A PRELIMINARY PLAN FOR THE DEVELOPMENT OF GEOTHERMAL ENERGY IN THE TOWN OF HAWTHORNE, NEVADA

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1.0 INTRODUCTION

Naturally occurring hot water has been identified in a number of water wells in the Hawthorne area; the town, therefore, is considered a prime candidate for the utilization of this alternative energy source. In order for the citizens of Hawthorne to benefit from this resource, the Nevada Department of Energy (NDOE) contracted with Geothermal Development Associates to prepare a plan for geothermal development at the town site. To lay the groundwork for a plan, the potential for development was first analyzed and a set of required procedures identified. This report describes the results of the analyses as well as a plan for the development of the geothermal resource.

In the second section of the report, site characteristics pertinent to the geothermal development are described. These characteristics include physiography, demography, economy, and goals and objectives of the citizens as they would relate to geothermal development. The third section describes the geothermal resource. The reservoir is characterized on the basis of available information. The probable drilling depth to the reservoir, anticipated water production rates, water quality, and resource temperatures are indicated.

Uses of the energy that seem appropriate to the situation both now and in the near future at Hawthorne are described in the fourth section of the report. The amounts and types of energy currently consumed by end users are estimated. Using this data base, conceptual engineering designs and cost estimates for three alternative district heating systems are presented. In addition, the results of a life cycle cost analysis for these alternatives are discussed. The content of the fourth section is based upon earlier analyses performed by Chilton Engineering (1981); The Spink Corporation (1981); and the Oregon Institute of Technology, Geo-Heat Utilization Center (1981).

The fifth section of the report discusses the essential institutional requirements for geothermal energy development, including the financial, environmental, and legal and regulatory aspects. The sixth section describes the various steps that are necessary to accomplish the construction of the geothermal district heating system at Hawthorne. A time-line chart shows the tasks, the time estimated to be required for each, and the interrelationships among the activities.

2.0 SITE DESCRIPTION

2.1 Physiography

Hawthorne is an unincorporated community in Mineral County, Nevada. To the west of it lies the Wassuk Mountain Range and to the north Walker Lake. The terrain at the town site is flat (Figures 2.1 and 2.2).

Hawthorne is situated in the Great Basin section of the Basin and Range physiographic province, at an elevation of 4,400 feet. Characteristic features are internal drainage, ephemeral lakes, and high seismic activity.

Precipitation is light, averaging only four inches per year. Average temperatures are 34°F in January and 75°F in July, but daily variations of 50°F are not uncommon (Murray - McCormick Environmental Group of Nevada, 1974). Heating-degree-day (hdd) records are available only for Mina, 35 miles away. With a slightly more severe climate than Hawthorne, Mina experiences an annual 5,082 hdd (National Oceanic and Atmospheric Administration, 1978).

2.2 Population

The area's ammunition depot was established by the U.S. Navy in 1930, and since has attracted a large number of residents to Hawthorne, particularly during wartime.

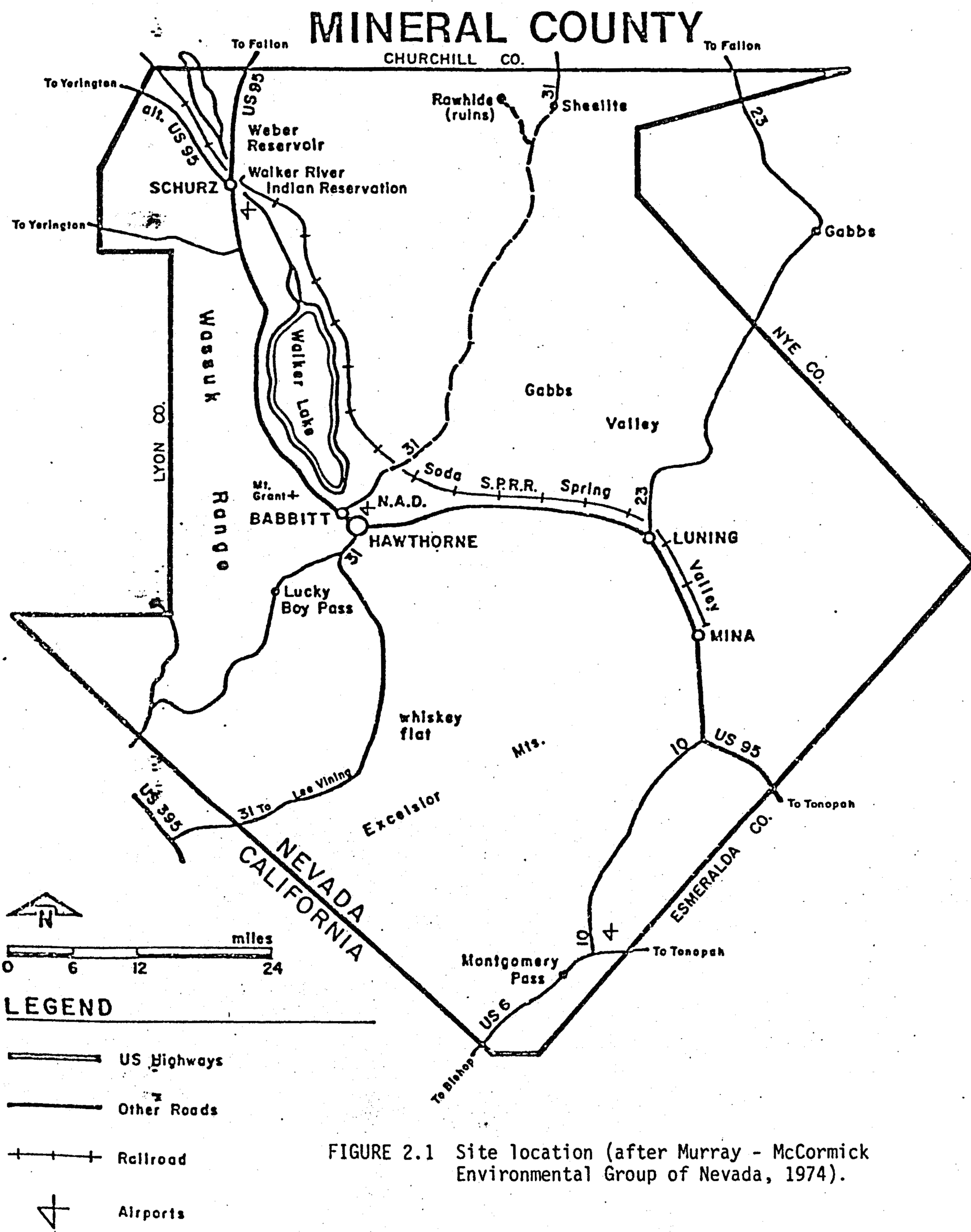


FIGURE 2.1 Site location (after Murray - McCormick Environmental Group of Nevada, 1974).

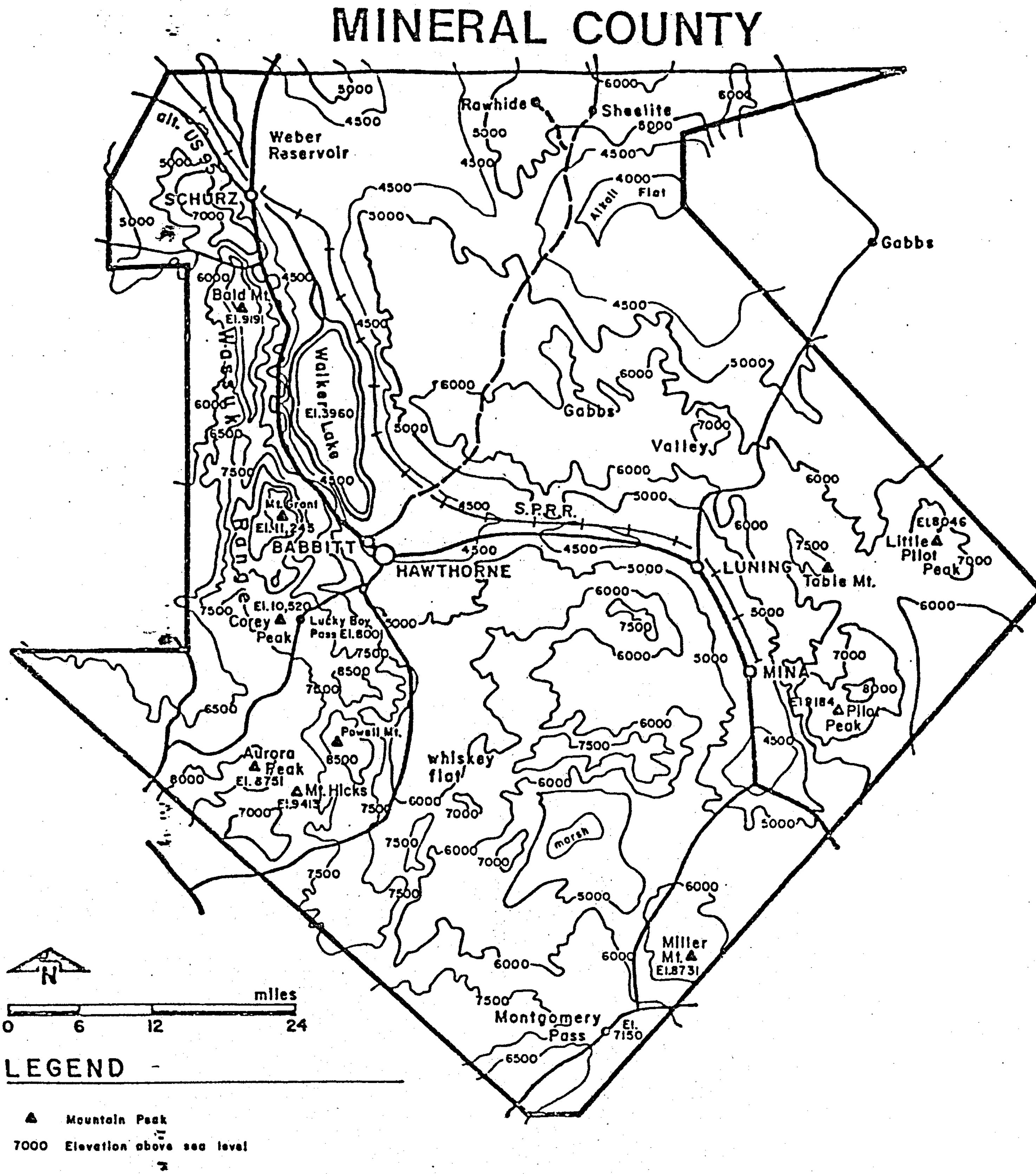


FIGURE 2.2 Topography (after Murray - McCormick Environmental Group of Nevada, 1974).

Preliminary 1980 census data show a population of 3,690 persons (Table 2.1).

TABLE 2.1 Hawthorne population (after R. Rigsby, Oral Communication, 1980).

	1980 Population	Change 1970-1980	% of County Population
Hawthorne	3,690	+ 4%	60%

Mineral County projects a 20-year growth of 30 percent, for the county as a whole (Table 2.2).

TABLE 2.2 Mineral County population (after R. Rigsby, Oral Communication, 1980).

	1980	1985 (est.)	1990 (est.)	2000 (est.)
Mineral County	6,168	6,559	7,006	7,990

If as expected Hawthorne experiences an equivalent growth rate, its year 2000 population would be 4,800 (R. Rigsby, Oral Communication, 1980).

2.3 Infrastructure

Water resources are obtained primarily from two in-town wells, with supplementation from a half-million-gallon storage reservoir (Figure 2.3). The latter, by itself, has insufficient capacity to supply the town. The

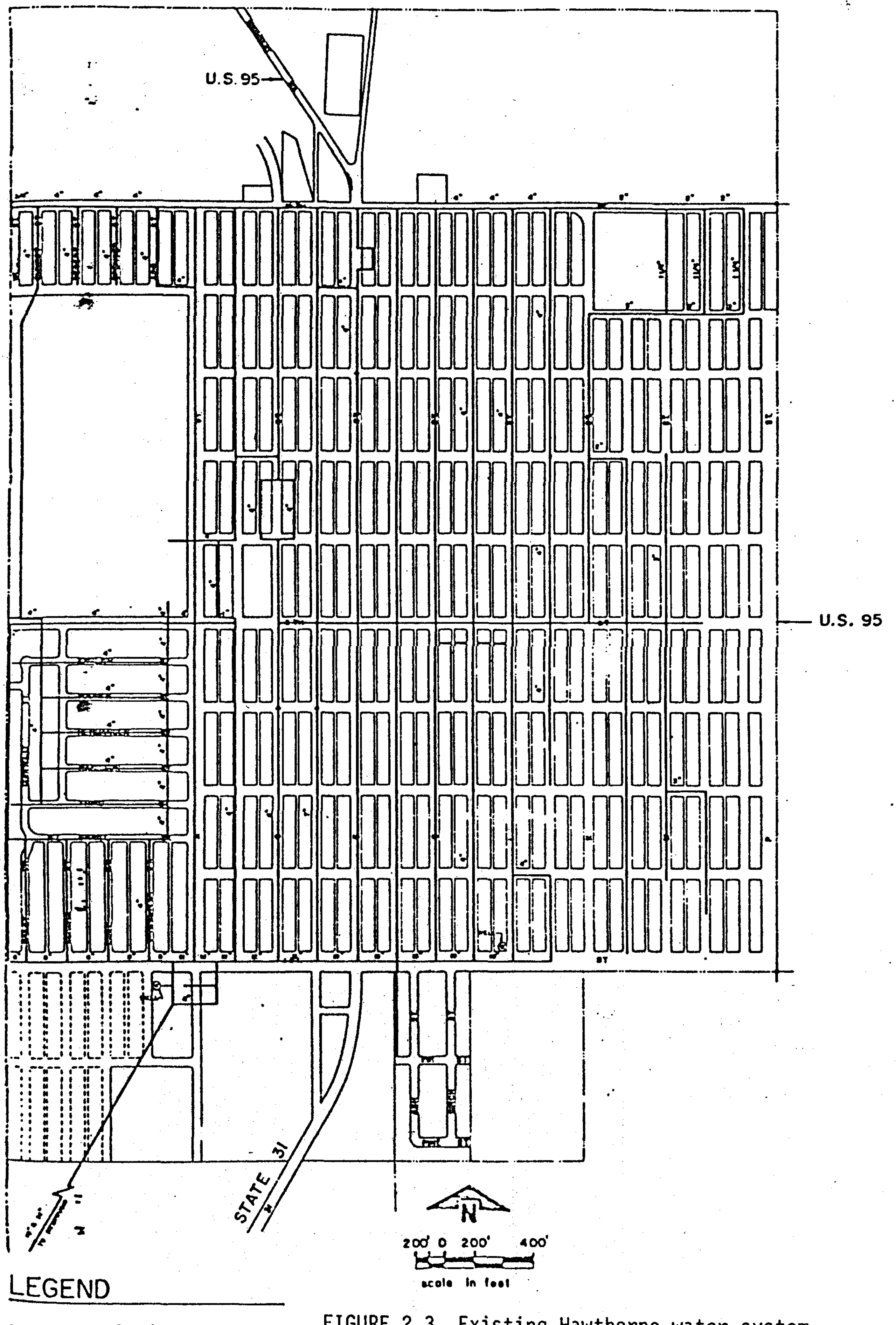


FIGURE 2.3 Existing Hawthorne water system (after Murray - McCormick Environmental Group of Nevada, 1974).

