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GEOTHERMAL RESOURCE AREA 3

Elko County

Area Development Plan

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by

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SUMMARY

Geothermal Resource Area 3 includes all of the land in Elko County, Nevada. There are in excess of 50 known thermal anomalies in this area. Several of the more major resources have been selected for detailed description and evaluation in this Area Development Plan. The other resources are considered too small, too low in temperature, or too remote to be considered for development in the near future.

Various potential uses of the energy found at each of the studied resource sites in Elko County were determined after evaluating the area's physical characteristics; the land ownership and land use patterns; existing population and projected growth rates; transportation facilities and energy requirements. These factors were then compared with resource site specific data to determine the most likely uses of the resource. The uses considered in this evaluation were divided into five main categories: electrical generation, space heating, recreation, industrial process heat, and agriculture. Within two of these categories several subdivisions were considered separately.

It was determined that several of the geothermal resources evaluated in the Area Development Plan could be commercially developed. The following summarizes the potential for development for the seven sites considered in this study:

Sulfur Hot Springs

Sulfur Hot Springs are the hottest known geothermal resource in Elko County. They have a measured temperature of 205° F. and an estimated reservoir temperature of 352° F. Though the temperature characteristics of the resource appear good, it is located about 40 miles from any population base. Electrical generation, industrial process heat, and greenhousing appear to have the most potential for development. Recreation and district space heating appear to have the least.

Hot Sulfur Springs

Hot Sulfur Springs are the second hottest resource in Elko County with spring temperatures measured at 194° F. Though the temperature characteristics of the resource appear good, it is located in a remote area. Greenhousing, industrial process heat, and aquaculture have the highest development potential; recreation and district space heating have the least.

Elko Hot Springs

The Elko Hot Springs geothermal resource has a measured temperature range between 150° F. and 192° F. It is located very near the community of Elko. Residential/commercial space heating, district space heating, greenhousing, and animal husbandry all have good potential for development. Electrical generation has low development for potential.

San Jacinto Ranch Springs

The San Jacinto Ranch Springs are located in the remote northern portion of Elko County near the town of Contact. Measured water temperatures are only as high as 148° F. Animal husbandry activities are considered to have the most potential. Applications that require some population base such as recreation and district space heating are considered to have the least potential.

Humboldt Wells

The Humboldt Wells geothermal anomaly is a moderately low temperature (maximum 142° F.) resource. It is located very near the community of Wells. Animal husbandry and residential/commercial space heating appear to have the highest development potential; electrical generation has the least.

Hot Springs near Carlin

The Carlin geothermal resource has a surface temperature near boiling. It is believed that a small district space heating system supplying the heating needs of the residents living in the community has the most potential for development at this time.

Thousand Springs

The Thousand Springs area has spring temperatures up to 111° F. The area has a very remote location. Only those applications not requiring high temperature geothermal fluids or a nearby population base are considered feasible at this time.

I. INTRODUCTION

Geothermal Resource Area 3 encompasses all of Elko County, Nevada. There are numerous geothermal anomalies within this area and the seven which are considered major are evaluated in this document: Sulfur Hot Springs, Hot Sulfur Springs, Elko Hot Springs, San Jacinto Ranch Springs, Humboldt Wells, Hot Springs near Carlin, and Thousand Springs.

The purpose of this document is to provide public and private decision makers with information that will facilitate the development of the various geothermal resources found in the study area. To further this goal, this Area Development Plan was prepared to provide information about the geothermal resource, the physical and socio-economic setting of Elko County, and the potential for developing various uses of these underutilized resources.

This report has been divided into three major sections to enable the reader to interpret the information more easily. The first section describes Elko County in terms of its physical and socio-economic characteristics. The second section describes the resource itself based upon the best currently available information. The third section describes the potential uses for the resources based upon a study of the geothermal resource characteristics, land-use, and various other factors.

II. THE AREA

A. Physical Characteristics

1. Location and Relief

Elko County has a total land area of 17,162 square miles. It is the second largest county in Nevada comprising about 15 percent of the land in the state. Elko County is located in north-eastern Nevada and is bordered on the north by the State of Idaho, on the east by the State of Utah, on the south by White Pine County, and on the west by Eureka, Lander, and Humboldt Counties.

Elko County is essentially mountainous with interspersed low valleys. The more notable mountain ranges in the study area include the Toana Range, Ruby Mountains, Sulphur Springs Range, Independence Mountains, Adobe Range, Tuscarora Mountains, Cherry Creek Range, Pequop Mountains, Goshute Mountains, and Windemere Hills. The larger valleys in the study area include Goshute Valley, Clover Valley, Tecoma Valley, Independence Valley, Lamoille Valley, Ruby Valley, and Antelope Valley. The elevations in Elko County range from a high of 11,300 feet found on Ruby Dome in the Ruby Mountains to a low of about 4,900 feet which is found in several of the lower basins.

2. Climatic Conditions(24-29)

The climatic conditions in Elko county are quite variable be- due to the large physical size and relief of the area. Detailed climatological information is available for Elko County at six meteorological stations: Elko, elevation 5,050 feet; Jiggs, eleva- tion 5,415 feet; Lamoille, elevation 6,290 feet; Owyhee, elevation 5,400 feet; Ruby Lake, elevation 6,012 feet; and Wells, elevation 5,650 feet. See Tables 1 through 6 for detailed climatological summaries of these stations.

Precipitation in Elko County is generally light, averaging

FIGURE 1

FIGURE 2
 TOPOGRAPHICAL AND PHYSICAL FEATURES
 OF ELKO COUNTY

about ten inches per year, with the greatest amounts falling during the winter as snow. A second maximum period for precipitation occurs in May and June. Summer precipitation is mostly scattered showers and thunderstorms which make only a minor contribution to the overall precipitation totals. The annual snowfall averages 36 inches per year in the lower elevations. A maximum 24 hour snowfall of 16.7 inches has been recorded at an elevation of 5,050 feet. Precipitation amounts are much higher in the surrounding mountains.

The high overall elevation of the region, the mountainous terrain, and the general dryness of the atmosphere all contribute to a wide daily range in temperature which averages 25° F. in December and 43° F. in August. Daily ranges greater than 55° F. are not uncommon. Summer maximum temperatures of 90° F. or higher occur on an average of 43 days per year while minimums of zero or less occur on an average of 18 days a year. There are approximately 7,397 mean heating-degree days in the study area. The growing season is relatively short, averaging only 81 days per year.

Temperature characteristics at other locations in Elko County may be inferred by applying the environmental lapse rate of an increase or decrease of 3-1/2° F. per 1,000 vertical feet lower or higher than the recording station. Care must be taken, however, in using temperatures developed from the environmental lapse rate as local conditions may influence exact temperature readings.

3. Geological Setting(12, 17, 23)

Elko County has a varied geological setting. The southern portion of the county has a geological character more or less typical of the Basin and Range Geomorphic Province with elongate mountains separated by long alluvial filled valleys. The northern portion of the county is a high, dissected plateau transitional between the Basin and Range and the Snake River Plateau Geomorphic Provinces.

The geological formations in Elko County range in age from

Pre-Cambrian to Recent. Pre-Cambrian rocks are primarily quartzite and outcrop only in a few places on the eastern edge of the county. The Paleozoic period is represented by two major rock facies: 1) slate, chert, and metamorphosed volcanic rock in the western area; and 2) impure sandstones and carbonates in the eastern area. Triassic sandstone, shale, and limestone are found in eastern Elko County. All of these formations were strongly folded and broken by thrust faults in the middle to late Mesozoic time. The largest of the thrust faults displaced much of the Paleozoic rock eastward several tens of miles.

Volcanic activity began in the Tertiary and lasted until the Quaternary. This gave rise to a thick sequence of lavas and pyroclastic deposits. These, together with intermixed continental sedimentary rock units, cover much of Elko County.

The Basin and Range topography that characterizes much of Elko County has been developed over all of these rock types. This topography has been developed by normal faulting creating large fault blocks and is expressed as long north-south trending mountains and valleys. The Great Basin portion of the Basin and Range province is an area of internal drainage and has several large ephemeral lakes.

The northern portion of Elko County is transitional between the Basin and Range Province and the Snake River Plateau Province. This area lacks the characteristic topographic assemblage of isolate mountain ranges and adjacent intermountain basins with their alluvial fills and ephemeral lakes. Folding is more common than faulting making the area structurally an unwarped area.

The geothermal resource in the study area is associated with the long north-south trending normal faults characteristic to the Basin and Range Province. Water, originating as rainfall, sinks deep into the earth where it is heated by contact with a geothermal heat source. This heat source may be either a cooling magmatic body or rock heated by the earth's geothermal gradient. The heated water then rises to the surface along the deep faults

which offer permeable conduits for fluid movement. If these faults cut the earth's surface, hot springs and other surface expressions of geothermal energy may appear. It should be noted that geothermal resources may be present without such surface indications. One of the goals of modern exploration geology is to locate these "hidden" resources.

4. Hydrology(7, 8, 9)

The Elko County area contains portions of four of the hydrographic regions found in Nevada. These regions include the Snake River Basin; Humboldt River Basin; Central Region; and Great Salt Lake Basin.

A minor portion of the Snake River Basin occurs in the northern portion of Elko County and is a small portion of the headwater area of the Snake River which extends into Idaho, Utah, and Oregon. The large streams in the Snake River Basin portion of Elko County are the East Little Owyhee River, the South Fork Owyhee River, East Fork Owyhee River, Bruneau River, Jarbidge River, Salmon Fall Creek, and Goose Creek. There are no closed basins. All drainages contribute to the Snake River system which joins the Columbia River and eventually enters the Pacific Ocean.

The Humboldt River Basin is another large hydrographic region found in Elko County. The Humboldt River is a slow meandering river beginning near the town of Wells and flowing over 300 miles to the west before it finally enters the Humboldt Sink where infiltration and evaporation consume all of the remaining water. During years of extremely high flow, runoff water will flow into the Carson Sink which is about 20 feet lower.

The Central Region covers much of the southern portion of the county and is characterized by long, narrow valleys with small, intermittent streams emptying into the valley bottoms where the flows evaporate. The perennial streams are usually only a few miles long. There are no standing bodies of water even though the area is characterized by internal drainage.

