtained before work may commence. (Regulations, Rules 302, 303.)

XI. REGULATIONS FOR INJECTION AND DISPOSAL WELLS

A. California. Before commencing injection activities a person must file with the Division (1) a Notice of Intention to Drill New Well (if a new well is contemplated) or a Notice of Intention to Deepen, Redrill, Plug or Alter Casing (if conversion of an old well is contemplated), (2) a fee and (3) a bond. Injection may not commence until written approval is granted by the Division. (14 Cal.Admin.Code Sec. 1960-1967.)

B. Nevada. No provision.

C. Arizona. When the Commission determines that it would be in the interests of the maintenance of underground geothermal resources, the prevention and subsidence of land surface or the maintenance of the quality of surface and other groundwaters, it may require reinjection of geothermal effluent or injection of other water supplies into producing zones. (ARS 27-652(d).)

Before commencing injection activities, a person must file with the Commission an application for a permit to inject. Until authorized by the Commission after notice and hearing, the injection of any substance into a geothermal reservoir to increase the recovery of geothermal resources or any other substance is prohibited. (Regulations, Rules G-501-504.)

D. New Mexico. No well may be utilized as a geothermal injection or disposal well until authority for such use has been obtained by filing with the Commission an Application To Place Well On Injection -- Geothermal Resources Area. (Regulations, Rules 501-506.)

XII. REGULATION OF WELL AND PROPERTY TRANSFERS

A. California. Operators who sell, assign, transfer, convey or exchange the right to operate a well or wells and the land, owned or leased, where the well is located, must notify the Division within thirty (30) days after the transaction occurs. (PRC Sec. 3722.) Thirty (30) days notification is also required from persons who acquire ownership or operation of any well and the land, owned or leased, upon which it is located, whether by purchase, transfer, assignment, conveyance, exchange or otherwise. (PRC Sec. 3723.) The person who acquires such ownership or operation of any well or wells shall, within thirty (30) days after such transaction, file an individual or blanket indemnity bond with the Supervisor. (PRC Sec. 3723.5.)

B. Nevada. No provision.

C. Arizona. The owner or operator of a well must notify the Commission in writing within ten (10) days of any sale, assignment, transfer, conveyance or exchange by the owner or operator of such well and the land, owned or leased, on which such well is located. The person acquiring such ownership or operation is also required to notify the Commission within ten (10) days. (ARS 27-658.)

Each producer or operator of any well must execute under oath and file with the Commission an Operator's Certificate of Compliance and Authorization to Transport Geothermal Resources From Lease. This Certificate must also be filed whenever a change occurs in the operating ownership of any developed unit, or whenever a change occurs in the identity of the transporter from any developed unit. (Regulations, Rule G-601.)

D. New Mexico. The Commission must be notified when there is (1) a change in the identity of a purchaser from, a well (Regulations, Rule 204), (2) a change in the ownership of a producing well, injection well or disposal well (Regulations, Rule 204), or (3) a change of ownership of a drilling well (Regulations, Rule 203).

XIII. STATE LAND LEASING REGULATIONS

Each of the four states has regulations regarding the development of geothermal resources on state lands:

A. California. PRC Sec. 6902 et seq.; 2 Cal.Admin. Code Sec. 2250 et seq.

B. Nevada. NRS, Chapter 322. The moratorium on the leasing of state land was recently lifted for the purpose of extracting oil, coal, gas or geothermal resources. (NRS 232.158.)

C. Arizona. ARS 27-651 and ARS 27-668 et seq. (see generally, ARS 37-231 et seq. and 37-281 et seq.). Regulations implementing these recently enacted statutes are being drafted.

D. New Mexico. NMS 7-15-1 et seq.; Rules and Regulations Concerning the Sale, Lease, and Other Disposition of State of New Mexico Trust Lands, Office of the Commissioner of Public Lands, Rules and Regulations Relating to Geothermal Resources Leases, p. 50 (January 1977 Edition).

XIV. FEDERAL LAND LEASING REGULATIONS

Regulation regarding the development of geothermal resources on Federal lands in each of the four states is governed by the Geothermal Steam Act of 1970 (30 U.S.C.A. Sec. 1001 et seq.).

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