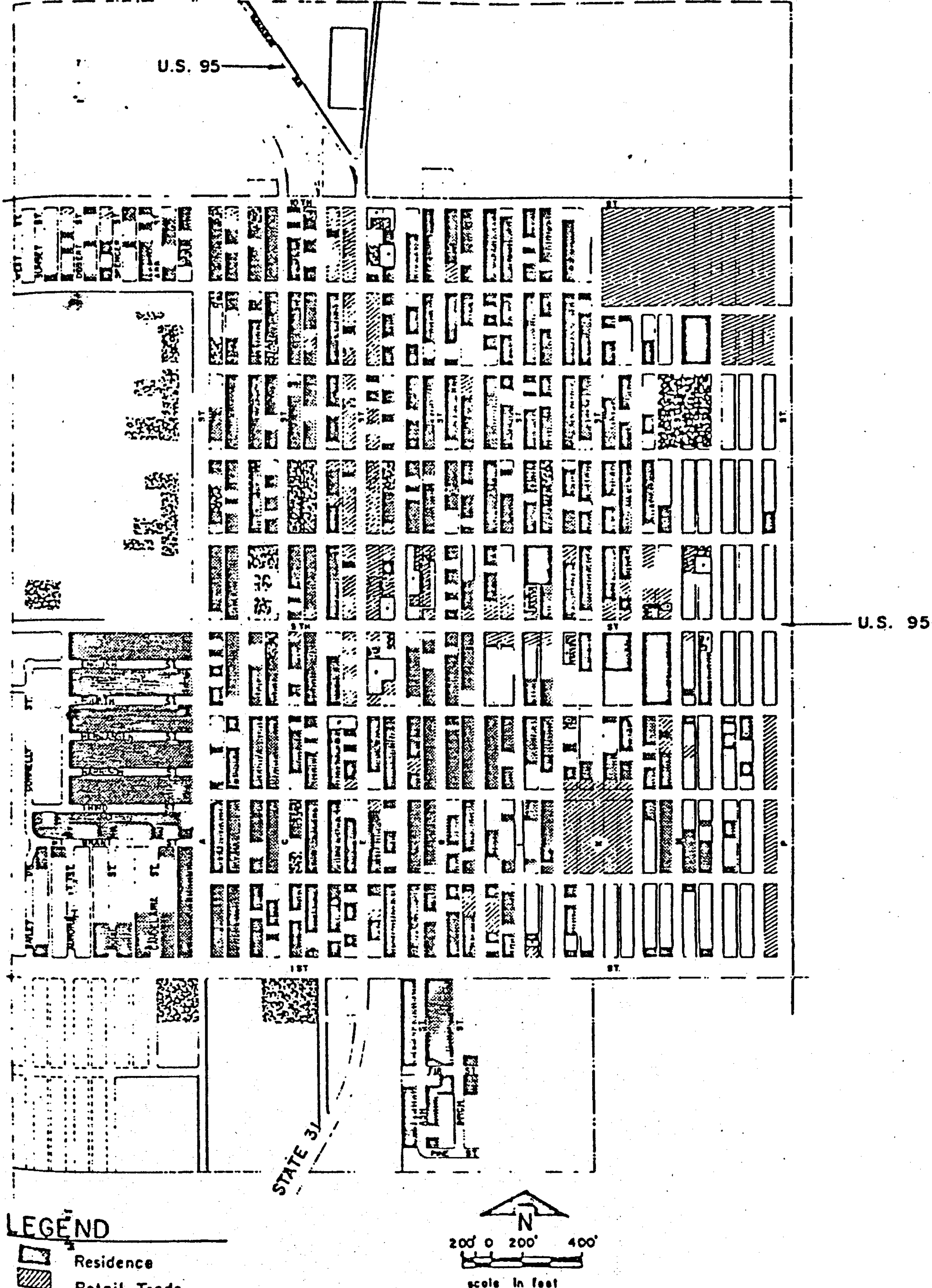
wells, however, yield water of high salinity. Together, a 2,400 gallon per minute (gpm) system of marginal quality is achieved. The water table levels beneath the town have been found to be receding at more than one foot per year (Murray - McCormick, Oral Communication, 1980), which apparently reflects recent drier than average conditions in the region (W. Cuchine, Oral Communication, 1980).

2.4 Land Use

As shown in Table 2.3 and Figure 2.4, commercial land uses in Hawthorne are concentrated mostly on F Street, K Street and P Street. The public buildings are largely in the northeast corner. Residences are the largest user of land, but they are relatively widely separated within the city limits.

TABLE 2.3 Hawthorne land use (after Murray - McCormick Environmental Group of Nevada, 1974).

	Acreage
Residential	168
Public (parks, schools, etc.)	80
Retail	50
Industrial	25
Vacant	125
Other (cemetary, trailer park, etc.)	223
Total:	1,391



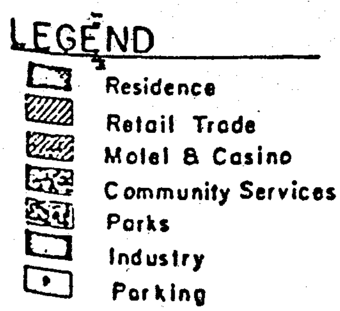


FIGURE 2.4 Existing Hawthorne land use (after Murray - McCormick Environmental Group of Nevada, 1974).

Of the 1,424 residential units, seventy-two percent are single family houses and another 16 percent are mobile homes. Most are owner occupied, with only 17 percent renter occupied (W. Cuchine, Oral Communication, 1980). Additional industry (Figure 2.5) is being encouraged for several sites in and around Hawthorne (Adams and Conger, 1977). Much of the land surrounding the town is used for military purposes, with ownership of these areas having been transferred from the Navy to the Army in 1977.

2.5 Economy

The ammunition depot has long been the primary source of employment in Hawthorne. This is changing, however, for two reasons. First, the post-Vietnam reduction of ammunition procurements has reduced the labor force at the depot from 1,800 persons in 1969 to 647 persons in 1980. Second, a recent surge of mining activity in Mineral County has proved beneficial to Hawthorne, in particular, as workers and corporate branch offices have located there (W. Cuchine, Oral Communication, 1980).

Also fundamental to the economy are the tourism and entertainment industries. The El Capitan Casino brings in thousands of tourists each year. Many more pass through the town on U.S. 95, the major thoroughfare connecting Las Vegas and Reno (W. Cuchine, Oral Communication, 1980).

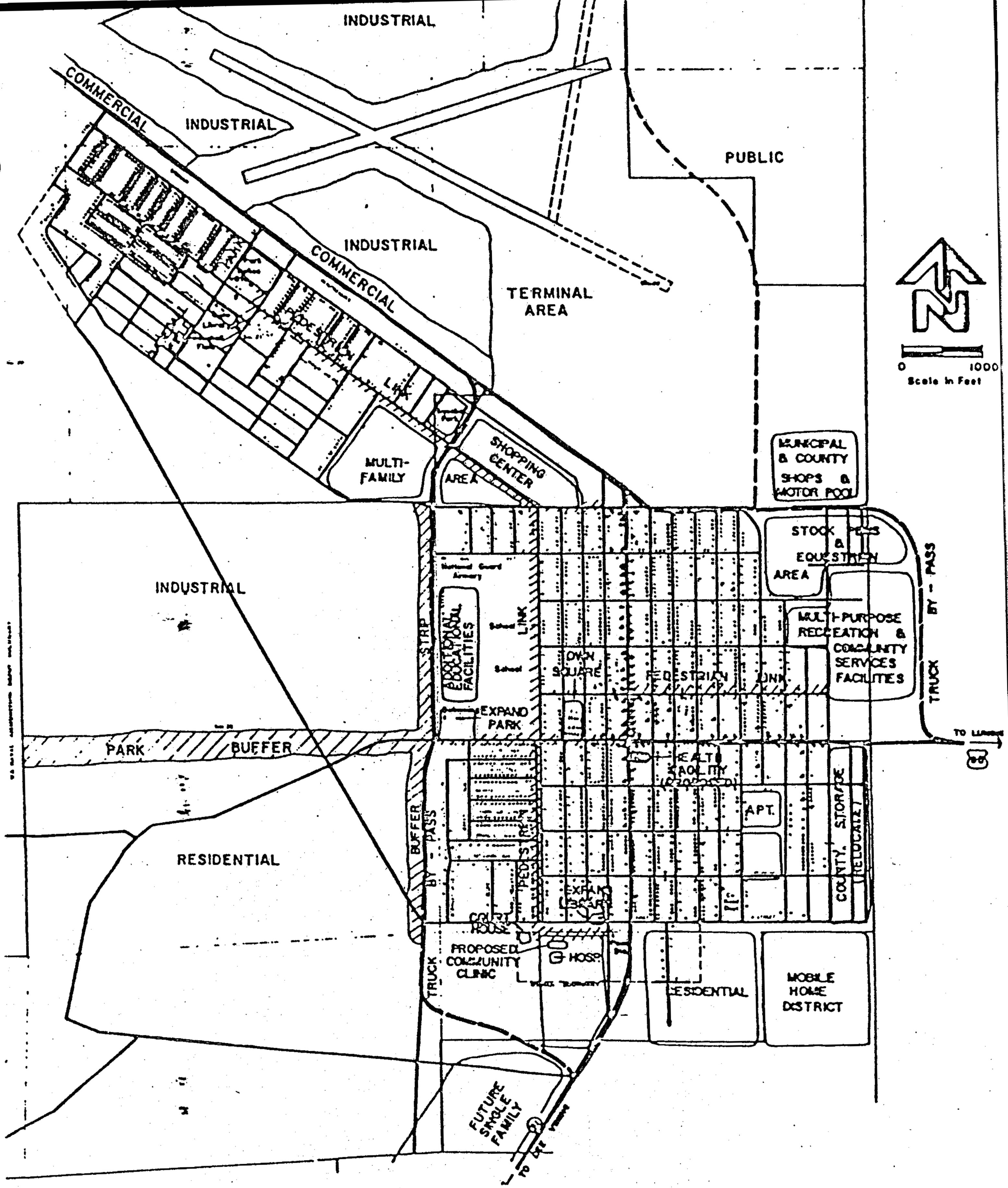


FIGURE 2.5 Future land use plan, Hawthorne & Babbitt (after Adams and Conger, 1977).

3.0 RESOURCE EVALUATION

3.1 Introduction

The Hawthorne geothermal resource area lies within the Whiskey Flat-Hawthorne segment of the Walker Lake Valley hydrographic area. This is a structural depression 10 to 15 miles in width, trending in a southeasterly direction between the Gillis and Wassuk Ranges. The valley terminates against the Garfield Hills to the southeast (Plate I).

3.2 General Geology

3.2.1 Stratigraphy

The City of Hawthorne is situated only three miles from the Wassuk Range which is comprised primarily of Mesozoic intrusive granodiorites and quartz monzonites with several volcanic roof pendants of the Triassic Excelsior formation. The Gillis Range is similar in lithologies with the addition of Mesozoic flows. The Garfield Hills show the most recent volcanic activity, with basaltic and andesitic flows dating 17 to 6 million years in age (Stewart and Carlson, 1976).

Several volcanic (or cinder) cones, dating less than 6 million years in age, including the Aurora

Crater, are located to the south and west of the study area.

The valley proper is alluvium-covered "valley fill" of unconsolidated to poorly consolidated clay, silt, sand, and gravel of Quaternary and Tertiary ages. Beneath this clastic section are Tertiary volcanics. The depth of the valley fill is unknown, but is believed to be over 1,000 feet thick, taking into account the depth of existing water wells.

3.2.2 Structure

Walker Lake Valley, together with the rest of Nevada, has been the scene of extensive, high -angle faulting which penetrates deep into the earth's crust. These faults, many of which have been active from Tertiary to Recent times, frequently act as conduits for rising geothermal waters.