The fourth hydrographic region found in Elko County is the Great Salt Lake Basin which is characterized by small intermittent streams and large dry playas. Precipitation that does fall runs off to the east before infiltrating into the groundwater system or evaporating back into the atmosphere.

The hydrology of Elko County is typical of that occurring in high deserts. Precipitation is very seasonal, some occurring in the summer as thundershowers, but most occurring in the winter as snow. Snowmelt streamflows are equally seasonal with peaks occurring in late spring. Flows from thundershowers can occur at any time during the summer months and can be quite destructive in nature. Runoff typically reaches a peak flow in the late spring and an annual low flow in the late summer or early fall. Approximately 50 percent of the runoff occurs during April and May with only four percent occurring in August and September. These wide ranges in flow create multiple problems. Seasonal high flows often result in flood damage with serious erosion and sedimentation. Low flows limit agricultural production and tend to cause high water temperatures. Both sedimentation and high water temperatures can adversely effect fish life and general water quality.

The Nevada State Engineer has defined four designated groundwater basins in Elko County (Table 7). Such basins are ones in which more groundwater has been allocated than is believed to be annually recharged into the basin. The Division of Water Resources has special regulations and permitting procedures which are required before water from these designated basins can be used.

Table 7

DESIGNATED GROUNDWATER BASINS IN ELKO COUNTY

Basin Name	Basin Number	Order Number	Date
Clover's Area	64	700	12-30-1977
Steptoe Valley	179	731	9-21-1979
		179	8-21-1980
Salmon Creek Falls	40	736	2-15-1980
		737	
North Fork Area	44	744	5-28-1980

Because Elko County's geothermal resources are the water dominated type, any use of those resources may affect local groundwater conditions. This may impact historical use of groundwater in those areas and raise questions concerning water rights and water allocation. However, geothermal energy development is considered to be a preferred use of the groundwater. Any developer of geothermal resources in these basins must contact the State Water Engineer early in any project's planning phases to insure that all such water related questions are answered.

B. Land Ownership and Land Use(15)

Elko County totals nearly 17,162 square miles in size. Table 8 shows the land ownership pattern found in the County.

Table 8

LAND OWNERSHIP PATTERNS IN ELKO COUNTY

<u>Public Land</u>	<u>Acres</u>	<u>Percent</u>
Federal	7,866,907	71.50
State	3,403	0.03
County	3,280	0.03
Total Public	7,873,621	71.56
Private Land		
Indian	164,605	1.50
Tax Roll	2,957,614	26.90
Total Private	3,122,219	28.40

FIGURE 3

LAND OWNERSHIP IN ELKO COUNTY

Existing land use patterns in Elko County are based primarily on the proximity to the major community of Elko and other smaller population centers. Away from these centers the land has historically been used for agriculture, ranching, mining, wildlife management, and open space. The Bureau of Land Management has classified most of the 6,780,334 acres of the public land it administers as multiple use. This classification includes all types of uses from recreation, wildlife management, watershed management, livestock grazing, and timber production on the more heavily forested portions of the land. Other federal agencies holding title to the land in Elko County, such as the U.S. Forest Service and the Bureau of Reclamation, are also managing their lands according to multiple use concept where possible. The only BLM lands not being managed for multiple use are those units being studied as potential wilderness areas.(18)

There are nine wilderness study areas in Elko County. The units currently having this designation are Devil's Corral, Owyhee Canyon, North Fork Little Humboldt, Little Humboldt River, Rough Hills, Badlands, Goshute Peak, South Pequop, and Bluebell. These study areas are those which the BLM believes meets the following criteria:

1. Size--must have at least 5,000 or more acres of contiguous public land or be of a size to make practical its preservation and use in an unimpaired condition;
2. Naturalness--must be substantially natural or generally appear to have been affected primarily by the forces of nature with the imprint of man's work substantially unnoticeable;
3. Outstanding solitude or recreation--must have either outstanding opportunities for solitude or a primitive and unconfined type of recreation;
4. Supplemental values--must have supplemental values, which include ecological, geological, or other natural features of scientific, educational, scenic, or historical value.

These nine Wilderness Study Areas will continue to be managed

under special guidelines directed by Congress to preserve the wilderness values until a final determination of wilderness suitability or unsuitability is made.

There are no known geothermal resources within the boundaries of any of the potential wilderness areas. Should any be located in the future, the development of those resources will be subject to BLM Wilderness Area Management Policy.

Larger urban communities develop various zoning classifications to segregate various land uses within the community to those which are deemed compatible. Such uses include residential, commercial, governmental/institutional, various types of industrial, and agricultural. Geothermal development must be compatible with existing development in these zoned areas.

C. Population(19)

The population of Elko County has steadily increased during the past century. Between 1920 and 1976 the population of this county area increased by 92 percent. For several economic and social reasons the State Planning Coordinator's Office anticipates that such growth will continue into the future. Table 9 illustrates the past and projected growth in Elko County.

Table 9

POPULATION TREND IN ELKO COUNTY

<u>Year</u>	<u>Population</u>	<u>Year</u>	<u>Population</u>
1920	8,083	1973	15,254
1930	9,960	1974	15,400
1940	10,912	1975	15,200
1950	11,654	1976	15,418
1960	12,011	1977	15,098
1961	12,211	1978	16,073
1962	12,187	1979	17,048
1963	12,168	1980	18,024
1964	12,217	1981	18,565
1965	12,841	1982	19,105
1966	13,299	1983	19,646
1967	13,131	1984	20,186
1968	13,076	1985	20,727
1969	14,056	1990	23,620
1970	13,958	1995	26,240
1971	13,800	2000	28,940
1972	14,600		

The existing population of Elko County is not evenly distributed but is localized into distinct population centers with only scattered persons in the rural areas. The largest of the population centers is the city of Elko located in the central portion of the county along the Humboldt River. Other cities with populations greater than 500 persons include Carlin, Wells, Jackpot and Owyhee (Figure 10). Other small communities include Lamoille, Montello, Mountain City, Wendover, Deeth, and Tuscarora.

Table 10 graphically illustrates the anticipated growth of the communities of Elko County. The State Planning Coordinator's Office projections indicate that all cities will experience growth with Elko, Jackpot, and Wendover growing by the largest number of people. Even though the smaller communities will experience a larger rate of population growth, the total number of persons will be less than the larger communities.

The community and county population projections are based on historical population growth data. Should any types of new, unanticipated development activities occur, these estimates could be invalidated.

Table 10

POPULATION PROJECTIONS TO THE
YEAR 2020 IN ELKO COUNTY*

City	1980	1990	2000	2010	2020
Carlin	1,300	1,300	1,400	1,450	1,500
Elko	10,500	14,100	18,000	23,000	26,000
Wells	1,130	1,200	1,300	1,400	1,500
Jackpot	1,000	1,400	1,750	2,200	2,430
Owyhee	700	800	900	1,000	1,100
Lamoille	300	450	600	750	850
Montello	200	300	400	500	600
Mountain City	100	150	200	250	300
Deeth	60	80	90	100	110
Tuscarora	60	80	90	100	110
Wendover	150	500	700	900	1,000

*Projections supplied by Governor's Office of Planning
Coordination.

D. Transportation Facilities(4, 5, 6)

Two highways pass through Elko County. U.S. 93 is a major north-south route connecting the towns of Jackpot, Wells, Ely, Pioche, Caliente, and Las Vegas. Interstate 80, the second major route, connects the towns of Wells, Elko, Carlin, Battle Mountain, Winnemucca, Lovelock, Fernley, Wadsworth, Sparks, Reno, and Verdi.

The Elko County area has approximately 8,189 miles of roadway with 665 miles on the federal aid system, 194 miles on the state aid system, 7,235 miles on the county system, and 77 on city or local systems. The area has approximately 7,430 miles of unpaved road and 759 miles of roadway paved to various standards.

Transportation services are very good for a rural county. Those areas located along I-80 have access to all major interstate trucking firms with some terminal facilities available in the City of Elko. Limited air service is available from the Elko Municipal Airport. Two commercial airlines make daily stops with charter service also available. The two nearest full-service airports in the region are Salt Lake City International Airport located about 290 miles to the east of Elko and Cannon International Airport located about 289 miles to the southwest in Reno. Two railroads, Western Pacific and Southern Pacific, have main lines through the area and maintain large yard areas in Elko. Western Pacific usually runs two trains per day and Southern Pacific has about 20 trains per day. All of these trains are freight only. The only passenger service is AMTRAK which serves the area with two trains per day. Additionally, two interstate bus lines provide passenger transportation needs.

FIGURE 4
MAJOR TRANSPORTATION FACILITIES
IN ELKO COUNTY

E. Economic Activities

1. Background(15)

Elko County was once part of Lander County. The first settlers established a small community just east of the Ruby Mountains in what today is the City of Elko. In 1868 the city was booming due to construction of the railroad. This prosperity led to plans by Elko's citizens for breaking away from Lander County and creating a new county. On March 5, 1869, Elko County was created by the State Legislature.

Weather has had a significant impact on development of the county. In the late 1800's severe blizzards wrecked the local businesses by destroying the cattle industry, which provided the main support for the City of Elko. By the year 1900 the City of Elko's population had decreased from 4,000 to 849.

Recovery in Elko was slow but was aided by the legalization of gambling in 1931. Today about 31 different companies mine gold, silver, tungsten, barite, copper, molybdenum, and various aggregates. Ranching and tourism remain vital to the economic stability of the county.

2. Employment and Income(11)

Services, government, and wholesale and retail trade are the county's leading employers. Services accounted for 31 percent of employment in 1979; government accounted for 27 percent and wholesale and retail trade accounted for 16 percent. The service industry today is playing a bigger role in the economy of the county and appears to be taking over from the historic agricultural industry (Table 10).

Elko County's unemployment rate has been decreasing since 1976 when it was 5.7 percent. In 1979 it was 4.1 percent, one percentage point lower than the state average.