Northerly-trending faults of this age are particularly in evidence along the western perimeter of Walker Lake and beyond to the south along the eastern flank of the Wassuk Range. Segments of this fault set have displaced the Quaternary alluvium between the mountains and Hawthorne.

A northeasterly-trending fault set extends from the bedrock into the valley where the faults displace Recent sediments.

3.3 Hydrogeology

3.3.1 Ground-water Flow System

Delineation of the hydrologic system is essential in understanding the geothermal potential in the Hawthorne area. Major divisions in the ground-water system include the near-surface alluvial aquifers and the underlying bedrock aquifer. The alluvial aquifers' permeability is primarily controlled by its unconsolidated sedimentary structure. Due to compaction, the permeability generally decreases with depth until fractures in the consolidated rock become chiefly responsible for the transmission of water. This is the case with the deep bedrock aquifers.

The source of recharge for the ground-water system occurs in the mountains as meteoric water which, in part, collects in intermittent streams and infiltrates to the ground-water table through unconsolidated valley deposits and along range faults. Part of the precipitation enters fractures in the mountains and is transmitted to the valley fill and the deep bedrock aquifer.

Several wells near Hawthorne report a loss of head with depth, indicating some downward flow of water in the alluvium. Due to low permeability in the alluvium at depth, this source of recharge to the bedrock is only significant on a broad regional basis. Everett and Rush (1967) estimated the average annual recharge for the Whiskey Flat -Hawthorne subarea (Figure 3.1) to be 5,400 acre -feet.

Meteoric water in the bedrock fractures is heated by abnormally high crustal heat flow common in the Basin and Range province. In response to the density gradient induced by the increased temperature, the water circulates upward along the range front faults into alluvial aquifers. Once in the alluvium, the thermal water flows outward from the fault into the unconsolidated sand and gravel, and mixes with the cooler water. The thermal wells in and around the Hawthorne vicinity intersect the thermal water in the alluvial aquifers.

Figure 3.2 shows generalized ground-water levels in the Hawthorne area. The direction of ground -water flow is toward Walker Lake which is the prime sink for the ground-water system in the valley. Water levels range upward to 500 feet in depth near the Wassuk Mountains, to Walker Lake

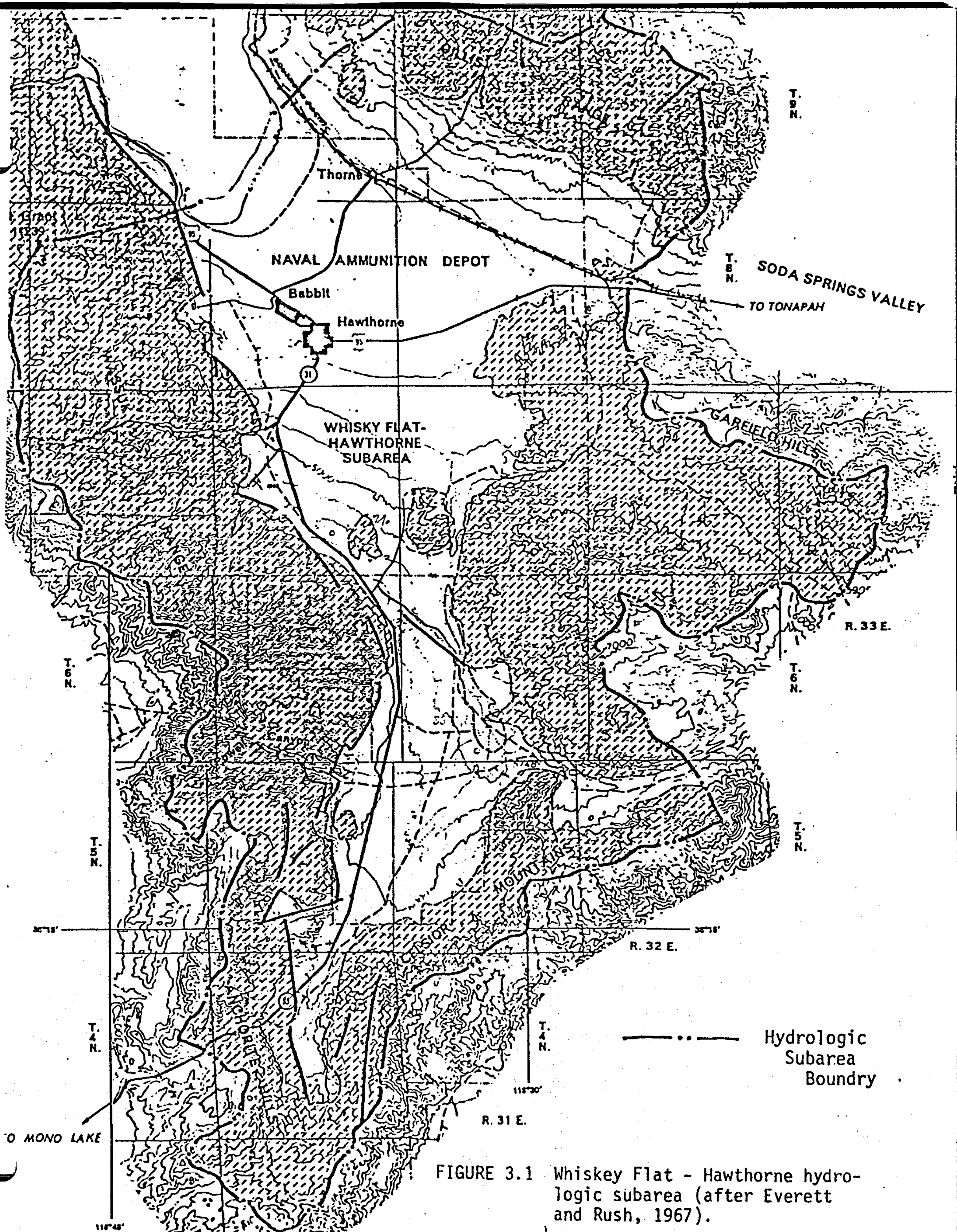


FIGURE 3.1 Whiskey Flat - Hawthorne hydrologic subarea (after Everett and Rush, 1967).

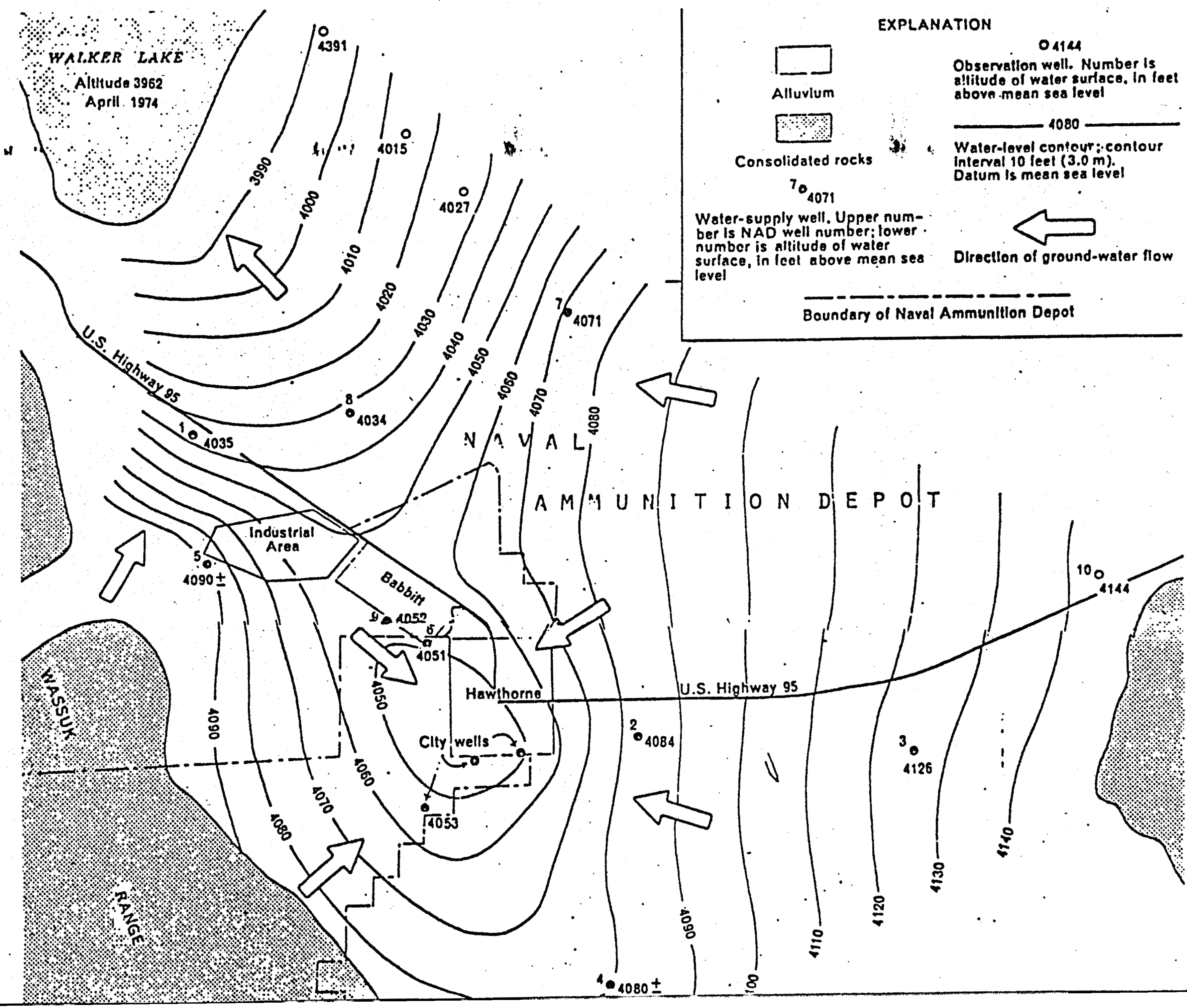


FIGURE 3.2 Groundwater level contour map with control from water wells in the Hawthorne area (after Van Denburgh and Rush, 1975).

which is a surface expression of the water table. There has been a reversal of hydraulic gradients in the vicinity of Hawthorne due to extensive pumping of the ground water by the city.

Movement of water through the ground-water system and the ability of the water to move to wells is controlled principally by aquifer transmissivity. Pump-tests made at Naval Ammunition Depot (NAD) supply wells 1, 6, 7, and 8 show widely varying transmissivities (Table 3.1). The tests indicate that the ground-water system penetrated by these wells is highly transmissive at NAD wells 1 and 6, along the western side of the valley, but much less transmissive at NAD well 7 in mid-valley. Coarser-grained sediments (sand and gravel) deposited adjacent to the mountain front conduct water more freely, while finer-grained sediments (silt and clay), transported further from the source area, are responsible for the lower transmissivity value observed in the central valley.

TABLE 3.1 Reported transmissivity values of NAD supply wells in the Hawthorne area (after Van Denburgh and Rush, 1975).

NAD SUPPLY WELL #	TRANSMISSIVITY (sq.ft./day)
1	40,000
6	25,000
7	270
8	1,300

3.3.2 Water Well Chemistry

Chemical analysis of water samples from wells in the vicinity of Hawthorne are listed in Table 3.2. Concentrations of chemical constituents show wide variations with time and space. The arsenic level exceeds the U.S. Public Health Service drinking water standards (0.05 ppm) in well NAD 15. High levels of fluoride were also encountered; and several wells reported boron, with NAD well 2 reporting the highest level at 2.1 ppm. Ground -water samples contain comparatively high amounts of sulfate if they originate in the alluvial valley fill. Sulfate values range from less than 50 ppm for Squaw Springs and well Hawthorne Utilities Well (HUW) 3 in Corey Canyon outside the alluvium, to more than 500 ppm in well HUW 1 within the alluvium. The highest value of 854 ppm applies to the shallow aquifer of well HUW 5 at a depth of 450 feet. The

TABLE 3.2 Chemistry of various wells near Hawthorne (after Bohm and Jacobson, 1977).