Per capita income in Elko County was Nevada's fifth highest

Table 11

1979 EMPLOYMENT PATTERNS -- ELKO COUNTY(11)

Industry	Number of Firms	Number of Employees	Percent of Employees	Total Wages	Percent of Wages
Mining	34	284	4	5,028,743	6
Construction	78	377	5	5,566,378	7
Manufacturing	10	173	2	1,799,214	2
Trans., Comm., and Util.	36	355	5	5,908,636	7
Wholesale & Retail Trade	184	1,477	21	12,574,893	16
Fin., Ins., and Real Estate	43	220	3	2,663,586	3
Service Industries*	157	2,623	37	24,807,735	31
Government	39	1,665	23	21,134,427	27
TOTAL	581	7,174	100	79,483,612	99

*Includes Agricultural Services and Firms not Elsewhere Classified.

in 1977--\$7,543. The estimated median income of families in the area was \$18,600 in 1978, fourth highest in Nevada.

F. Design Information(1)

The engineering design characteristics for the community of Elko in Elko County are as follows:

Latitude	40°50'
----------	--------

Longitude	115°47'
-----------	---------

Elevation	5,075 feet
-----------	------------

Winter Design Dry-Blub Temperature

99%	-8°F.
95.5%	-2°F.

Summer Design Dry/Blub and Mean
Coincident Wet-Blub Temperature

1%	94°/59°F.
2.5%	92°/59°F.
5%	90°/59°F.

Mean Daily Temperature Range

	42°F.
1%	63°F.

Design Wet-Blub Temperature

2.5%	62°F.
5%	60°F.

Degree Heating Days	7,397
---------------------	-------

Degree Cooling Days	573
---------------------	-----

Additional degree heating and cooling day information is available for the following sites in Elko County:

	<u>Elevation</u>	<u>Degree-Heating Days</u>	<u>Degree-Cooling Days</u>
Contact	5,365	6,969	286
Jiggs	5,415	8,679	---
Lamoille	6,290	7,277	270
Owhyee	5,396	7,415	272
Ruby Lake	6,012	7,257	280
Wells	5,650	7,686	---
Wilkins	5,640	7,905	136

G. Energy Information

The energy situation in Elko County is typical of that in northern Nevada. Most of the electrical energy in the region is supplied by Idaho Power Company, C.P. National, Raft River Rural Electric Cooperative, or Wells Rural Electric. C.P. National receives all of their electricity for resale from Sierra Pacific Power Company. Idaho Power Company supplies the majority of the remaining electrical energy in the serviced area. There are areas, however, that have no electrical service and developments in these areas must generate their own electricity using diesel generators.

Electrical energy supplied by Sierra Pacific Power Company tends to be more costly than electricity supplied by most other power companies in Nevada. The primary reason for this fact is that Sierra Pacific's only generation facilities, the Tracy and Fort Churchill Powerplants, use oil or natural gas as a fuel. Approximately 60 percent of the natural gas used comes from Canada and the majority of the oil is imported from neighboring states or foreign countries. Substantial price increases for both of these fuels in the years since the 1973-1974 Arab Oil Embargo have caused rapid escalation in costs to electrical users.

Wells Rural Electric Company supplies the electrical needs of consumers throughout much of central Elko County. The electrical energy supplied in this area is generated at hydroelectric projects in southern Idaho which is less expensive to produce because there are no costs for high priced fossil fuels.

Idaho Power Company has a somewhat broader supply base as an electrical source. Not only does the company have access to conventional fossil fuel generated electricity but they also have access to hydroelectric power from both their own hydroelectric plants and from purchases from the Bonneville Power Administration.

Southwest Gas Company supplies natural gas to the communities of Carlin and Elko. The company also has authority to service areas within one mile of its main pipeline. The cost of the natural

gas obtained through Southwest Gas is steadily rising because most of the natural gas purchased for use in northern Nevada is from Canada. Substantial price increases have been imposed on this gas in the last few years.

Natural gas is available in the study area only in the more urbanized areas. Consumers in outlying areas must rely on electricity, liquified petroleum gas (LPG), or other petroleum products to satisfy their energy demands. In remote rural areas, the costs of importing these fuels has become extremely high. Energy costs for petroleum products have more than doubled in the last few years.

Coal is another energy source that has seen some limited use in the study area. The amount used, in relation to other energy sources, is very small and consists mostly of residential applications.

Other potential alternative energy sources that have some development possibilities in the near future include solar, geothermal, and wind systems. The Nevada Department of Energy is actively encouraging the development of all of these alternative energy resources.

Several various groups around the United States have designed computer models projecting on-line geothermal energy use for the next several decades. The NDOE prefers the model prepared by the New Mexico Energy Institute (NMEI) because it is easy to work with, modify data inputs, and interpret. The model prepared by NMEI covers the period between 1980 and 2019 and separates development categories between private and municipal developers. Tables 12 and 13 give the NMEI geothermal energy on-line projections based on these two categories.

Based on these projections, it is believed that private developers developing the geothermal resources for residential and/or industrial applications could have about 1.95×10^{12} BTUs of energy on-line by the year 2000 and 2.77×10^{12} BTUs on-line by 2019. In these two years alone, about 14,130,400 and 20,072,400 barrels of oil respectively could be replaced by geothermal energy. This is also equal to a savings of 5.71×10^8 and 8.12×10^8 kilowatt hours of electricity.

Table 12

NEW MEXICO ENERGY INSTITUTE--GEOTHERMAL DIRECT USE ENERGY PROJECTIONS--
 COMBINED INDUSTRIAL AND RESIDENTIAL APPLICATION WITH PRIVATE DEVELOPER
 --ELKO COUNTY--

Year	Projected geothermal energy on-line (BTUs)	Gallons of Oil Replaced	Kilowatt hours of electricity replaced
1980	-0-		
1981	-0-		
1982	-0-		
1983	5.93 x 10 ¹¹	173,749,000	1.74 x 10 ⁸
1984	8.83 x 10 ¹¹	6,398,550	2.59 x 10 ⁸
1985	1.25 x 10 ¹²	9,057,971	3.66 x 10 ⁸
1986	1.42 x 10 ¹²	10,289,855	4.16 x 10 ⁸
1987	1.46 x 10 ¹²	10,579,710	4.28 x 10 ⁸
1988	1.50 x 10 ¹²	10,869,565	4.40 x 10 ⁸
1989	1.54 x 10 ¹²	11,159,420	4.51 x 10 ⁸
1990	1.58 x 10 ¹²	11,449,275	4.63 x 10 ⁸
1991	1.62 x 10 ¹²	11,739,130	4.75 x 10 ⁸
1992	1.67 x 10 ¹²	12,101,449	4.89 x 10 ⁸
1993	1.70 x 10 ¹²	12,318,841	4.98 x 10 ⁸
1994	1.73 x 10 ¹²	12,536,232	5.07 x 10 ⁸
1995	1.77 x 10 ¹²	12,826,087	5.19 x 10 ⁸
1996	1.80 x 10 ¹²	13,043,478	5.27 x 10 ⁸
1997	1.84 x 10 ¹²	13,333,333	5.39 x 10 ⁸
1998	1.87 x 10 ¹²	13,550,725	5.48 x 10 ⁸
1999	1.91 x 10 ¹²	13,840,580	5.60 x 10 ⁸
2000	1.95 x 10 ¹²	14,130,435	5.71 x 10 ⁸
2001	1.98 x 10 ¹²	14,347,826	5.80 x 10 ⁸
2002	2.02 x 10 ¹²	14,637,681	5.92 x 10 ⁸
2003	2.06 x 10 ¹²	14,927,536	6.04 x 10 ⁸
2004	2.10 x 10 ¹²	15,217,391	6.15 x 10 ⁸
2005	2.14 x 10 ¹²	15,507,246	6.27 x 10 ⁸
2006	2.18 x 10 ¹²	15,797,101	6.39 x 10 ⁸
2007	2.22 x 10 ¹²	16,086,957	6.50 x 10 ⁸
2008	2.26 x 10 ¹²	16,376,812	6.62 x 10 ⁸
2009	2.30 x 10 ¹²	16,666,667	6.74 x 10 ⁸
2010	2.35 x 10 ¹²	17,028,986	6.89 x 10 ⁸
2011	2.39 x 10 ¹²	17,318,841	7.00 x 10 ⁸
2012	2.44 x 10 ¹²	17,681,159	7.15 x 10 ⁸
2013	2.48 x 10 ¹²	17,971,014	7.27 x 10 ⁸
2014	2.53 x 10 ¹²	18,333,333	7.41 x 10 ⁸
2015	2.57 x 10 ¹²	18,623,188	7.53 x 10 ⁸
2016	2.62 x 10 ¹²	18,985,507	7.68 x 10 ⁸
2017	2.67 x 10 ¹²	19,347,829	7.82 x 10 ⁸
2018	2.72 x 10 ¹²	19,710,145	7.97 x 10 ⁸
2019	2.77 x 10 ¹²	20,072,464	8.12 x 10 ⁸

Table 13

NEW MEXICO ENERGY INSTITUTE--GEOTHERMAL DIRECT USE ENERGY PROJECTIONS--
 COMBINED INDUSTRIAL AND RESIDENTIAL APPLICATION WITH MUNICIPAL
 DEVELOPER--ELKO COUNTY.

Year	Projected geothermal energy on-line (BTUs)	Gallons of Oil Replaced	Kilowatt hours of electricity replaced
1980	-0-		
1981	-0-		
1982	-0-		
1983	6.53 x 10 ¹¹	4,731,884	1.91 x 10 ⁸
1984	9.44 x 10 ¹¹	6,840,580	2.77 x 10 ⁸
1985	1.25 x 10 ¹²	9,057,971	3.66 x 10 ⁸
1986	1.42 x 10 ¹²	10,289,855	4.16 x 10 ⁸
1987	1.46 x 10 ¹²	10,579,710	4.28 x 10 ⁸
1988	1.50 x 10 ¹²	10,869,565	4.40 x 10 ⁸
1989	1.54 x 10 ¹²	11,159,420	4.51 x 10 ⁸
1990	1.58 x 10 ¹²	11,449,275	4.63 x 10 ⁸
1991	1.63 x 10 ¹²	11,811,594	4.78 x 10 ⁸
1992	1.67 x 10 ¹²	12,101,449	4.89 x 10 ⁸
1993	1.71 x 10 ¹²	12,391,304	5.01 x 10 ⁸
1994	1.74 x 10 ¹²	12,608,696	5.10 x 10 ⁸
1995	1.78 x 10 ¹²	12,898,551	5.22 x 10 ⁸
1996	1.81 x 10 ¹²	13,115,942	5.30 x 10 ⁸
1997	1.84 x 10 ¹²	13,333,333	5.39 x 10 ⁸
1998	1.88 x 10 ¹²	13,623,188	5.51 x 10 ⁸
1999	1.91 x 10 ¹²	13,840,579	5.60 x 10 ⁸
2000	1.95 x 10 ¹²	14,130,435	5.71 x 10 ⁸
2001	1.98 x 10 ¹²	14,347,826	5.80 x 10 ⁸
2002	2.02 x 10 ¹²	14,637,681	5.92 x 10 ⁸
2003	2.06 x 10 ¹²	14,927,536	6.04 x 10 ⁸
2004	2.10 x 10 ¹²	15,217,391	6.15 x 10 ⁸
2005	2.14 x 10 ¹²	15,507,246	6.27 x 10 ⁸
2006	2.18 x 10 ¹²	15,797,101	6.39 x 10 ⁸
2007	2.22 x 10 ¹²	16,086,957	6.50 x 10 ⁸
2008	2.26 x 10 ¹²	16,376,812	6.62 x 10 ⁸
2009	2.30 x 10 ¹²	16,666,666	6.74 x 10 ⁸
2010	2.35 x 10 ¹²	17,028,986	6.89 x 10 ⁸
2011	2.39 x 10 ¹²	17,318,840	7.00 x 10 ⁸
2012	2.44 x 10 ¹²	17,681,159	7.15 x 10 ⁸
2013	2.48 x 10 ¹²	17,971,014	7.27 x 10 ⁸
2014	2.53 x 10 ¹²	18,333,333	7.41 x 10 ⁸
2015	2.57 x 10 ¹²	18,623,188	7.53 x 10 ⁸
2016	2.62 x 10 ¹²	18,985,507	7.68 x 10 ⁸
2017	2.67 x 10 ¹²	19,347,260	7.82 x 10 ⁸
2018	2.72 x 10 ¹²	19,710,145	7.97 x 10 ⁸
2019	2.77 x 10 ¹²	20,072,464	8.12 x 10 ⁸

Were a municipal developer to develop the resources in the study area, it is projected that more energy could be on-line faster. By the year 2000 1.95×10^{12} BTUs are projected and by the year 2010, 2.77×10^{12} BTUs, the maximum projected development, could be on-line. This would represent an annual energy savings of 14,130,400 barrels of oil or 5.71×10^8 hours of electricity in the year 2000 and 20,072,400 barrels of oil or 8.12×10^8 kilowatt hours of electricity in the year 2004. The reasons for the more rapid development of the geothermal resources by municipal utilities are complex. They do, however, depend upon the utilities' ability to get authority and funding priority.

Energy costs for fossil fuels such as natural gas and oil will continue to rise in the foreseeable future. This is primarily due to the fact that the source of much of this fuel is outside of the United States and decreased worldwide production. Coal, one of the major non-renewable energy resources found in abundance in the United States, can be processed into synthetic fuels which are quite expensive. Additionally, strip mining of the coal and the air pollution created when it is burned pose serious environmental questions.

Geothermal energy offers an attractive alternative to these non-renewable energy resources. It is relatively clean, less expensive to use, and attractive to many types of developers. Geothermal technology is becoming more available to manage geothermal reservoirs to obtain maximum production over the longest period of time and to make use of very difficult fluid types. Thus, the development of the geothermal resources in Elko County should be encouraged wherever and whenever possible. This development would benefit both Nevada's citizens and industries, and would assist in the development of an energy independent United States.

III. The Resource

A. General Information

There are approximately seven geothermal sites in Elko County with the potential for commercial development. The major of these include Sulfur Hot Springs, Hot Sulfur Springs and Elko Hot Springs. Additionally there are other geothermal sites in the county that have somewhat smaller and cooler reservoirs. The following portion of this report includes a discussion of several geothermal areas in Elko County with a brief description of the known characteristics of each resource.

Evaluation of the geothermal reservoir is difficult because of the limited information currently available. The size of the reservoir was determined from the U.S.DOE publication Geothermal Direct Heat Use Market Potential for the smaller resources, or from U.S.G.S. Circular 790 for the larger resources. The heat energy stored in the reservoir was determined by methodology developed by the U.S.G.S. Using this methodology, the potential heat energy in a geothermal reservoir is calculated using such known factors as the surface area of the reservoir, the depth of the reservoir, the temperature of the reservoir, and the specific heat of rock. The formula used for this calculation is:

(27)

$qr = pc \times a \times d (t - t_{ref})$ where:

qr = reservoir thermal energy in BTUs

pc = volumetric specific heat of rock plus water 40.284
BTU/ft³/°F

a = reservoir area

d = reservoir thickness

t = reservoir temperature

t_{ref} = reference temperature (59° F.)

Existing technology is not capable of extracting all of the energy from the geothermal reservoir. To give a more realistic value to the energy obtainable, an assumption of 25 percent of total reservoir capacity is used. This value should be considered an estimate and may or may not be representative of the actual reservoir conditions.

It should be emphasized that the information presented about each

FIGURE 5

LOCATIONS OF GEOTHERMAL RESOURCES IN ELKO COUNTY

geothermal reservoir is based on the best information currently available. The actual conditions in the reservoir may be considerably different than indicated. Any party investigating the development of any of these resources is urged to contact the Nevada Bureau of Mines and Geology or the UNLV Museum of Natural History for additional resource information and to engage the services of a reputable consulting firm that has had experience in assessing geothermal reservoirs.

B. Sulfur Hot Springs

1. Description(14)

Sulfur Hot Springs, located on the northwest side of Ruby Valley, is the hottest known geothermal reservoir in Elko County. The springs issue from a siliceous sinter mound about 1,500 feet in diameter. The mound is located on an alluvial fan developing along the east flank of the Ruby Mountains. Water from the springs flows into Stonier Lake. There is no reported existing use of the water from these hot springs.

The thermal water associated with Sulfur Hot Springs is probably rising to the surface from some depth along one of the several typical Basin and Range normal faults passing through the area. The largest of these is the range front fault separating the unconsolidated valley fill alluvium from the bedrock of the Ruby Mountains.

The geothermal reservoir of Sulfur Hot Springs is believed to cover a roughly circular area of about two square miles. The extensive area of sinter suggests that the reservoir may be quite hot.

2. The Reservoir

The following parameters are believed to describe the Sulfur Hot Springs geothermal reservoir:

Volume(31)

1.87 cubic mile

Temperature(34)

Measured temperature-----205° F.
Quartz adiabatic geothermometer-----340° F.*
Na-K-Ca geothermometer-----358° F.*
Quartz conductive geothermometer-----361° F.*
Mean reservoir temperature-----352° F. $\pm$ 2° F.

Discharge(14)

Spring discharge estimated to be about 132 gallons per minute.

Water Chemistry(14)

Three water chemistry analyses of water from Sulfur Hot Springs are reproduced in Appendix 1. Analysis of these samples indicates that the water from Sulfur Hot Springs meets all standards for safe drinking water set by the State of Nevada.

Energy Content(34)

Potential heat energy found in the reservoir-- 3.2×10^{15} BTUs
Heat energy extractable with
existing technology----- 8.1×10^{15} BTUs

C. Hot Sulfur Springs

1. Description(14)

The Hot Sulfur Springs resource is the second hottest known to occur in Elko County. The springs are located about ten miles northeast of Tuscarora in Independence Valley. Considerable quantities of sulfur are reported in and around the spring area. No past or present uses of the water from this reservoir are known at this time. There has been some geothermal exploration activities in the area of these springs by AMAX Exploration Company.

*Be cautious when using any geothermometer readings given in this document. Local conditions may influence the accuracy of the temperatures indicated.

2. The Reservoir

The following parameters are believed to describe the Hot Sulfur Springs geothermal reservoir:

Volume(34)

0.79 cubic mile

Temperataure(34)

Measured Temperature-----194° F.
Chalcedony geothermometer-----291° F.
Quartz conductive geothermometer-----332° F.
Na-K-Ca geothermometer-----363° F.
Mean reservoir temperature-----329° F. +4° F.

Discharge

No information currently available

Water Chemistry(14)

Two water chemistry analyses of water from Hot Sulfur Springs are reproduced in Appendix 1. Analysis of these samples indicates that water from these springs meets all standards for safe drinking water standards except for total dissolved solids.

Energy Content(34)

Potential heat energy found in the reservoir-- 1.3×10^{15} BTUs
Heat energy extractable with
existing technology----- 3.2×10^{14} BTUs

D. Elko Hot Springs

1. Description(14)

The Elko Hot Springs area is located about one and one-half miles southwest of downtown Elko. During pioneer days the springs were a landmark along the emigrant trail. The first development of the resource was in 1868 when a steam bathhouse was built. These buildings went through several different owners and two major fires before 1900. A brick building constructed after the second fire and the hot springs themselves have been incorporated into Elko County's Home for the Aged. Other uses of the springs have included greenhousing, hatching chickens, and an attempt to use the heat from the thermal water to distill oil from local oil shale.

Elko Hot Springs cover a narrow zone about one half mile long. The source of the thermal water for the springs appears to be an upflow of deep groundwater along typical Basin and Range faulting structures. The springs themselves flow from Tertiary sedimentary rocks.

At the north end of the Elko Hot Springs zone is an area called the Hot Hole and was the major emigrant stop. It was once used as Elko's municipal swimming pool.⁽¹⁴⁾ The Hot Hole is a 400 to 500-foot diameter travertine dome with a central hole about 200 feet in diameter. A pool of warm water about 35 feet by 75 feet stands in the center approximately 20 feet higher than the nearby Humboldt River and water drains from the Hot Hole directly into the Humboldt. One-half mile south of the Hot Hole is the site of the old spa and the Elko County Home for the Aged. Additionally, several wells throughout the community of Elko have encountered warm to hot water. The location of these wells suggests an extension of thermal activity on the same north-northeast trending fault present at Elko Hot Springs.

2. Summary of Exploration

There has been little formal exploration of the Elko Hot Springs geothermal resource other than that conducted by Chilton Engineering in their federally funded demonstration project for

the Elko Heat Company. To date, Chilton Engineering has completed various geologic and geophysical studies and has drilled three 1,000 foot wells. The temperature gradient in these wells was 2.2° F. per 100 feet. The most recent well has a substantial temperature and flow rate.