SAMPLE	DATE	T°F	Ca	Na	K	Cl	SiO_2	Ca/Na K T°F	SO_4	pH	TDS	HCO_3	F
NAD 1	4/77	124.7	61	174	6.4	63	31.8	150.8	386	8.1	749	51	1.75
NAD 1	4/76	-	58	196	8.0	66	-	167	413	-	792	-	-
NAD 2	8/75	81.5	82	187.5	11.9	85.6	58.4	176	405	7.52	987	134	1.09
NAD 2	4/76	-	78	219	15	97	-	195.6	-	-	1006	-	-
NAD 3	12/52	-	32	245	10	102	54	210.2	374	-	950	118	6.8
NAD 3	2/66	100.4	33	-	-	101	-	-	372	7.9	-	100	-
NAD 4	5/73	-	105	110	6.6	84	-	125.6	-	-	-	-	-
NAD 4	8/75	73.4	106	78	5.7	78	-	113	321	7.35	-	110	0.21
NAD 6	8/75	75.2	77.5	126	5.9	68	23.8	132.8	340	7.5	752	96	0.9
NAD 6	10/71	-	78	136	6.0	87	-	134.6	334	-	816	-	-
NAD 7	8/75	-	18.2	135	4.4	60.4	136	170.6	204	8.62	625	61	3.35
NAD 8	8/75	78.8	74	137.5	7.4	52.9	43.9	147.2	193	7.42	780	259	2.85
NAD 8	4/77	79.7	92.5	120	5.0	51	44.5	118.4	147	7.4	840	297	1.8
HUW 1	1/74	-	150	66	7	63	-	109.4	533	7.75	1033	68	0.23
HUW 1	4/71	-	138	-	-	65	-	-	447	7.86	903	93	0.32
HUW 2	7/75	-	69	168	6	87	-	141.8	383	7.99	790	88	1.43
HUW 2	6/76	-	64	172	7.0	87	-	154.4	366	7.95	808	102	1.59
HUW 3	7/75	-	63	31	4	17	-	98.6	91	7.35	319	168	0.08
HUW 3	6/76	-	34	19	3	7	-	96.8	19	7.35	191	146	0.15
HUW 4	4/71	-	67	-	-	11	-	-	75	7.64	341	173	0.11
HUW 6	4/71	-	120	45	3	26	-	71.6	157	8.2	578	307	0.58
HUW 6	11/73	-	92	45	3	30	-	78.8	171	7.9	404	212	0.21
NAD 14	6/75	60.8	3.2	286	10.8	150	20.1	311	138	8.23	1000	382	3.57
NAD 16	6/75	62.6	1.4	92	1.98	10.6	19.2	248	61	7.95	360	173	0.35
NAD 15B	6/75	66.2	17.6	155	8.34	63	21.2	300.2	114	8.05	631	245	0.95
EL CAP	6/80	90	37.7	2.58	10.6	87.5	25.2	-	502	8.65	-	25.5	-

All data reported in ppm.
NAD - Naval Ammunition Depot Wells; HUW - Hawthorne Utilities Wells
Sources: Boyle - Engineering Rept. (1975); Lawrence Livermore Pilot Study; Data from well owner; Desert Research Institute, Reno; Water Resources Reconnaissance Series, Report 40.

records of HUW 5 indicate that sulfate probably varies more in the vertical direction than in the horizontal direction. Bohm and Jacobson (1977), using data available from HUW 5, concluded that the ground water heated at depth apparently retains a comparatively good water quality. High amounts of dissolved solids are probably added from parts of the alluvium.

As previously mentioned, the thermal waters are located at a relatively shallow depth and thus are able to mix with cooler subsurface water. Using the molar Na, K, and Ca concentrations, an empirical method described by Fournier and Truesdell (1973) for estimating the geothermal reservoir temperature can be employed. A frequency distribution of calculated temperatures for various wells in the Hawthorne region is shown in Figure 3.3. This graph indicates a wide variation in estimated reservoir temperatures (up to 320°F), though calculations indicate a range of 104° to 212°F as being most prominent.

Geothermometers were developed in rapid flow, high-temperature systems (i.e., Yellowstone, WY; The Geysers, CA). The Hawthorne system is a comparatively slow circulating, low-temperature system, and therefore caution is advised in placing

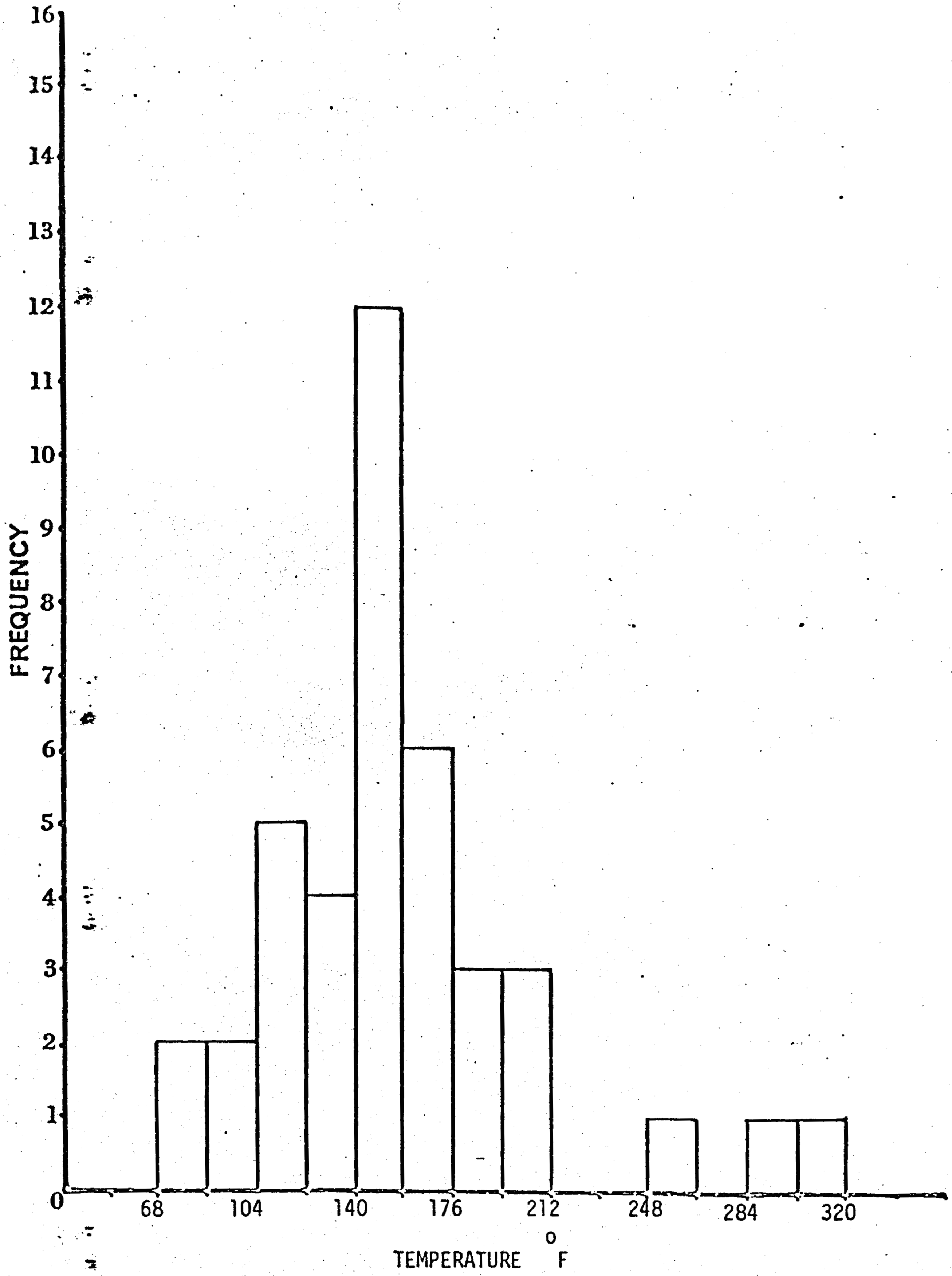


FIGURE 3.3 Distribution of calculated temperatures using the Na-K-Ca geothermometer for various wells in the Hawthorne region (after Bohm and Jacobson, 1977).

too much emphasis on the calculations. The Na-K -Ca geothermometer is at best a gross indication of the source water temperature.

3.4 Geothermal System

Direct evidence of thermal activity in the Hawthorne area are temperatures ranging from 71°F to 210°F (Table 3.3) in several wells. Presumably, deep circulating thermal water flows upward along the range front faults, and mixes with cooler water flowing eastward and northward from the Wassuk Range and Whiskey Flat areas in the shallower parts of the alluvium.

The El Capitan well encountered 210°F water at a depth of 1,000 feet. The well was not deep enough to intersect the main range front fault, but several Quaternary age faults, located between the well and the Wassuk Range, present the strong possibility of a fault passing beneath the well at depth (Plate I).

Well HUW 5 is of particular interest. It is 1,000 feet in depth with the temperature log showing an increase of temperature with depth from 64°F to shallow depths of 73°F at a depth of 859 feet. A pump test in 1972 caused an increase in temperature from 81° to 91°F within four hours at a pumping rate of 15 gpm. Bohm and Jacobson (1977) interpreted this as implying the occurrence of an extensive reservoir of warm water at depth.

TABLE 3.3 Highest reported temperatures and well depths in the Hawthorne area.

WELL	TEMPERATURE °F	DEPTH (ft)
NAD 1	125°F	345'
NAD 2	80°F	423'
NAD 4	73°F	610'
NAD 5	114°F	312'
NAD 6	77°F	394'
NAD 7	79°F	514'
NAD 8	79°F	500'
NAD 9	68°F	423'
NAD 11	71°F	SPRING
NAD 12	74°F	SPRING
HUW 1	-	482'
HUW 2	80°F	602'
HUW 3	-	-
HUW 4	52°F	250'
HUW 5	91°F	1000'
HUW 6	-	1013'
EL CAPITAN	210°F	1000'

The depth to and thickness of the geothermal reservoir is known only from wells drilled in the area. Data from NAD wells 1 and 5, and the El Capitan well (Plate I) allows a conservative characterization of the reservoir as delineated by the 100°F isothermal contour line. A minimum reservoir size may be assumed:

Dimension	Magnitude
length	4.5 miles
width	1 mile
thickness	655 feet

The geothermal reservoir volume, calculated solely on the water well information, would be grossly misleading because:

(1) The true dimensions and characteristics of the reservoir are not known; and

(2) The Wassuk Range front fault zone, which goes to great depth, can be assumed to be the source of rising thermal waters.

3.5 Conclusions

The geologic and hydrologic evidence presented suggest the area of highest probability for obtaining a viable geothermal resource is located adjacent to the Wassuk Range west of the city of Hawthorne. Low sun angle aerial photographs show significant faulting in the Quaternary age alluvium near the range front. The faulting is in two major trends presenting a strong possibility that the faults intersect. Fault intersections are often favorable locations to establish production in a geothermal resource. The El Capitan well (210°F) is located less than a mile west of a probable fault intersection.

Hydrologic evidence indicates that the highly faulted area near the Wassuk Range also has the highest transmissivity values, suggesting an area of more actively circulating water. This evidence suggests the presence of favorable conditions for the existence of a geothermal resource, namely: 1) large quantities of water for a convective geothermal reservoir system; 2) more rapid transmission of deep thermal water to shallow aquifers; 3) during the drilling phase, the high transmissivities would allow water to circulate at a greater distance from the fault, thereby increasing the chances of encountering thermal water if a fault was not directly intersected; 4) a well pumping water in the area would access a larger quantity of water per unit head drop; and 5) injection wells will be able to more efficiently pump larger volumes of water back into the geothermal system.

3.6 Recommended Geothermal Resource Assessment Program and Estimated Costs

The resource assessment program includes surveys designed to locate optimum drilling locations for a production test well (and subsequent production and injection wells), and the drilling, logging, and testing of a single production test well. The program is centered around the El Capitan well, since that well is the strongest evidence of an economically viable geothermal resource in the Hawthorne area. Emphasis is placed on the area northwest of the El Capitan well where preliminary air photo interpretation infers a major fault intersection coincident with an extension of the thermal anomaly. The survey will also include the area within the 100°F isothermal contour line (Plate I) west to the Wassuk Range.

Additional studies are being conducted by the U.S. DOE sponsored resource assessment team at the University of Nevada. A variety of techniques are being applied to define both the nature and extent of the resource. Included in the investigation are: geologic reconnaissance, two meter-depth temperature probe study, soil mercury study, low sun-angle photography, 1/2-mile grid gravity survey, and bulk chemical and stable light isotopic analyses of thermal and non-thermal fluids. Results of the one year study are expected to be available in published form by late summer 1981, and are anticipated to provide new data which will modify the recommended program outlined below.

3.6.1 Geological Survey $ 4,000

Photogeology, field mapping, and an additional literature search to include a 25 square mile area within the prescribed Hawthorne thermal zone.

3.6.2 Shallow Hole Temperature Survey $10,000

Two-meter deep temperature gradient holes on a quarter-mile to half-mile grid, two to eight square miles in area.

3.6.3 Seismic Survey $10,000 - $22,500

Two to three seismic profiles (one and one-half to three miles in length) to map the subsurface location of the major faults.

3.6.4 Geothermal Production Test Well $60,000

One production test well 1,000 to 2,000 feet in depth, directed to intersect at fault zone. Cost includes an 8 1/2-inch diameter, 1,000-foot well; 6 5/8-inch slotted casing; well logs, surveys, and services.

3.6.5 Pump Test $14,000

Step draw-down and continuous discharge test of the geothermal production test well and water analysis to determine optimum flow rate, reservoir temperature, and water chemistry for engineering design.

The total minimum cost of a resource assessment program to the point of development drilling is $98,000 to $101,500. Production test well results and the estimated thermal energy demand for the City of Hawthorne will determine the number of production and injection wells necessary for proper development.

4.0 GEOTHERMAL RESOURCE APPLICATIONS

The greatest potential application of geothermal energy at Hawthorne is district heating. A district heating system designed to supply space heating and domestic hot water heating for the county buildings, the public school buildings, commercial buildings, and residential subdivisions offers the greatest benefit to the residents of Hawthorne. Other applications, such as greenhousing and aquaculture were considered but excluded because of inadequate local markets. Electric power generation, although technically feasible with the resource temperatures encountered thus far at Hawthorne, is not thought to be economical on a large scale as a utility might consider. Therefore, district heating appears to be the most promising application and thus received all the attention of this study.

This section presents a summary of the technical and economic feasibility of district heating systems for Hawthorne. Three different alternatives are presented, encompassing a range of systems from one which would supply only the public buildings in Hawthorne along with the El Capitan Lodge and Casino, to an extensive system which would serve the entire town, including all of the residential heating load. These alternative systems, the preliminary engineering, and the economic analyses that are presented, are all based upon more detailed reports prepared by Chilton Engineering (1981), The Spink Corporation (1981), and the Geo-Heat Utilization Center

(1981). All data, tables, and schematics in this section are attributable to those three entities, which are herein fully credited for the engineering and economic evaluations.