3. The Reservoir

The following parameters are believed to describe the Elko Hot Springs geothermal reservoir:

Volume(31)

.79 $\pm$.2 cubic mile

Temperature(34)

Measured temperature range-----150°-192° F.

Na-K-Ca, Mg corrected geothermometer-----176° F.

Chalcedony geothermometer-----186° F.

Quartz conductive geothermometer-----237° F.

Mean reservoir temperature-----199° F. $\pm$ 4° F.

Discharge

No information currently available

Water Chemistry(14)

Two water chemistry analyses of water from Elko Hot Springs are reproduced in Appendix 1. These analyses indicate that water from this geothermal resource meets all standards for safe drinking water.

Energy Content(34)

Potential heat energy found in the reservoir-- 6.6×10^{14} BTUs

Heat energy extractable with existing technology-- 1.6×10^{14} BTUs.

E. San Jacinto Ranch (Mineral) Spring

1. Description(14)

Approximately eight miles north of Contact are several hot springs and wells with temperatures reported to be as high as 148° F. Nearby is the trace of a major fault which is believed to be present at the springs below a layer of alluvium.

2. The Reservoir

The following parameters are believed to describe the San Jacinto Ranch geothermal reservoir:

Volume(32)

0.24 cubic mile

Temperature(14)

Reported temperature-----148° F.

Discharge

No information available

Water Chemistry(14)

Three water chemistry analyses of water from the San Jacinto Ranch Springs is reproduced in Appendix 1. The water from these springs meets all standards set for safe drinking water set by the State of Nevada.

Energy Content(34)

Potential heat energy found in the reservoir-- 1.3×10^{14} BTUs

Heat energy extractable with

existing technology----- 3.2×10^{13} BTUs

Special Note

San Jacinto Ranch Springs is located in a designated groundwater basin and is subject to special regulation by the State Water Engineer's Office.

F. Humboldt Wells

1. Description(14)

There are several warm springs in the vicinity of Wells, Nevada scattered over several square miles. No determination has been made yet if they represent a single geothermal reservoir or are a composite of several different geothermal reservoirs. Several springs about one mile north of Wells have reported temperatures as high as 142° F. Several miles north of these springs in the Twelve Mile Canyon area is a spring with a temperature of 120° F. Other springs in the "system" have temperatures ranging from 97° F. to 140° F. The geothermal resource appears to be associated with a normal Basin and Range fault that runs along the east side of the Snake Mountains. This fault is thought to extend along the northeast side of the East Humboldt Range.

2. The Reservoir(14)

It is uncertain if the geothermal resource at Humboldt Wells represents a single or multiple reservoirs. For purpose of this evaluation it will be considered a single reservoir. It must be noted, however, that additional study may invalidate this assumption.

Reservoir Volume(32)

1.48 $\pm$.46 cubic mile

Temperature(14)

Reported surface temperature-----142° F.

Reported temperature (Twelve Mile Canyon)-120° F.

Na-K-Ca geothermometer-----363° F.

Discharge

No Information available

Water Chemistry(14)

Two water chemistry analyses from the Humboldt Wells geothermal reservoir are reproduced in Appendix 1. These water samples indicate that this reservoir meets all standards for safe drinking water except for total dissolved solids.

Energy Content(34)

Potential heat energy found in the reservoir-- 5.6×10^{14} BTUs

Heat energy extractable with

existing technology----- 1.3×10^{10} BTUs

G. Hot Springs near Carlin

1. Description(14)

Two hot springs can be found in the vicinity of Carlin in Elko County with temperatures reported to be as high as boiling. No past or current uses of these springs are known, although their location indicates that they probably have been used for stock watering.

2. The Reservoir

The following parameters are believed to describe the geothermal reservoir associated with the hot springs near Carlin.

Volume(32)

0.79 cubic mile

Temperatures(34)

Reported surface temperature-----boiling

Na-K-Ca geothermometer----- 177° F.

Chalcedony geothermometer----- 194° F.

Quartz geothermometer----- 244° F.

Mean reservoir temperature----- 205° F.

Discharge

No information available

Water Chemistry(34)

One water chemistry analysis has been run on water from the hot springs near Carlin. This analysis is reproduced in Appendix I. Due to the nature of this analysis it is not possible to determine if the water meets Nevada's Safe Drinking Water Standards.

Energy Content(34)

Potential heat energy found in the reservoir-- 6.8×10^{14} BTUs

Heat energy extractable with

existing technology----- 1.7×10^{14} BTUs

H. Thousand Springs

1. Description(14)

Several hot springs are reported along Thousand Springs Creek about eight miles north of Montello with temperatures in the springs and nearby wells ranging from 69° F. to 111° F.

2. The Reservoir

Very little is known of the characteristics of the Thousand Springs geothermal resource other than the temperatures reported above and one chemical analysis run on the Gamble Ranch Well Number 4. On the basis of insufficient information no statement can be made about the reservoir volume, temperature, or discharge. The single water chemistry analysis is available on the Gamble Ranch. This analysis is reproduced in Appendix I. This analysis indicates that the water from this well meets all standards for safe drinking water.

I. Other Hot Springs in Elko County

Elko County has up to 40 other areas where thermal waters have been encountered. Temperatures in these springs are 140° F. or cooler. They include areas such as Contact Mineral Spring, Rozzi Ranch Springs, Goose Creek, Wild Horse Hot Spring, White Cup Ranch, Ralph's

Warm Springs, and those along the northeast margin of the Ruby Mountains.

IV. THE USES

A. General Information

Uses for geothermal energy fall into two broad categories: electrical generation and direct use of the hot water. Electrical generation on a practical commercial scale requires both a high temperature resource and a large geothermal reservoir.

Direct uses of geothermal energy are more varied and can economically use both lower temperatures and less extensive resources. Hot water from a geothermal electrical generation plant can be used for other applications requiring lower temperatures after leaving the generation facility in a cascaded sequence. Figure 6 illustrates the various types of applications considered feasible for geothermal energy and the temperature requirements for each use.

For the purpose of this study, direct applications have been broken down into four major categories: space heating, recreation, industrial process heat, and agriculture. Space heating has further been divided into district and residential/commercial systems. Agriculture has been divided into greenhousing, animal husbandry, and the aquacultural raising of prawns and fish. Appendix 2 describes and illustrates the procedure developed by staff of the Nevada Department of Energy to evaluate these uses in reference to a specific resource site. The reader is encouraged to read this appendix before reading the following "Uses" section. The purpose in developing the geothermal use evaluation method described in Appendix 2 was to give some quantification to statements made about the development potential of a particular site. As with any method of this type there are problems with the most major being that the method only considers five major site characteristic parameters. There are obviously many more that must be considered by any developer of geothermal resources. At best, the method used in this document can give an overview of the potential of a certain type of application. The developer of the geothermal resource must look at detailed site specific information to evaluate the resource and its applicability to the proposed use.

FIGURE 6

GEOTHERMAL USE TEMPERATURES IN ELKO COUNTY

* Temperatures indicated are based
in part on various geothermometers.

B. Sulfur Hot Springs

The Sulfur Hot Springs resource, the hottest known in Elko County, is located about 40 miles south of Wells off of State Route 11. Two ranches, the Smith Ranch and the Meyers Ranch, are within one mile of the springs. Based on the Geothermal Use Evaluation Table for this site (Table 13) the following sequence of potential uses has been determined:

<u>Application</u>	<u>Development Feasibility</u>
1. Electrical Generation	H
2. Industrial Process Heat	H
3. Greenhousing	H
4. Aquaculture	H
5. Animal Husbandry	M
6. Residential/Commercial Space Heating	L
7. District Space Heating	L
8. Recreation	L

This ranking system is useful in assessing the potential for different kinds of geothermal applications. Those applications with development numbers higher than 200, as derived from the Geothermal Use Evaluation Table, probably have the higher potential for successful development, those with development numbers between 125 and 200 have moderate potential, and those with development numbers less than 125 have low potential. However, characteristics of the geothermal resource not considered in the ranking system may make the potential application more or less feasible than indicated by these development numbers.

Based on the evaluation of this table it can be seen that because of the remote location and high temperature of the resource and its remote location, electrical generation, industrial process heat, and greenhousing, aquaculture and animal husbandry can be considered feasible at this time. These geothermal applications are not too adversely affected by the location of the site. Developing an industry based on animal husbandry is probably more feasible than indicated by the development numbers as the area has historically been used for ranching. Such development should not be too costly and the benefits to be obtained are great. Greenhousing and the aquacultural raising of fish and prawns may be hampered by the severe winter climate of the area.

Notable Characteristics of Sulfur Hot Springs

1. Remote location, about four miles from paved road
2. Scenic area
3. High temperature
4. Water quality meets all of Nevada's Safe Drinking Water Standards

Table 14

Geothermal Use Evaluation--Sulfur Hot Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	2	162	
Water Chemistry	3	1.6	4.8	
Land Factors	27	2	54	239
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	1	81	
Water Chemistry	1	1.6	1.6	
Land Factors	3	1.6	5	105
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	2	54	
Water Chemistry	1	1.6	1.6	
Land Factors	3	1.5	4.5	78
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	1	27	
Water Chemistry	1	1.5	1.5	
Land Factors	9	2	18	52
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	2	162	
Water Chemistry	9	1.6	14.4	
Land Factors	27	2	54	236
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	2	162	
Water Chemistry	9	1.6	14.4	
Land Factors	1	2	2	232
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	1.5	4.5	
Land Factors	1	2	2	204
Population Centers	9	0	9	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	1	81	
Water Chemistry	3	1.6	4.8	
Land Factors	9	2	18	158
Population Centers	1	0	0	
Depth to Resource	27	2	54	

C. Hot Sulfur Springs

Hot Sulfur Springs are the surface expression of a high temperature (about 330° F.) geothermal resource located approximately 70 miles north of Elko on State Route 11. The resource is the second hottest in Elko County. Based on the Geothermal Use Evaluation Table for this site (Table 14) the following sequence of potential uses has been determined:

<u>Application</u>	<u>Development Feasibility</u>
1. Greenhousing	H
2. Industrial Process Heat	H
3. Aquaculture	M
4. Animal Husbandry	M
5. Electrical Generation	M
6. Residential-Commercial Space Heating	L
7. District Space Heating	L
8. Recreation	L

The Hot Sulfur Springs geothermal resource is not currently in use. The site is remote, although road access is adequate to within about two miles of the site. Based on the development numbers, greenhousing and industrial process heat have high development potential. Aquaculture, animal husbandry, and electrical generation have moderate potential. Because of the remote location of the resource, applications such as space heating and recreation are considered to have low potential.