4.1 Community Energy Consumption Data

Table 4.1 presents the heating loads that have been derived for the several facilities in Hawthorne. The peak heating loads and the annual heating loads have been determined from inspection of existing heat supply systems in the buildings, from calculations of the heating requirements based upon the area's heating characteristics, and from analyses of past energy consumption bills.

The six groupings of facilities in Table 4.1 provide a total annual heat load of 44.5 x 10^9 Btu. This collection of facilities is designated Alternate I in the engineering and economic evaluations presented later. Alternate II is the same as Alternate I except that the Mt. Grant and Lakeview Tracts are not included; therefore, the total annual heat load is reduced to 26.8 x 10^9 Btu. Not shown in Table 4.1 is the increment of energy utilized by the remainder of the town of Hawthorne, including all other residential and commercial users. A precise calculation of energy consumption for the entire town has not been performed, but a good estimate is 168.9 x 10^9 Btu (W. Cuchine,

TABLE 4.1 Summary of heating loads

	Peak Btu/h	Annual Btu
Courthouse, Public Safety Hospital & Library	2.44×10^6	2.45×10^9
Schools	6.32×10^6	8.34×10^9
Mt. Grant Subdivision	4.11×10^6	7.13×10^9
Lakeview Tract	6.11×10^6	10.60×10^9
El Capitan Subdivision	6.40×10^6	11.11×10^9
El Capitan Lodge & Club	3.13×10^6	4.91×10^9
TOTAL	28.51×10^6	44.54×10^9

Oral Communication, 1981); this then is Alternate III for a Hawthorne district heating system.

4.2 Engineering Design

4.2.1 Geothermal Well Field

The design and development of the geothermal well field for the Hawthorne district heating system is based upon the location and quality of an existing hot water well that was drilled and completed by the owners of the El Capitan Lodge. The 1,000 foot well is located approximately 1.5 miles southwest of Hawthorne. It produces 700 gpm of 210°F water with the existing 150 hp pumping equipment.

The well and pump are adequate to supply the quantity of hot water needed for Alternate II whioh requires a peak flow of 780 gpm. A 250 hp pump with a variable speed drive would be substituted for the existing pump in order to produce the 991 gpm peak flow required for Alternate I; only the one existing well is still required for Alternate I. Alternate III, however, would require the drilling of four additional wells each with approximately the same delivery rate as the existing well, for a total peak flow of 4025 gpm. For present purposes, it has been assumed that the four new wells would be located in a line to the northwest of the existing well at approximately half-mile intervals. Work presently in progress under the State Coupled Resource Assessment Program, will further define the resource location and will probably result in other locations for the proposed wells.

4.2.2 Hot Water Distribution Systems

Alternate I

Geothermal water at 210°F will be supplied by the existing 1,000 foot well located on El Capitan property 1.5 miles southwest of Hawthorne. The existing 150 hp pump would be replaced by a 250 hp unit with a variable speed drive. This would increase the maximum pumping rate from the present 700 gpm to the required 991 gpm.

An insulated 8" FRP pipeline would be installed to transport the geothermal water to Hawthorne (Figure 4.1). For design purposes a temperature of 200°F has been used. The 200°F water would pass through plate-type heat exchangers at the individual buildings and at the three subdivisions. A 10°F approach temperature was used, with the individual heat exchangers removing 30°F to 54°F from the geothermal water. Through

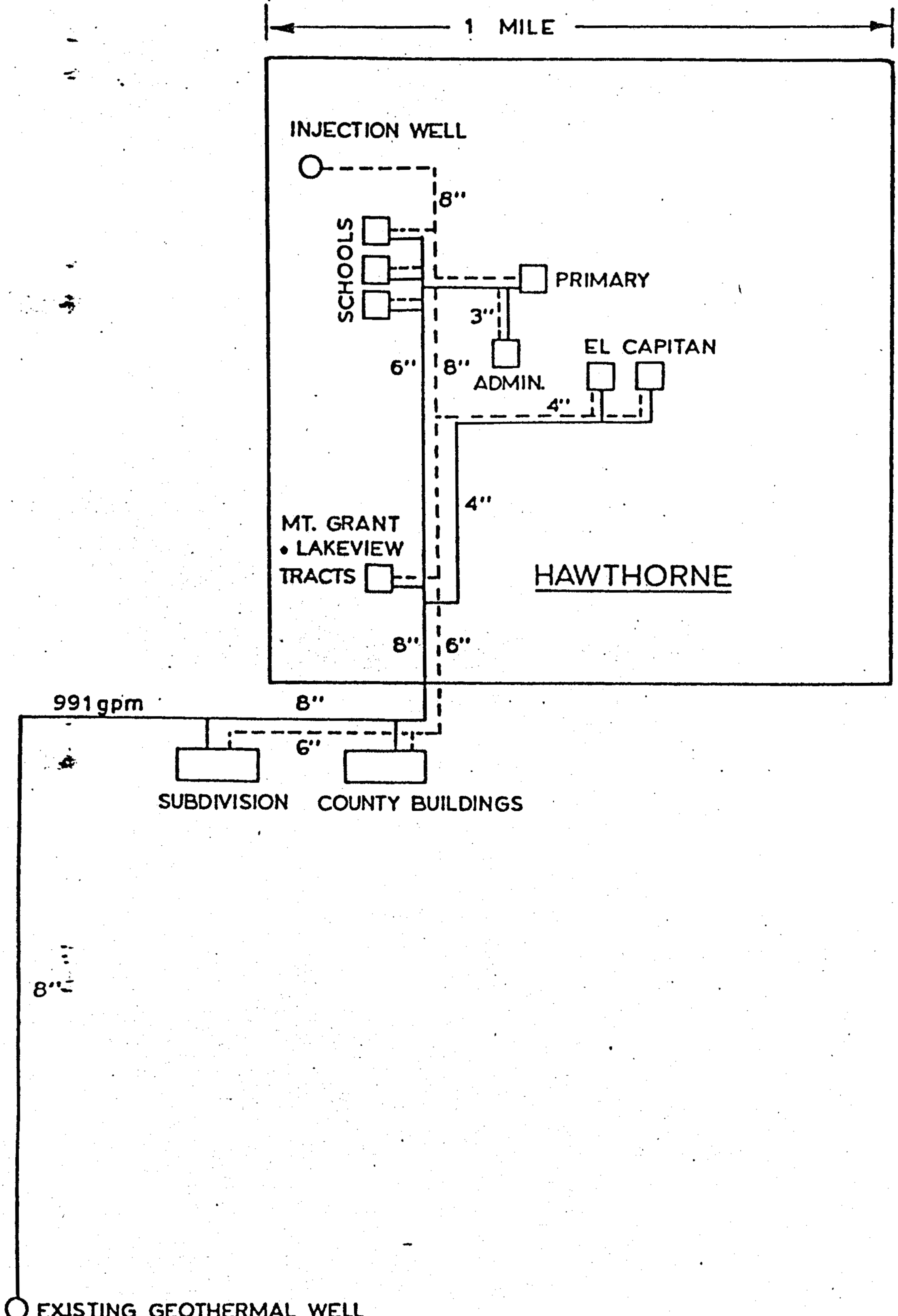


FIGURE 4.1 Alternate I plot plan (from Geo-Heat Utilization Center, 1981).

cascaded use of a portion of the flow, the overall temperature drop in the system would approach 59°F as shown in Figure 4.2.

The flow through each heat exchanger would be regulated by temperature activated control valves and would be measured and recorded. The control valves close as demand decreases. This increases the pressure in the geothermal lines, which causes the variable speed pump to decrease the well output.

The schools are the last user on the line and are at the lowest point in the system. It was assumed that the cooled geothermal water could be pumped into a well to be located on the school property.

When future development occurs at the planned industrial site on the north side of Hawthorne, the cooled water (141°F) can be used for heating there and then injected at a well located on site. The 141°F water will not be hot enough for most industrial applications but could provide space heating for up to 300,000 square feet of buildings.

The FRP pipelines carrying the water from the upstream users to the school injection site will be insulated so that very little heat will be

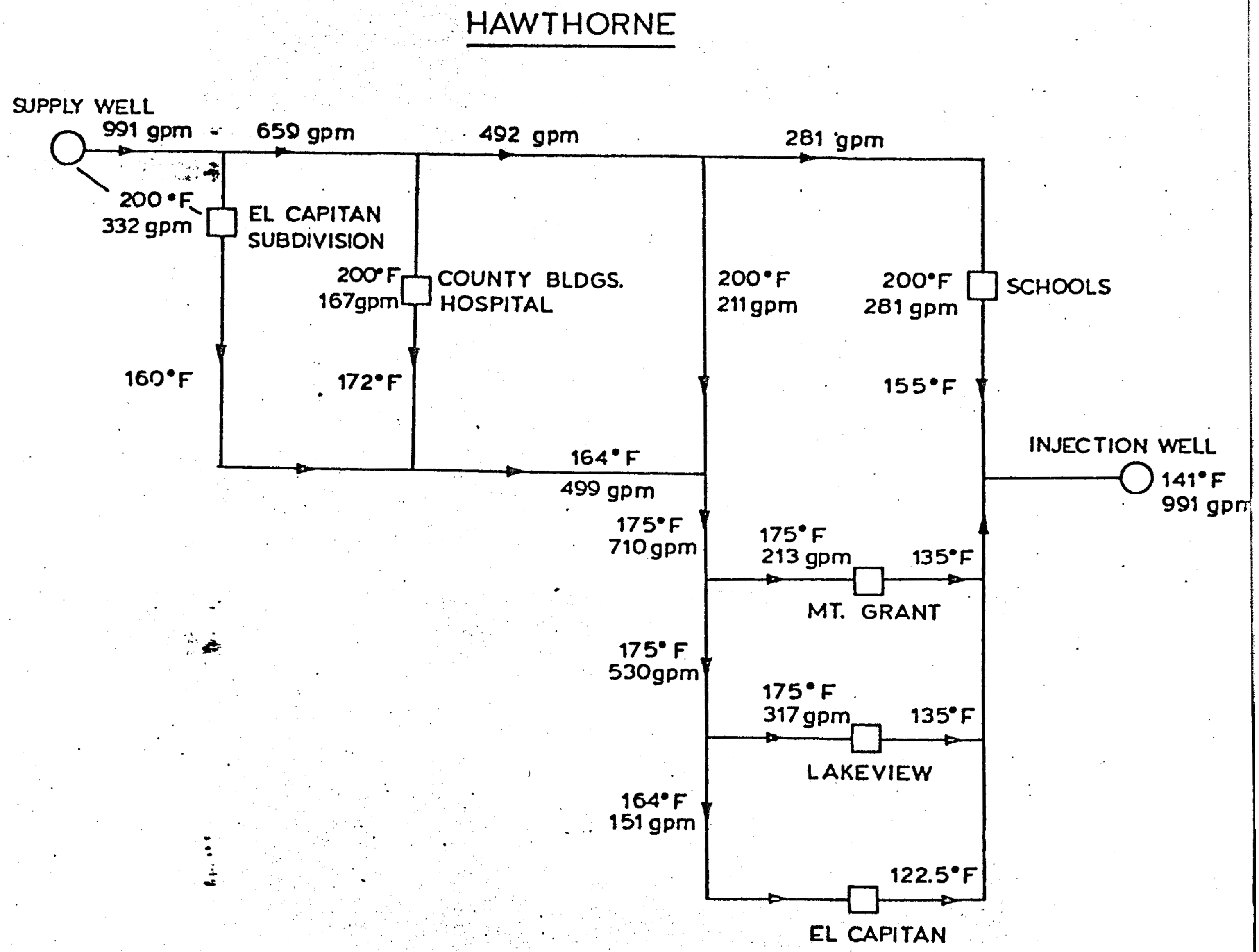


FIGURE 4.2 Alternate I flow diagram (from Geo-Heat Utilization Center, 1981).

lost. This heat will be available when the line is eventually extended to the industrial site.

Alternate II

All parts of the system are identical to those in Alternate I except that the Mr. Grant and Lakeview Tracts are not served. The peak flow is thereby reduced from 991 gpm to 780 gpm and the final temperature of the geothermal water would be 154°F as shown in the flow diagram in Figure 4.3. This Alternate does not require replacement of the existing well pump.

Alternate III

The entire town could be served using geothermal water supplied by the existing well and four additional wells. Geothermal water would be supplied to Hawthorne through 8", 10" and 14" insulated pipelines as shown in Figure 4.4. The heat exchangers and circulating pumps would be centrally located, with the cooled water (150°F) piped to the industrial park for further use and injection.