Notable Characteristics of Hot Sulfur Springs

1. Remote Location--roads adequate to within about two miles of the springs.
2. High temperature resource.

Table 15

Geothermal Use Evaluation--Hot Sulfur Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	1	81	
Water Chemistry	3	1	3	
Land Factors	27	1.6	43.2	145
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	1	81	
Water Chemistry	1	1	1	
Land Factors	3	1.3	3.9	104
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	2	54	
Water Chemistry	1	1	1	
Land Factors	3	1.3	3.9	77
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	1	27	
Water Chemistry	1	1	1	
Land Factors	9	1.5	13.5	48
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	2	162	
Water Chemistry	9	1	9	
Land Factors	27	1.6	43.2	220
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	2	162	
Water Chemistry	9	1	9	
Land Factors	1	2	2	227
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	1	3	
Land Factors	1	2	2	194
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	1	81	
Water Chemistry	3	1	3	
Land Factors	9	2	18	156
Population Centers	1	0	0	
Depth to Resource	27	2	54	

D. Elko Hot Springs

Elko Hot Springs are located near the community of Elko. These hot springs have a long history of past use which included a bathhouse, hatching chickens, greenhousing, and attempting to extract oil from oil shale. Table 16 evaluates various potential uses for the hot water from this geothermal reservoir. The following sequence was determined from that table:

<u>Application</u>	<u>Development Feasibility</u>
1. Residential/Commercial Space Heating	H
2. District Space Heating	H
3. Greenhousing	H
4. Animal Husbandry	H
5. Aquaculture	H
6. Recreation	H
7. Industrial Process Heat	M
8. Electrical Generation	L

This sequence of potential applications illustrates the quality of the resource. It is large enough, high enough in temperature, and located in an area that makes development for a number of different uses practical. Currently Chilton Engineering is studying the potential of developing a heating system for several businesses in the area. Should the reservoir valuation process indicate that the geothermal reservoir is adequate, further district heating systems could be developed. Several small greenhouses using geothermal energy currently exist and the further development of such applications should be encouraged. Should the reservoir extend into the residential area and have characteristics suitable for residential space heating, such an application could be developed.

Only one application appears to have poor development potential-electrical generation. This application needs a higher temperature than is currently known to exist in the Elko Hot Springs geothermal reservoir.

Notable Characteristics of Elko Hot Springs Geothermal Reservoir

1. Moderate to moderately low temperature
2. Location near the community of Elko
3. Good water quality
4. Long history of use

Table 16

Geothermal Use Evaluation--Elko Hot Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	0	
Water Chemistry	3	2	6	
Land Factors	27	1.6	43.2	69
Population Centers	1	2	2	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	2	162	
Water Chemistry	1	2	2	
Land Factors	3	2	6	242
Population Centers	27	2	54	
Depth to Resource	9	2	18	
-District				
Temperature	27	2	54	
Water Chemistry	1	2	2	
Land Factors	3	2	6	242
Population Centers	81	2	162	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	1	27	
Water Chemistry	1	2	2	
Land Factors	9	2	18	215
Population Centers	81	2	162	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	81	
Water Chemistry	9	2	18	
Land Factors	27	1.6	43.2	150
Population Centers	1	2	2	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	2	162	
Water Chemistry	9	2	18	
Land Factors	1	2	2	242
Population Centers	3	2	6	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	2	6	
Land Factors	1	2	2	215
Population Centers	9	2	18	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	2	162	
Water Chemistry	3	2	6	
Land Factors	9	2	18	242
Population Centers	1	2	2	
Depth to Resource	27	2	54	

E. San Jacinto Ranch Springs

The San Jacinto Ranch Springs have a temperature of 148° F. This geothermal resource is located about 50 miles north of Wells along US 93 and only one mile from the paved roadway. Geothermal Use Evaluation Table 17 summarizes the potential geothermal applications. The following sequence is determined from this table:

<u>Application</u>	<u>Development Feasibility</u>
1. Animal Husbandry	H
2. Aquaculture	H
3. Residential/Commercial Space Heating	M
4. Greenhousing	M
5. Electrical Generation	M
6. Industrial Process Heat	M
7. Recreation	L
8. District Space Heating	L

This sequence of potential applications indicates that animal husbandry and aquaculture have the highest development potential. Historically the area has been dominated by ranching. The development of animal support facilities using geothermal energy is considered to be both practical and feasible at this time. There is insufficient information available on several of the characteristics of the site, specifically flow rate, to determine if aquaculture is feasible. The area where these springs are located has a very harsh climate with cold weather. To maintain the aquaculture ponds at the required constant temperature of 80° F. would require a fairly large flow rate. If further study indicates that flow from these springs is adequate to support such an industry, its development should be encouraged. One other limited application considered feasible is the development of space heating for the various farm buildings.

Several other applications are considered to have moderate development potential. These include electrical generation and industrial process heat. Recreation and district space heating have low potential as these applications either require too large of a population base or too high of a temperature to be developed at the present time.

Notable Characteristics of the San Jacinto Ranch Hot Springs

1. Remote location, with fairly good roads.
2. Moderately low temperature
3. Good water quality

Table 17

Geothermal Use Evaluation--San Jacinto Ranch Springs

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	1	81	
Water Chemistry	3	1.6	4.8	
Land Factors	27	1.6	43.2	147
Population Centers	1	0	0	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	2	162	
Water Chemistry	1	1.6	1.6	
Land Factors	3	1.3	3.9	186
Population Centers	27	0	0	
Depth to Resource	9	2	18	
-District				
Temperature	27	1	27	
Water Chemistry	1	1.6	1.6	
Land Factors	3	1.5	4.5	51
Population Centers	81	0	0	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	2	54	
Water Chemistry	1	1.5	1.5	
Land Factors	9	2	18	80
Population Centers	81	0	0	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	81	
Water Chemistry	9	1.6	14.4	
Land Factors	27	1.6	43.2	145
Population Centers	1	0	0	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	1	81	
Water Chemistry	9	1.6	14.4	
Land Factors	1	2	2	151
Population Centers	3	0	0	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	2	54	
Water Chemistry	3	1.5	4.5	
Land Factors	1	2	2	222
Population Centers	9	0	0	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	2	162	
Water Chemistry	3	1.6	4.8	
Land Factors	9	2	18	239
Population Centers	1	0	0	
Depth to Resource	27	2	54	

F. Humboldt Wells

A series of geothermal resources with temperatures ranging between 90° and 140° F. are located in the vicinity of Wells in Central Elko County. Because of the nature of the resource it is not known whether or not all of the springs are surface expressions of the same geothermal reservoir or several different reservoirs. In light of this qualification the potential uses for the hot water from the Humboldt Wells area were evaluated on Table 18. The following sequence of potential applications was developed from this table:

<u>Application</u>	<u>Development Feasibility</u>
1. Animal Husbandry	H
2. Residential/Commercial Space Heating	H
3. Aquaculture	M
4. Recreation	M
5. Industrial Process Heat	M
6. Greenhousing	M
7. District Space Heating	M
8. Electrical Generation	L

Due to the moderate temperature of the Humboldt Wells geothermal resource and its close proximity to the small community of Wells several different types of potential applications are considered feasible at this time. The application with the highest potential is animal husbandry and compatible with the character of the community which is essentially agricultural. Residential space heating applications also have high development potential. Recreation, aquaculture, industrial process heat, greenhousing, and district space heating have moderate potential for development in the area. Because of the low temperature of the resource, electrical generation is not considered practical.

Notable Characteristics of Humboldt Wells

1. System irregular, boundaries not determined
2. Water quality good except for total dissolved solids
3. Moderately low temperature resource
4. Located close to community of Wells, Nevada

Table 18

Geothermal Use Evaluation--Humboldt Wells

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	0	
Water Chemistry	3	0.6	1.8	
Land Factors	27	2	54	75
Population Centers	1	1	1	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	2	162	
Water Chemistry	1	0.6	0.6	
Land Factors	3	2	6	214
Population Centers	27	1	27	
Depth to Resource	9	2	18	
-District				
Temperature	27	1	27	
Water Chemistry	1	0.6	0.6	
Land Factors	3	2	6	132
Population Centers	81	1	81	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	2	54	
Water Chemistry	1	1	1	
Land Factors	9	2	18	160
Population Centers	81	1	81	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	81	
Water Chemistry	9	0.6	5.4	
Land Factors	27	2	54	147
Population Centers	1	1	1	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	1	81	
Water Chemistry	9	1	9	
Land Factors	1	2	2	149
Population Centers	3	1	3	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	2	54	
Water Chemistry	3	1.5	4.5	
Land Factors	1	2	2	160
Population Centers	9	1	18	
Depth to Resource	81	1	81	
-Animal Husbandry				
Temperature	81	2	162	
Water Chemistry	3	0.6	1.8	
Land Factors	9	2	18	237
Population Centers	1	1	1	
Depth to Resource	27	2	54	

G. Hot Springs near Carlin

The hot springs in the vicinity of Carlin, Nevada have a maximum surface temperature reading of approximately 178° F. This resource is located within two miles of the city. Because of the temperature of the geothermal resource and its proximity to a nearby population center, the Nevada Department of Energy selected this site for additional in depth study. A private consultant, under contract to the NDOE, has prepared a Site Specific Development Plan for this geothermal area. This plan is divided into several information categories: background information about the people and community of Carlin; resource evaluation; and development plan. The resource evaluation discusses the known characteristics of the resource and suggests potential exploration programs to enhance knowledge about the resource. The development plan discusses different types of potential applications, financing options, legal and institutional questions, and barriers to development. This plan is available by writing or calling the Nevada Department of Energy.

The Hot Springs near Carlin were evaluated according to the standard methodology presented in this document. Based on this evaluation, the following sequence of potential applications was developed:

<u>Application</u>	<u>Development Feasibility</u>
1. Animal Husbandry	H
2. Residential/Commercial Space Heating	H
3. Aquaculture	H
4. Greenhousing	M
5. District Space Heating	M
6. Electrical Generation	M
7. Industrial Process Heat	M
8. Recreation	M

An evaluation of this sequence of potential applications indicates that all are considered to have moderate to high development potential. The known temperature of the resource is believed sufficient to allow almost any type of development. Electrical generation may not be practical until technology becomes available to use the lower temperature fluids.

The Site Specific Development Plan prepared for the Carlin area indicates that district space heating in the community would be both feasible and economically viable. The study indicated that the community of Carlin was receptive to such development and there did not seem to be any barriers to exploration or development. The prospect of replacing natural gas usage by the residents of Carlin would be economically attractive with anticipated payback time for the individual homeowner in the range of two to three years.

Notable Characteristics of the Geothermal Resource near Carlin

1. Temperature is in the favorable range for direct applications.
2. Resource is located within two miles of a small population center.
3. Chemical characteristics of the water are good.

H. Thousand Springs

The Thousand Springs area is located almost on the Utah border north of State Route 30. These springs cover a several square mile area and may or may not be part of the same geothermal reservoir. Very little is known about the area. Temperatures tend to be low with no flow information available and only one water chemistry analysis known. Based on the location of the resource and the limited information available about the area, only a few applications are considered possible at this time. An animal husbandry industry may or may not be feasible depending on the exact needs of the specific application. One or more of the springs could be used by the residents of Montello, about eight miles to the south, for recreation purposes. Other applications such as district space heating, industrial process heat, or electrical generation are not considered feasible at this time.

Table 19

Geothermal Use Evaluation--Hot Springs Near Carlin

	Rank	Weight	Product	Development Number
Electrical Generation				
Temperature	81	0	81	
Water Chemistry	3	1.6	4.8	
Land Factors	27	2	54	159
Population Centers	1	1	1	
Depth to Resource	9	2	18	
Space Heating				
-Residential-Commercial				
Temperature	81	2	162	
Water Chemistry	1	1.6	1.6	
Land Factors	3	2	6	215
Population Centers	27	1	27	
Depth to Resource	9	2	18	
-District				
Temperature	27	2	54	
Water Chemistry	1	1.6	1.6	
Land Factors	3	2	6	161
Population Centers	81	1	81	
Depth to Resource	9	2	18	
Recreation				
Temperature	27	1	27	
Water Chemistry	1	1.5	1.5	
Land Factors	9	2	18	134
Population Centers	81	1	81	
Depth to Resource	3	2	6	
Industrial Process Heat				
Temperature	81	1	81	
Water Chemistry	9	1.6	14.4	
Land Factors	27	2	54	156
Population Centers	1	1	1	
Depth to Resource	3	2	6	
Agriculture				
-Greenhousing				
Temperature	81	2	162	
Water Chemistry	9	1.6	14.4	
Land Factors	1	2	2	149
Population Centers	3	1	3	
Depth to Resource	27	2	54	
-Aquaculture				
Temperature	27	1	27	
Water Chemistry	3	1.5	4.5	
Land Factors	1	2	2	160
Population Centers	9	1	9	
Depth to Resource	81	2	162	
-Animal Husbandry				
Temperature	81	2	162	
Water Chemistry	3	1.6	4.8	
Land Factors	9	2	18	240
Population Centers	1	1	1	
Depth to Resource	27	2	54	

I. Other Hot Springs in Elko county

There are approximately 40 other geothermal resources in Elko County. The temperatures in these other springs run up to 140° F. Most are located some distance from any residence or community over poor roads. Because of the low temperatures and remote location it is not foreseen that any commercial development of these springs will occur in the next few years. If future conditions change, the characteristics of these resources may become conducive to development.

V. CONCLUSION

Geothermal Resource Area 3 has several major geothermal resources that are believed capable of supporting development with a wide range of different applications. In addition to the major sites there are many smaller thermal areas around the county that could supply the heating needs of single residences or small developments. Table 20 summarizes the development potential for various applications at five of the more major resource sites. Based on the information presented in this document, the geothermal resources in the study area that appear most appropriate for each type of development have been identified and are listed below:

Electrical Generation

Sulfur Hot Springs

Residential-Commercial Space Heating

Elko Hot Springs

Humboldt Wells

Hot Springs near Carlin

District Space Heating

Elko Hot Springs

Humboldt Wells

Hot Springs near Carlin

Recreation

Elko Hot Springs

Humboldt Wells

Industrial Process Heat

Sulfur Hot Springs

Hot Sulfur Springs

Greenhousing

Elko Hot Springs

Sulfur Hot Springs

Hot Sulfur Hot Springs

Aquaculture

San Jacinto Ranch Springs

Sulfur Hot Springs

Elko Hot Springs

Animal Husbandry

Elko Hot Springs

San Jacinto Ranch Hot Springs

Humboldt Wells

Hot Springs near Carlin

There are many benefits to be derived from the development of the geothermal resources in Elko County, including but not limited to:

1. Creation of new industry.
2. Expanding old industry.
3. Creation of new jobs.
4. Adding spendable income to the region.
5. Broadening both the economic and tax base of the region and state.
6. Displacing the use of expensive, diminishing fossil fuels for either direct use or electrical generation.

The development of the geothermal resources located in Elko County is thusly considered to be beneficial to the local region, the state, and the nation. For these reasons, such development should be encouraged wherever and whenever possible.

Table 20--Geothermal Use Evaluation-Summary
Elko County

Site	Electrical Generation	Space Heating		Recreation	Industrial Process Heat	Agriculture		
		Residential- Commercial	District			Green- housing	Aqua- culture	Animal Husbandry
Hot Sulfur Springs	M	L	L	L	H	H	M	M
Sulfur Hot Springs	H	L	L	L	H	H	H	M
Elko Hot Springs	L	H	H	H	M	H	H	H
San Jacinto Ranch Springs	M	M	L	L	M	M	H	H
Humboldt Wells	L	H	M	M	M	M	M	H
Hot Springs near Carlin	M	H	M	M	M	M	H	H

VI. ADDITIONAL INFORMATION

Additional information on the occurrence, character, or development of Nevada's geothermal resources may be obtained by writing, calling, or visiting any of the following:

Division of Earth Sciences
Environmental Resource Center
Museum of Natural History
255 Bell
Reno, Nevada 89503
(702) 784-6151

Nevada Department of Energy
400 West King Street, Room 106
Carson City, Nevada 89710
(702) 885-5157

Nevada Department of Conservation
and Natural Resources
Nevada Division of Water Resources
201 South Fall Street
Carson City, Nevada 89710
(702) 885-4380

Nevada Bureau of Mines and Geology
University of Nevada-Reno
Reno, Nevada 89557
(702) 784-6691

U.S. Bureau of Land Management
Room 3008, Federal Building
300 Booth Street
Reno, Nevada 89509
(702) 784-5748

U.S. Geological Survey
District Geothermal Office
4600 Kietzke Lane
Reno, Nevada 89502
(702) 784-5676

VII. BIBLIOGRAPHY

1. ASHRAE Handbook and Product Directory - 1977 Fundamentals.
New York: American Society of Heating, Refrigeration,
and Air Conditioning Engineers, Inc. 1979.
2. Department of Economic Development. Elko County-Datafile.
1976.
3. Department of Economic Development. Nevada Industrial Di-
rectory. 1978.
4. Department of Highways. Nevada's Federal and State Systems -
Descriptions and Index. 1978.
5. Department of Highways. Non-Federal Aid State Aid Routes.
1978.
6. Department of Transportation. Status of Road Systems. 1979.
7. Division of Water Resources. Alternative Plans for Water
Resource Use--Humboldt River Basin --Area III. 1974.
8. Division of Water Resources. Alternative Plans for Water
Resource Use--Central Region Basin--Area IV. 1974.
9. Division of Water Resources. Alternative Plans for Water
Resource Use--Snake River Basin--Area VI. 1974.
10. EG&G, Inc. Nevada Hydrothermal Commercialization Baseline.
1979.
11. Employment Security Department. Nevada Employment and Pay-
rolls. 1976, 1977, 1978, 1979.
12. Flynn, Thomas, et. al. Area Specific Investigations of Three
Low-to Moderate-Temperature Geothermal Resource Loca-
tions in Nevada. Nevada Bureau of Mines and Geology.
Unpublished report.
13. Garside, Larry Geothermal Exploration and Development in
Nevada Through 1973. Nevada Bureau of Mines and Geolo-
gy, Bulletin 21. 1974.
14. Garside, Larry J., and Schilling, John H. Thermal Waters of
Nevada. Mackay School of Mines, Bulletin 91. 1979.
15. Governor's Office of Planning Coordination. The Comprehen-
sive Economic Development Plan. Vol. 1, 2, and 3. 1980
16. Governor's Office of Planning Coordination. Directory of
Local Planning Organizations. 1979.

17. Granger, Arthur, et. al. Geology and Mineral Resources of Elko County. Nevada Bureau of Mines and Geology, Bulletin 54. 1954.
18. Nevada Bureau of Land Management. Wilderness Study Area Decisions.
19. Nevada Department of Energy. Energy in Nevada. 1980
20. Rush, E. Eugene. Index to Hydrographic Areas. Division of Water Resources. Water Resources-Information Series. Report 6. 1978.
21. Thornbury, William D. Regional Geomorphology of the United States. New York: John Wiley and Sons, Inc. 1965.
22. Trexler, D.T., et. al. Assessment of Low-to Moderate-Temperature Geothermal Resources of Nevada. Nevada Bureau of Mines and Geology. Final Report-NV0701556-1. 1979.
23. Stewart, John H. Geology of Nevada. Nevada Bureau of Mines and Geology, Special Publication 4. 1980.
24. U.S. Department of Commerce. Climatological Summary-Elko, Nevada. 1936-1968.
25. U.S. Department of Commerce. Climatological Summary-Jiggs, Nevada. 1936-1968.
26. U.S. Department of Commerce. Climatological Summary-Lamoille, Nevada. 1941-1970.
27. U.S. Department of Commerce. Climatological Summary-Owyhee, Nevada. 1945-1970.
28. U.S. Department of Commerce. Climatological Summary-Ruby Lake, Nevada. 1936-1968.
29. U.S. Department of Commerce. Climatological Summary-Wells, Nevada. 1936-1968.
30. U.S. Department of Energy. Direct Heat Application Program Summary. 1979.
31. U.S. Department of Energy. Environmental Development Plan - Geothermal Energy Systems. 1979.
32. U.S. Department of Energy. Geothermal District Heat Use Market Potential Penetration Analysis for Nevada, DOE, Region IX. 1979.
33. U.S. Department of Energy. Regional Operations Research Program for Development of Geothermal Energy in the Southwestern United States. Appendix 8. 1979.
34. U.S. Geological Survey. Assessment of Geothermal Resources of the United States. Circular 790. 1978.