The distribution system, as shown in Figure 4.5, consists of parallel supply and return lines, all of which would be insulated. Two heat exchangers, each with 50 million Btuh capacity and three 100

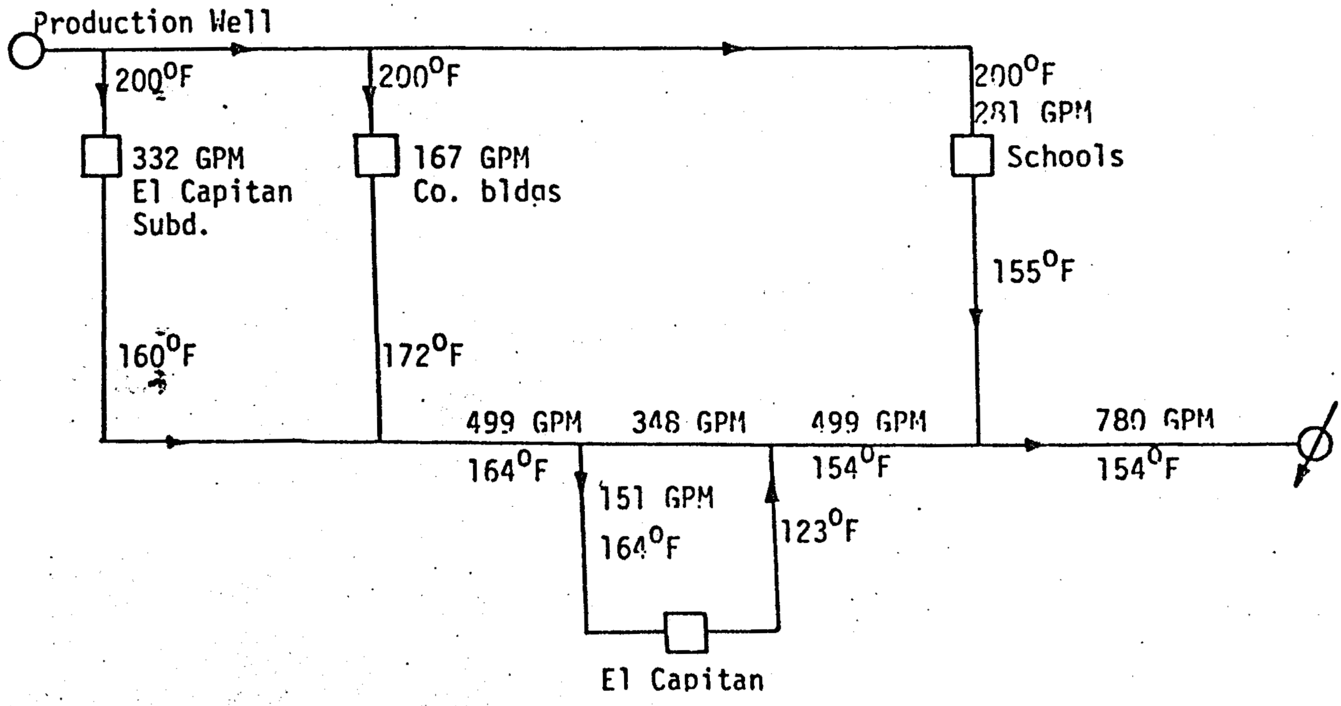


FIGURE 4.3 Alternate II flow diagram (from Geo-Heat Utilization Center, 1981).

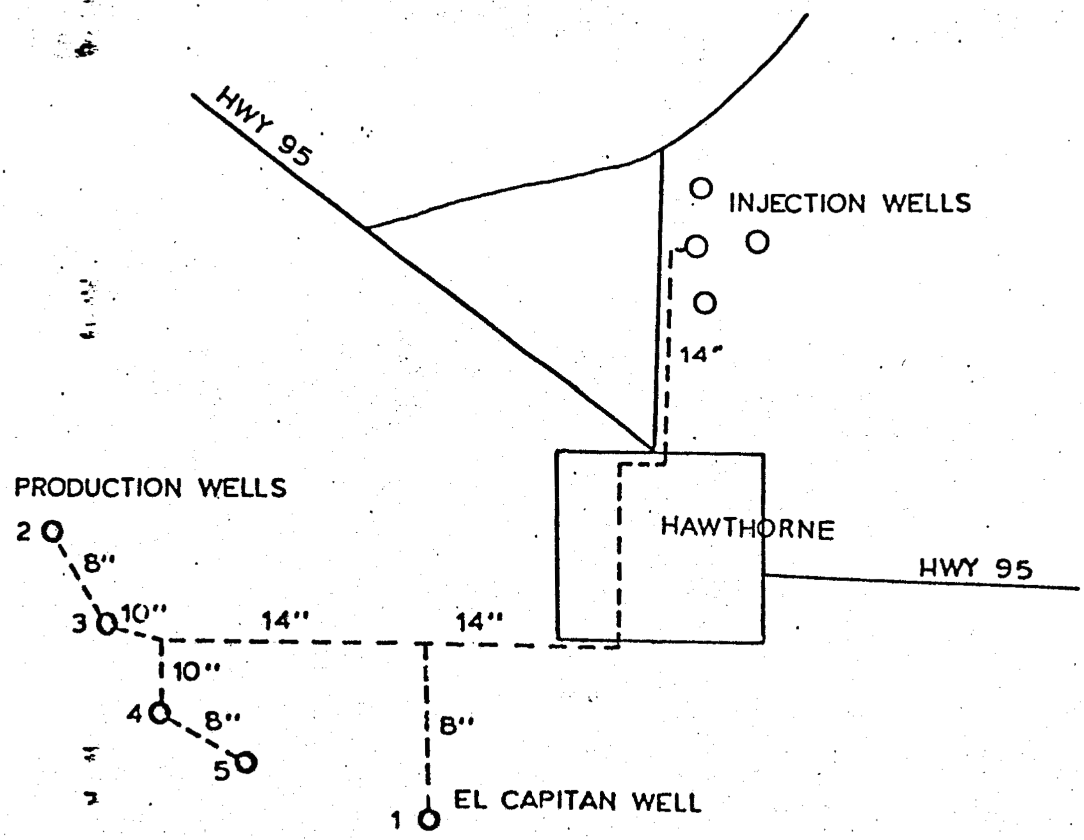


FIGURE 4.4 Alternate III plot plan of gathering system (from Geo-Heat Utilization Center, 1981).

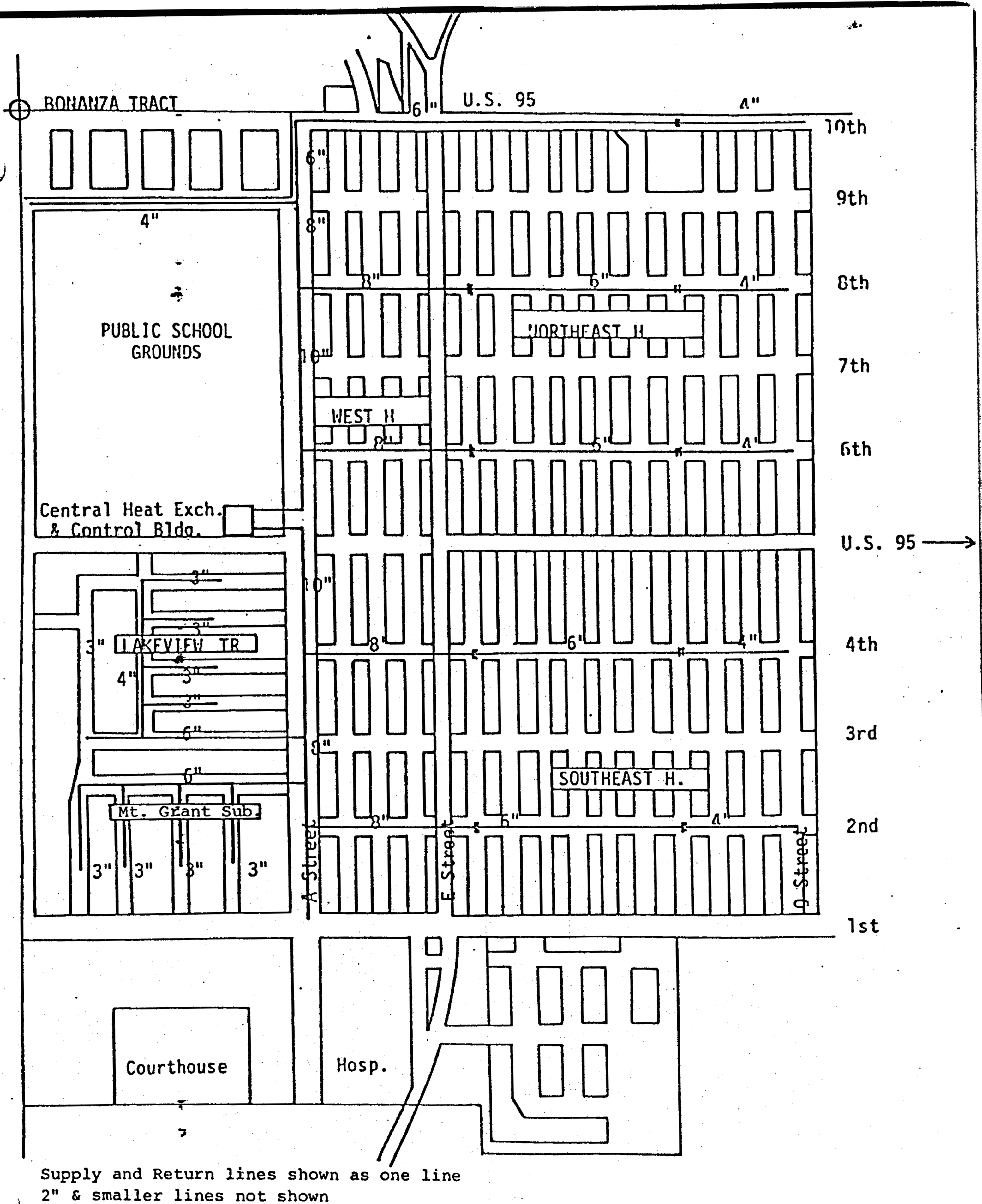


FIGURE 4.5 Alternate III plot plan of distribution system (from Geo-Heat Utilization Center, 1981).

hp circulating pumps, would be located at the central heat exchanger building. The third pump would be a standby unit and the use of two heat exchangers allows for service and cleaning of one unit during periods of lower heat demands.

4.3 Capital Equipment Costs and Operating Expenses

The geothermal district heating system cost estimates for the three alternates are shown in Tables 4.2, 4.3, and 4.4. They are each separated into two parts: the well supply system and the distribution system. Each system is treated separately in the economic analysis, because of the possibility of different system ownership which will be defined in Section 4.4. Cost estimates are based on present prices (1981) with no inflation factors for construction in later years.

The Alternate I distribution system cost is \$1,866,560 and the supply system cost is \$154,000, a portion of which has already been invested in the existing well.

Alternate II costs are the same for the supply system, but are reduced to \$1,418,640 for the distribution system with the elimination of the distribution lines to the Mt. Grant and Lakeview Tracts.

The costs for Alternate III, the entire town, are \$8,590,000 for the distribution system and \$757,000 for

TABLE 4.2 Alternate I capital and operating costs

Supply System:			
Existing well and new pump			$ 154,000
Operation & maintenance cost	$ 3,100		
Electrical power	18,700		
	$21,800		
Distribution System:			
Capital Costs -			
Injection well		$ 60,000	
Heat exchangers		21,000	
Distribution pipelines		1,409,900	
Circulating pumps		33,000	
Buildings, controls, and misc. ICL		99,200	
Subtotal			1,623,100
Contingency			243,460
Total capital cost			$1,866,560
Operating Costs - (1st yr)			
Electrical power	$ 3,200		
Maintenance	16,600		
	19,800		

TABLE 4.3 Alternate II capital and operating costs

Supply System:			
Existing well & new pump			$ 154,000
Operation & maintenance cost	$ 3,100		
Electrical power	18,700		
Total annual cost	$21,800		
Distribution System:			
Capital Costs -			
Injection well		$ 60,000	
Distribution system		1,082,500	
Controls & misc. ICL		91,100	
Subtotal			1,233,600
Engineering & Contingencies @ 15%			185,040
Total			$1,418,640
Annual Operation & Maintenance Cost	$9,440		

TABLE 4.4 Alternate III capital and operating costs

Supply System:			
4 Production wells		$ 320,000	
4 Well pumps & variable speed drives		184,000	
Existing well & pump		154,000	
Subtotal			$ 658,000
Engineering & Contingencies			99,000
Total			$ 757,000
Operation & maintenance cost	$ 74,800		
Electrical power	86,300		
Total annual cost	$101,100		
Distribution System:			
Distribution lines		$6,619,000	
Heat exchangers		146,000	
Circulating pumps		85,000	
Buildings & controls		220,000	
Misc. electric & mechanical		160,000	
Four injection wells		240,000	
Subtotal			$7,470,000
Engineering & Contingencies			1,120,000
Total			$8,590,000
Operation & maintenance cost	$45,500		
Electrical power	15,900		
Total annual cost	$61,400		

the supply system making the total investment $9,347,000.

4.4 Economic Evaluations

4.4.1 Ownership of Geothermal Systems

The life cycle cost analysis of the geothermal district heating system and the resultant prices of energy delivered to the various customers are determined not only by the capital and operating costs but also by the ownership structure for the basic components of the system. For the Hawthorne geothermal system, the most practical structure appears to be for the well supply system to be privately owned and operated by the El Capitan Lodge and for the distribution system to be publicly owned and operated by Mineral County.

El Capitan owns the geothermal water rights, the existing well and the land upon which future wells might be drilled. The county is a legally established governmental body with state-granted authority to own and operate public utility systems. The county would also be a major consumer of the geothermal energy for its county buildings and the schools. As the energy distributor, the county could also sell energy to the private sector of existing residences, future subdivisions, retail/commercial establishments and the entire El Capitan complex.

If El Capitan were the well developer and producer, it could exercise tax deductions and tax credits available only to the private sector under Federal tax law. Further, El Capitan would probably not be subject to regulation under the state public utilities commission, since it would sell its commodity - energy - to a single customer, the county, under a negotiated contract.

As the energy distributor and as the only wholesale customer of the well developer and producer, the county would hold significant negotiating strength in establishing purchase contracts with that geothermal supplier. In addition, the county would be in a position to "sell" the energy to itself at favorable prices.

The county would also sell geothermal energy to the private sector. It could set a price for private sales different from sales to itself in order to assure that the private sector sales are basically competitive with other fuel forms over time and that the revenues from the mix of sales to the county and sales to the private sector are adequate to service the county's debt as well as operating and maintenance costs for the distribution system.