Appendix 1 -- Water Chemistry Analyses
Elko County(14)

Identification	pH	SiO ₂	Fe	Ca	Mg	Na	K	HCO ₃	CO ₃	SO ₄	Cl	F	NO ₃	B	TDS
HOT SULFUR SPRINGS															
Spring	-	84	-	49	13	390	41	1180	-	18	40	7.2	-	.77	-
Spring	-	165	-	12	.3	160	16	345	-	61	22	10	-	1.2	-
SULFUR HOT SPRINGS															
Spring	8.5	210	-	1.0	.03	135	8.9	244	15	40	23	17.7	-	.2	-
Spring	-	72	-	18	5.8		106	242	-	59	12	8	.5	.04	400
Spring	8.6	230	-	1.6	.02	150	9.8	247	12	40	4	19	-	.23	-
ELKO HOT SPRINGS															
City of Elko Well #12	-	81	-	3	12		20	139	3	27	35	-	-	-	269
Hot Hole	7.2	65	-	60	15.5	120	39	488	1	72	16	1.9	-	.7	-
SAN JACINTO RANCH SPRING															
Spring	-	-	-	69	15	124	-	528	0	42	19	-	-	-	-
Spring	8.1	18	0	25	8.6	13	3.9	132	0	11	3.9	.5	.1	0	245
Spring	-	-	-	54	17	8.3	-	254	14	107	30	-	-	-	-
HUMBOLDT WELLS															
Spring	7.3	105	0	75	37	300	31	1135	-	32	27	7.2	-	.89	-
Spring	6.6	86	-	48	13	370	46	1123	-	12	37	7.4	-	.73	-
NEVADA SAFE DRINKING WATER STANDARDS															
			.03		125					250	250				500

Appendix 1 -- Water Chemistry Analyses - Elko County -(continued)

Identification	pH	SiO ₂	Fe	Ca	Mg	Na	K	HCO ₃	CO ₃	SO ₄	Cl	F	NO ₃	B	TDS
HOT SPRINGS															
NEAR CARLIN															
Spring	7.6	70	-	60	15	45	16	335	-	52	12	-	-	-	-
THOUSAND SPRINGS															
Gamble Ranch															
Well #4	8.2	-	-	74	27	93		278	-	103	117	-	-	-	-
NEVADA SAFE															
DRINKING WATER			.03		125					250	250				500
STANDARDS															

Appendix

2A. Methodology for Evaluating Geothermal Applications

A major problem in evaluating potential uses of Nevada's geothermal resources are their diverse character. Temperatures range from 60° F. to over 400° F. The total dissolved solids (TDS) found in the geothermal fluid can range from less than 150 parts per million to well over 6,000 parts per million. The resource may have surface discharge points or may be located over 5,000 feet in depth. It may be located in an urban environment or it may be many miles from the nearest community and inaccessible by land vehicles.

In order to develop any method of evaluating geothermal resources the following criteria must be met:

1. The method must be generally applicable.
2. The method must be sufficiently flexible to allow for future data input or changing priorities in resource requirements.
3. The method must be simple and yet produce semi-quantitative results.

To develop the method of evaluating geothermal resources used in this and in similar Area Development Plans, the Nevada Department of Energy borrowed and expanded the method developed by the Nevada Bureau of Mines and Geology.⁽²²⁾ This method describes eight potential geothermal application categories: residential/commercial-space heating; district space heating; recreation; electrical generation; industrial process heat; greenhousing; aquaculture; and animal husbandry. Most types of known geothermal applications fit into one of these categories.

Several different parameters can be used to describe the development potential of a particular geothermal resource. These parameters include, but are not limited to: temperature, rock type and age, depth to resource, population centers nearby,

geophysical data, water chemistry, flow rate, permeability, recharge, economics, structural controls, environmental considerations, and land factors such as areal extent, accessibility, and existing land use and zoning. Though all of these factors influence the development potential of a geothermal resource, data about several of the factors are insufficient to evaluate at this time. For this reason, the decision was made to evaluate only the following parameters in which the data are generally available: temperature, water chemistry, land factors, population centers, and depth to the resource. It must be remembered however, that these represent only a portion of the total number of development parameters that make geothermal application successful and as such indicate only the potential of a site. Any actual developer must use this information only for preliminary purposes and must develop more site specific data before any development occurs.

These five parameters are of differing importance to different applications. After consulting with professionals in the specific applications, Nevada Department of Energy staff ranked the parameters according to their relative importance to the application. For example in the electrical generation industry, the temperature of the resource is the prime parameter followed by land factors, depth to resource, water chemistry, and population centers. Each rank is accorded a number based on decreasing powers of three. This method was selected because it preserves the established order of importance. Temperature in the electrical generation industry has a rank of 81; land factors 27; depth to resource 9; water chemistry 3; and population centers 1.

The second step in evaluating the resource is to assign weighting factors to the characteristics of the specific resource. A weighting factor of "2" indicates the most desirable range of the parameter; a weighting factor of "1" is an intermediate factor; and a weighting factor of "0" is considered least desirable. These weighting factors have been tailored for each particular

application. Appendix 2B and 2I illustrate the specific weighting factors assigned to specific resource characteristics for each potential application.

For each particular application, all of the parameters are ranked and weighted. The development number for the application is obtained by adding all of the separate products. This number can be used in conjunction with the other seven development numbers to give a relative sequence of development potential. Those applications with the lower development numbers probably would have less potential for successful development than those with higher development numbers.

Appendix 2B - Electrical Generation Weighting Factors

Temperature	
less than 300° F.	0
300° - 350°	1
greater than 350° F.	2

Water Chemistry--average all three categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2

Corrosives-Scaling Compounds	
high	0
moderate	1
low	2

Land Factors--average all three categories for weighting factor

Areal extent--square miles	
less than .5	0
.5 to 1.5	1
greater than 1.5	2

Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet	
greater than 7000	0
3500 - 7000	1
0 - 3500	2

Appendix 2C - Residential-Commercial - Space Heating Weighting Factors

Temperature	
less than 86° F.	0
87° - 140° F.	1
140° - 250° F.	2
greater than 250° F.	1

Water Chemistry--average all three categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2

Corrosives-Scaling Compounds	
high	0
moderate	1
low	2

Land Factors--average all three categories for weighting factor

Areal extent--square miles	
less than .5	0
.5 to 1.5	1
greater than 1.5	2

Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet	
greater than 800	0
400 - 800	1
0 - 400	2

Appendix 2D - District - Space Heating Weighting Factors

Temperature	
less than 150° F.	0
150° - 200° F.	1
greater than 200° F.	2

Water Chemistry--average all three categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2

Corrosives-Scaling Compounds	
high	0
moderate	1
low	2

Land Factors--average both categories for weighting factor

Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet	
greater than 800	0
400 - 800	1
0 - 400	2

Appendix 2E - Recreation -- Weighting Factors

Temperature	
less than 70° F.	0
70° - 90° F.	1
90° - 200° F..	2
greater than 200° F.	1
Water Chemistry--average both categories for weighting factor	
pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0
TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2
Land Factors--average both categories for weighting factor	
Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2
Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2
Population Centers--within 30 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2
Depth to Resources---feet	
greater than 200	0
100 - 200	1
0 - 100	2

Appendix 2F - Industrial Process Heat Weighting Factors

Temperature	
less than 105° F.	0
106° - 212° F.	1
greater than 212° F.	2
Water Chemistry--average all three categories for weighting factor	
pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0
TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2
Corrosives-Scaling Compounds	
high	0
moderate	1
low	2
Land Factors--average all three categories for weighting factor	
Areal extent--square miles	
less than .5	0
.5 to 1.5	1
greater than 1.5	2
Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2
Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2
Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2
Depth to Resources---feet	
greater than 7000	0
3500 - 7000	1
0 - 3500	2

Appendix 2G - Greenhousing Weighting Factors

Temperature	
less than 100° F.	0
100° - 200° F.	1
200° - 350° F.	2
greater than 350° F.	1

Water Chemistry--average all three categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2

Corrosives-Scaling Compounds	
high	0
moderate	1
low	2

Land Factors--average both categories for weighting factor

Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet	
greater than 800	0
400 - 800	1
0 - 400	2

Appendix 2H - Aquaculture Weighting Factors

Temperature	
less than 70° F.	0
70° - 110° F.	1
110° - 150° F.	2
greater than 150° F.	1
Water Chemistry--average both categories for weighting factor	
pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0
TDS-ppm	
greater than 2000	0
1000 - 2000	1
0 - 1000	2
Land Factors--average both categories for weighting factor	
Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2
Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2
Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2
Depth to Resources---feet	
greater than 400	0
200 - 400	1
0 - 200	2

Appendix 2I - Animal Husbandry Weighting Factors

Temperature	
less than 100° F.	0
100° - 150° F.	1
150° - 250° F.	2
greater than 250° F.	1

Water Chemistry--average all three categories for weighting factor

pH	
less than 5	0
5 - 6.6	1
6.6 - 7.4	2
7.4 - 9	1
greater than 9	0

TDS-ppm	
greater than 1000	0
500 - 1000	1
0 - 500	2

Corrosives-Scaling Compounds	
high	0
moderate	1
low	2

Land Factors--average both categories for weighting factor

Accessibility--miles from paved road	
greater than 15	0
5 - 15	1
0 - 5	2

Zoning/Land Use	
not appropriate	0
semi-appropriate	1
appropriate	2

Population Centers--within 10 miles	
0 - 500 persons	0
500 - 5000 persons	1
greater than 5000 persons	2

Depth to Resources---feet	
greater than 800	0
400 - 800	1
0 - 400	2