4.4.2 Geothermal Energy Prices

Considerable effort was expended by the OIT Geo-Heat Utilization Center in their economic analyses to determine reasonable first year (1981) values for the wholesale price, from the supplier to the distributor, and for the retail price, from the distributor to the private customers, of the geothermal energy. The wholesale price was found to be \$0.90 per MMBtu (10^6 Btu), and the retail price was estimated to be \$5.50 per MMBtu. The wholesale price of \$0.90/MMBtu provides the well developer/producer with a nominal 16.5 percent return on investment after taxes. The retail price of \$5.50/MMBtu, when coupled with the energy cost savings realized by the county in replacing its current consumption of propane and fuel oil with geothermal energy, provides the county with a cash flow (undiscounted) that would pay off its original capital investment plus interest in nine years for Alternate II, and in sixteen years for Alternate III. Alternate I, which is quite similar to Alternate II, was not fully studied by

OIT. Therefore, life cycle cost information for Alternate I is not presented.

4.4.3 Economic Data and Assumptions

Table 4.5 provides a summary of data used by OIT in their final series of economic analyses. The energy consumption and cost data for the school buildings and the county buildings are taken, with some modification by OIT, from the reports of The Spink Corporation and Chilton Engineering. The total annual heat load for the set of buildings listed in Table 4.5 is 26.8 x 10^9 Btu, which corresponds to Alternate II. It excludes the Lakeview Tract and the Mt. Grant Subdivision, but includes the construction of 256 new residences and condominiums for the El Capitan Subdivision.

Life cycle cost analyses were also performed for Alternate III, a geothermal district heating system serving the entire county and community. The total annual heat load for this case is 168.9 x 10^9 Btu. The results are presented following the results for Alternate II.

All capital and operating costs for the analyses were in 1981 dollars, the assumed year of

TABLE 4.5 Hawthorne summary sheet

	Current Fuel Consumption		Geothermal Use			
	Annual Consumption Gals.	Annual Cost	Annual Load (10^9 Btu)	Annual Cost @ $0.90/MMBtu	Electric Pumping Cost	Retrofit Cost
Mineral County Schools						
Administration	2,949	$ 3,096	0.28	$ 257	$ 38.50	$ 32,988
Primary	5,276	5,540	0.51	459	103.00	40,957
Laundry & Maint. Shop	3,836*	4,318	0.38	345	34.00	47,073
Elementary No. 2	5,439	5,711	0.53	473	64.00	59,582
Elementary No. 1	27,652	29,035	2.67	2,403	377.00	347,002
and Music Bldg.	1,553*	1,305	0.11	103		
Vocational Bldg.	7,718*	6,483	0.57	510	38.50	53,924
Gymnasium	17,547	18,424	1.70	1,526	103.00	45,653
High School	16,451	17,274	1.59	1,431	360.00	152,289
Total County Schools		$91,186	8.34	$7,505	$1,118.00	$779,468
County Buildings						
Court House and Public Safety Bldg.	6,620	$ 6,951	0.64	$ 576	$ 400.00	$ 35,603
Mt. Grant Hospital	17,685	18,569	1.71	1,538	100.00	39,783
Library	1,002	1,052	0.10	87	50.00	19,541
Total County Buildings		$26,572	2.45	$2,201	$ 550.00	$ 94,927
Total County		$117,758	10.79	$9,706	$1,668.00	$874,395
				Annual Cost @$5.50/MMBtu		
Private Sector						
El Capitan Club	44,131	37,070	3.24	$17,826	$ 70.00	$ 60,000
Lodge	22,781	19,136	1.67	9,202	34.00	20,000
Total	66,912	$56,206	4.91	$27,028	$ 104.00	$ 80,000
El Capitan Subdivision			11.11			
Grand Total			26.77			

*Indicates propane; all other data are for oil.

construction. The first year (year 1) of operation was assumed to be 1982.

The costs for the replacement of the existing conventional fuel heating equipment at the end of its normal economic life are tabulated in Table 4.6. Several of the school building heating systems have already surpassed their economic life, as indicated by zero in the replacement year column. The vocational building and gymnasium systems have six and nineteen years yet until their economic lives expire. Therefore, based upon economic life, $428,218 worth of replacement should be accomplished immediately.

OIT assumed a schedule of inflation rates for future years that was forecast in 1980 by the Oregon Department of Energy. The inflation rates for heating oil and propane were as follows: 7.9 percent through 1984; 9.0 percent through 1989; 11.5 percent through 1994; and 11.6 percent through 2000. The economic inflation rate was forecast at 7 percent annually for the life of the project. It was realized that these inflation rates were very conservative and that, more than likely, conventional energy will inflate much more rapidly. Any project that is economically feasible with conservative inflation

TABLE 4.6 Replacement times and costs for existing heating systems

School Building	Retrofit Cost	Conventional System Replacement Year	Conventional System Replacement Cost
Administration	$ 32,988	0	$ 18,407
Primary	40,957	0	31,044
Laundry & Maint. Shop	47,073	0	10,801
Elementary No. 2	59,582	0	34,294
Elementary No. 1 and Music Bldg.	347,002	0	222,554
Vocational Bldg.	53,924	6	18,817
Gymnasium	45,653	19	91,125
High School	152,289	0	121,919

rates will be even more attractive with higher inflation rates.

4.4.4 Life Cycle Cost Analyses

As previously mentioned, only the life cycle cost analyses for Alternate II and Alternate III were reported by OIT. The results are summarized here. Alternate II is presented in Tables 4.7, 4.8 and 4.9. Alternate III is presented in Table 4.10.

Tables 4.7a and 4.7b present the costs and cash flows for the county operating the district heating system as owner and distributor of the geothermal energy. Geothermal energy is purchased at $0.90 per MMBtu and sold at $5.50 per MMBtu. Explanation of the column headings are as follows:

Column 1 indicates the 20-year forecast for conventional energy, starting at 10.91/MMBtu in 1981.

Column 2 projects the 20-year cash flow for the cost of geothermal at $0.90/MMBtu, inflating at 7 percent per annum.

Column 3 projects the 20-year cost for electricity for the circulation pumps for the geothermal system.

Column 4 shows the 20-year cash flows generated from the reduced costs of geothermal versus conventional fuel.

TABLE 4.7a Alternate II Mineral County total system

YEAR	(1) PROJECTED 20 YEAR COST OF CONVENTIONAL FUEL	(2) PROJECTED GEOTHERMAL HEAT COST	(3) PROJECTED ELECTRICAL COST FOR PUMPING	(4) VALUE OF ENERGY SAVINGS	(5) SALES OF GEOTHERMAL TO NON-COUNTY USERS AT $5.50/MMBTU	(6) NET ANNUAL CASH FLOW	(7) NET ANNUAL CASH FLOW DISCOUNTED AT 10%
0	$117,758.	$24,120.	$1,668.		$ 88,084.		
1	127,061.	25,808.	1,817.	99,436.	94,251.	193,686.	176,079.
2	137,099.	27,615.	1,978.	107,505.	100,848.	208,353.	172,193.
3	147,929.	29,548.	2,154.	116,227.	107,908.	224,135.	168,396.
4	161,243.	31,616.	2,346.	127,281.	115,461.	242,742.	165,796.
5	175,755.	33,830.	2,555.	139,370.	123,543.	262,914.	163,249.
6	191,573.	36,198.	2,782.	152,593.	132,191.	284,784.	160,753.
7	208,815.	38,731.	3,030.	167,053.	141,445.	308,498.	158,308.
8	227,608.	41,443.	3,291.	182,875.	151,346.	334,220.	155,916.
9	253,783.	44,344.	3,574.	205,865.	161,940.	367,806.*	155,985.
10	282,968.	47,448.	3,881.	231,639.	173,276.	404,915.	156,112.
11	315,509.	50,769.	4,215.	260,525.	185,405.	445,931.	156,296.
12	351,793.	54,323.	4,577.	292,892.	198,384.	491,276.	156,536.
13	392,249.	58,125.	4,971.	329,152.	212,270.	541,423.	156,831.
14	437,750.	62,194.	5,398.	370,157.	227,129.	597,286.	157,284.
15	488,529.	66,548.	5,863.	416,118.	243,028.	659,147.	157,794.*
16	545,198.	71,206.	6,367.	467,625.	260,040.	727,665.	158,361.
17	608,441.	76,191.	6,914.	525,336.	278,243.	803,579.	158,984.
18	679,020.	81,524.	7,509.	589,987.	297,720.	887,707.	159,662.
19	757,786.	87,231.	8,155.	662,401.	318,561.	980,962.	160,395.
20	845,690.	93,337.	8,856.	743,497.	340,860.	1,084,357.	161,183.
Totals				$6,187,534.		$10,051,385.	$3,216,113.

*Payback

TABLE 4.7b Alternate II Mineral County total system

YEAR	(8) DEBT SERVICE ON TOTAL SYS. COSTS	(9) VALUE OF ENERGY SVGS. INCLUDING LOAN PMT.	(10) CUMULATIVE CASH FLOW	(11) ASSUME 50% REPLACEMENT OF EQUIP. WITH ZERO LIFE	(12) ASSUMES 100% EQUIP. RE-PLACEMENT IN APPROP. YEAR	(13) SALES OF GEOTH. TO NON-COUNTY USERS AT $3.60/MMBTU	(14) CUMULATIVE CASH FLOW
0	$269,339.					$ 57,655.	
1	269,339.	-75,653.	-75,653.	138,456.	352,565.	61,691.	320,006.
2	269,339.	-60,986.	-136,638.	77,471.	291,580.	66,010.	224,182.
3	269,339.	-45,205.	-181,843.	32,266.	246,375.	70,630.	141,700.
4	269,339.	-26,597.	-208,440.	5,669.	219,778.	75,575.	75,216.
5	269,339.	-6,425.	-214,865.	-756.	213,353.	80,865.	26,112.
6	269,339.	15,445.	-199,420.	14,689.	247,615.	86,525.	14,709.
7	269,339.	39,159.	-160,261.	53,848.	286,774.	92,582.	5,005.
8	269,339.	64,881.	-95,380.	118,729.	351,655.	99,063.	17,603.
9	269,339.	98,467.	3,086.	217,195.	450,121.	105,997.	60,126.
10	269,339.	135,576.	138,662.	352,771.	596,498.	113,417.	146,644.
11	269,339.	176,591.	315,254.	529,363.	773,090.	121,356.	259,187.
12	269,339.	221,937.	537,191.	751,300.	995,027.	129,851.	412,591.
13	269,339.	272,084.	809,275.	1,023,384	1,267,111.	138,941.	611,345.
14	269,339.	327,947.	1,137,222.	1,351,331.	1,595,058.	148,667.	860,830.
15	269,339.	389,808.	1,527,030.	1,741,139.	1,984,866.	159,073.	1,166,682.
16	269,339.	458,326.	1,985,356.	2,199,465.	2,443,192	170,208.	1,535,176.
17	269,339.	534,240.	2,519,596.	2,733,705.	2,977,432.	182,123.	1,973,296.
18	269,339.	618,368.	3,137,964.	3,352,073.	3,595,800.	194,871.	2,488,815.
19	269,339.	711,623.	3,849,587.	4,063,696.	4,398,548.	208,512.	3,181,515.
20	269,339.	815,018.	4,664,604.	4,878,713.	5,213,565.	223,108.	3,878,781.
Totals		$4,664,604.	$4,664,604.	$4,878,713.	$5,213,565.		$3,878,781.

TABLE 4.8 Alternate II well field developer, Hawthorne

COLUMN	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
YEAR	GEOTHERMAL ENERGY SALES	PERCENTAGE DEPLETION	STRAIGHT LINE DEPRE.	PUMPING COST	MAINTENANCE COST	NET INCOME BEFORE TAXES	FEDERAL INCOME TAXES	NET INCOME AFTER TAXES	ADD DEPRECIATION & DEPLETION	AFTER TAX CASH FLOW (INCLUDES 25% INVESTMENT TAX CREDIT)	DISCOUNTED AFTER TAX CASH FLOW AT 16.5%
0	$ 24,120			$14,436.	$ 3,100.						
1	25,808	0	6,930	15,721	3,317	-160	-77	-83	6,930	45,347	38,924
2	27,615	8	6,930	17,120	3,549	7	4	4	6,938	6,942	5,115
3	49,062	7,850	6,930	18,644	3,798	11,841	5,684	6,157	14,780	20,937	13,242
4	52,497	7,875	6,930	20,303	4,063	13,325	6,396	6,929	14,805	21,734	11,799
5	56,172	8,426	6,930	22,110	4,348	14,358	6,892	7,466	15,356	22,822	10,635
6	60,104	9,016	6,930	24,078	4,652	15,428	7,405	8,022	15,946	23,968	9,587
7	64,311	9,647	6,930	26,221	4,978	16,535	7,937	8,598	16,577	25,175	8,643
8	68,813	10,322	6,930	28,476	5,326	17,758	8,524	9,234	17,252	26,486	7,806
9	73,630	11,044	6,930	30,925	5,699	19,031	9,135	9,896	17,974	27,870	7,050
10	78,784	11,818	6,930	33,585	6,098	20,353	9,769	10,584	18,748	29,331	6,369
11	84,299	12,645	6,930	36,473	6,525	21,726	10,428	11,297	19,575	30,872	5,754
12	90,199	13,530	6,930	39,610	6,982	23,148	11,111	12,037	20,460	32,497	5,199
13	96,513	14,477	6,930	43,016	7,471	24,620	11,817	12,802	21,407	34,209	4,698
14	103,269	15,490	6,930	46,716	7,993	26,140	12,547	13,593	22,420	36,013	4,245
15	110,498	16,575	6,930	50,733	8,553	27,707	13,299	14,408	23,505	37,912	3,836
16	118,233	17,735	6,930	55,096	9,152	29,320	14,074	15,246	24,665	39,911	3,466
17	126,509	18,976	6,930	59,835	9,792	30,976	14,868	16,108	25,906	42,014	3,132
18	135,365	20,305	6,930	64,980	10,478	32,672	15,683	16,989	27,235	44,224	2,830
19	144,841	21,726	6,930	70,569	11,211	34,405	16,514	17,890	28,656	46,546	2,557
20	154,979	23,247	6,930	76,638	11,996	36,169	17,361	18,808	30,177	48,985	2,310
										TOTAL	$157,197

TABLE 4.9 Alternate III well field developer, Hawthorne

COLUMN	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
YEAR	GEOTHERMAL ENERGY SALES	PERCENTAGE DEPLETION	STRAIGHT LINE DEPRE.	PUMPING COST	MAINTENANCE COST	NET INCOME BEFORE TAXES	FEDERAL INCOME TAXES	NET INCOME AFTER TAXES	ADD DEPRECIATION & DEPLETION	AFTER TAX CASH FLOW (INCLUDES 25% INVESTMENT TAX CREDIT)	DISCOUNTED AFTER TAX CASH FLOW AT 7.5%
0	$152,010			$ 86,300	$ 14,800						
1	162,651	9,385	34,065	93,981	15,836	9,385	4,505	4,880	43,450	237,579	221,004
2	174,036	10,341	34,065	102,345	16,945	10,341	4,965	5,377	44,406	49,783	43,157
3	186,219	11,285	34,065	111,454	18,131	11,285	5,417	5,868	45,350	51,218	41,228
4	199,254	12,208	34,065	121,373	19,400	12,208	5,860	6,348	46,273	52,621	39,403
5	213,202	13,102	34,065	132,175	20,758	13,102	6,289	6,813	47,167	53,980	37,600
6	228,126	13,956	34,065	143,939	22,211	13,956	6,699	7,257	48,021	55,278	35,818
7	244,095	14,757	34,065	156,749	23,766	14,757	7,084	7,674	48,822	56,496	34,053
8	261,181	15,729	34,065	170,230	25,429	15,729	7,550	8,179	49,794	57,973	32,506
9	279,464	16,660	34,065	184,870	27,209	16,660	7,997	8,663	50,725	59,388	30,976
10	299,027	17,540	34,065	200,768	29,114	17,540	8,419	9,121	51,605	60,725	29,463
11	319,959	18,354	34,065	218,035	31,152	18,354	8,810	9,544	52,419	61,962	27,966
12	342,356	19,086	34,065	236,785	33,332	19,086	9,161	9,925	53,151	63,076	26,483
13	366,321	19,720	34,065	257,149	35,666	19,720	9,466	10,255	53,785	64,040	25,012
14	391,963	20,236	34,065	279,264	38,162	20,236	9,713	10,523	54,301	64,824	23,551
15	419,400	20,611	34,065	303,281	40,834	20,611	9,893	10,718	54,676	65,393	22,101
16	448,758	20,819	34,065	329,363	43,692	20,819	9,993	10,826	54,884	65,710	20,658
17	480,172	20,834	34,065	357,688	46,750	20,834	10,000	10,834	54,899	65,733	19,224
18	513,784	20,623	34,065	388,449	50,023	20,623	9,899	10,724	54,688	65,412	17,795
19	549,748	20,152	34,065	421,856	53,525	20,152	9,673	10,479	54,217	64,695	16,372
20	588,231	19,380	34,065	458,135	57,271	19,380	9,302	10,077	53,445	63,522	14,954
										TOTAL	$759,324

TABLE 4.10 Alternate III Mineral County.total system

COLUMN	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
YEAR	PROJECTED 20 YEAR COST OF CONVENTIONAL FUEL	PROJECTED GEOTHERMAL HEAT COST	PROJECTED ELECTRICAL COST FOR PUMPING	VALUE OF ENERGY SAVINGS	SALES OF GEOTHERMAL TO NON-COUNTY USERS AT $5.50/MMBTU	NET ANNUAL CASH FLOW	DEBT SERVICE ON TOTAL SYS. COSTS	VALUE OF ENERGY SVGS. INCLUDING LOAN PMT.	CUMULATIVE CASH FLOW
0	$117,758	$151,920	$15,900		$ 869,605		$1,008,978		
1	127,061	162,554	17,315	-52,809	930,477	877,669	1,008,978	-131,309	-131,309
2	137,099	173,933	18,856	-55,691	995,611	939,920	1,008,978	-69,058	-200,368
3	147,929	186,109	20,534	-58,713	1,065,304	1,006,590	1,008,987	-2,388	-202,756
4	161,243	199,136	22,362	-60,255	1,139,875	1,079,620	1,008,987	70,642	-132,114
5	175,755	213,076	24,352	-61,673	1,219,666	1,157,993	1,008,987	149,015	16,901
6	191,573	227,991	26,519	-62,937	1,305,043	1,242,105	1,008,987	233,127	250,028
7	208,815	243,950	28,880	-64,015	1,396,396	1,332,380	1,008,987	323,402	573,430
8	227,608	261,027	31,363	-64,782	1,494,143	1,429,361	1,008,987	420,383	993,813
9	253,783	279,299	34,061	-59,577	1,598,733	1,539,157	1,008,987	530,179	1,523,992
10	282,968	298,850	36,990	-52,872	1,710,645	1,657,773	1,008,987	648,795	2,172,786
11	315,509	319,769	40,171	-44,431	1,830,390	1,785,959	1,008,987	776,981	2,949,767
12	351,793	342,153	43,626	-33,986	1,958,517	1,924,531	1,008,987	915,553	3,865,320
13	392,249	366,104	47,377	-21,232	2,095,613	20,74,381	1,008,987	1,065,403	4,930,723
14	437,750	391,731	51,452	-5,433	2,242,306	2,236,873	1,008,987	1,227,895	6,158,618
15	488,529	419,152	55,877	13,500	2,399,268	2,412767	1,008,987	1,403,789	7,562,407
16	545,198	448,493	60,682	36,023	2,567,216	2,603,239	1,008,987	1,594,261	9,156,668
17	608,441	479,887	65,901	62,653	2,746,922	2,809,574	1,008,987	1,800,596	10,957,264
18	679,020	513,479	71,568	93,972	2,939,206	3,033,178	1,008,987	2,024,200	12,981,465
19	757,786	549,423	77,723	130,640	3,144,950	3,275,591	1,008,987	2,266,613	15,248,077
20	845,690	587,882	84,407	173,400	3,365,097	3,538,497	1,008,987	2,529,519	17,777,596
TOTALS				-$188,218		$37,957,159		$17,777,596	$17,777,596

Column 5 includes sales of geothermal energy to the El Capitan Lodge and Club plus new residential developments designed for geothermal heating at $5.50/MMBtu.

Column 6 provides net annual cash flow and simple payback.

Column 7 presents a 20-year discounted cash flow with discounted payback all at 10 percent per year.

Column 8, Table 4.7b, continues the total county system and includes a loan payment based on total system costs of $2,293,035 which includes retrofit of county buildings and distribution system costs.

Columns 9 and 10 present the net cash flow including the loan payment and the 20-year cumulative cash flow, respectively.

The table thus far is an effort to present the worst case for the county assuming that no existing residences or business other than the El Capitan would hook up. It is understood that many county buildings have heating systems that have already surpassed their economic life. Of course, conversion to geothermal provides all new heating systems to these buildings. Based on economic life, $425,218 worth of replacement should be accomplished immediately.

If we assume that only 50 percent of this cost occurs in the next year, Column 11 indicates the 20-year cash flows would be positive throughout the project life.

If existing equipment were replaced as its economic life expires, Column 12 indicates considerable savings of the geothermal system over the conventional system.

Column 13 shows that sales price could be reduced from \$5.50/MMBtu to \$3.60/MMBtu and the project would still pay for itself.

All of the above tables included no maintenance costs for the geothermal system. It was felt that maintenance costs for the new system would be less than that for the old systems and, therefore, these costs were omitted.

Table 4.8 presents the life cycle costs over 20 years for the well field developer. It was assumed that the developer would be a taxable corporation capable of claiming investment tax credits and depletion allowances on the well. By selling energy to the county distribution system at the well head, the developer could avoid the dilemma of becoming a regulated utility.

The annual heat load assumed for Table 4.8 is 2.68×10^9 Btu, which includes all county buildings, El Capitan Lodge and Club and the new residential subdivision proposed by the El Capitan.

Column 1 is geothermal energy sales starting at \$0.90/MMBtu and inflating at 7 percent per annum.

Column 2 is the percentage depletion allowance, which is 20 percent in 1981, 18 percent in 1982, 16 percent in 1983 and 15 percent thereafter. Percentage depletion is limited to 50 percent of net income before taxes.

Column 3 presents straight line depreciation on total investment assuming 20-year life and 10 percent salvage value.

Column 4 is a 20-year forecast of electrical pumping costs.

Column 5 forecasts the maintenance costs increasing at the economic inflation rate.

Columns 6 through 8 are self-explanatory; the federal tax rate is assumed to be 48 percent.

Column 9 adds back the depletion and depreciation expenses since these are not out-of-pocket cash flows and also a 25 percent investment tax credit in year one.

Column 10 shows the 20-year after-tax cash flow.

Column 11 presents the discounted cash flow at 16.5 percent which is the after-tax rate-of-return on this project.

Table 4.9 presents the same data changing the heat load to 168.9 x 10^9 Btu annually, which is the total heating load of the area. This represents an increase of 3.8 times in the heat load, while the total capital investment increases nearly five times. As a result the after-tax rate-of-return decreases to 7.5 percent, and the developer would probably have to more than double the price of geothermal energy at the well head in order to make the project feasible.

Table 4.10 presents life cycle costs for the county distribution system assuming the total available heat load of 168.9 x 10^9 Btu. Data is presented the same as in Tables 4.7a and 4.7b. The conclusion is that this project is highly feasible for the county and probably indicates that the county could afford to pay a higher price for energy at the wellhead.

5.0 INSTITUTIONAL REQUIREMENTS FOR GEOTHERMAL DEVELOPMENT

Equally important to the development of geothermal energy as the engineering and economic feasibility is "institutional" feasibility. The financial, environmental, and legal and regulatory systems must allow the development. This section of the report describes the requirements for Hawthorne for each of these institutional topics.

5.1 Financial Considerations

For many prospective geothermal developments, the need for substantial front-end capital has been a deterrent to development. Even where a very advantageous and clear-cut saving over other fuels can be realized over the life of an energy system, a new system may not be possible because the funds for initial construction are simply unavailable; or they may be available at too high a price in the form of interest payments or in other priority investment opportunities that would be lost.

The financing options appropriate for geothermal development depend largely upon the total amount of the project. If a geothermal well is already available and the heating system is one that is easily retrofitted at low cost (e.g. a forced air system), then the total cost would not be high. If, at the other end of the spectrum, geothermal development requires an extensive exploration program, a test well, several production wells and injection wells, and expensive retrofitting of buildings (e.g. radiant electric systems), then the front-end costs would be considerably greater. The appropriate financing form must, therefore, be ascertained from the total capital required for development. The primary financing options available for geothermal development are described in this section. For public agencies, the financing options for geothermal development generally take four forms. These include:

- Budget appropriations
- General obligation bonds
- Revenue bonds
- Assistance programs from another level of government.

5.1.1 Budget Appropriations

If a public agency has sufficient financial means relative to the cost of a geothermal development, a budget appropriation is the easiest and most expeditious means of providing the necessary funds. If the project cost is low or the budget surplus is large, this method of funding could readily fit the requirement.

5.1.2 General Obligation Bonds

General obligation bonds are often used by local governments to fund projects that must be paid for over a period of time. A disadvantage of their use is that they encumber the general resources of the local government for the life of the bonds.

5.1.3 Revenue Bonds

Front-end capital can also be obtained by issuing revenue bonds. The bonds are repaid from revenues received from the specific activity, without any encumbrance on the government's general revenues. In cases where geothermal development requires large front-end capital expenditures, the issuance of revenue bonds might be the most desirable financing approach. The project cost can be amortized over a sufficiently long period of time so that annual costs for the geothermal system would approximate or even be lower than the current operating costs for heat.

The 1981 Nevada Legislature impowered the State Department of Commerce to issue Industrial Development Revenue Bonds for the purpose of financing new construction, improvement, rehabilitation, or development of qualified industrial and commercial projects. Qualified projects include manufacturing, industrial, warehousing, commercial, research and development, health care facilities, and additions to hotels, casinos, motels, apartment buildings, and office buildings.

5.1.4 Assistance from Another Level of Government

Several Federal programs in the past have provided financial assistance for alternative energy development. Some of these might be available again in the future for financing the conversion of local government buildings to geothermal energy. When discussion of the development begins, a thorough examination of all the financing alternatives should be reviewed, including their applicability, and as to whether a specific funding program still exists. Those that are most applicable are listed below:

- Program Research and Development Announcement (PRDA)

  This cost-sharing program is also made available by DOE from time to time to conduct economic and engineering feasibility studies. These awards are based on competitive proposals but generally are directed toward geothermal uses that have not previously been studied. Cost sharing by the proposer is required. Interested parties should contact the DOE, Division of Geothermal Energy, for information about upcoming announcements.

- DOE Geothermal Loan Guaranty Program

Still another DOE program is the Geothermal Loan Guaranty Program. The program will guarantee 100 percent of a loan for up to 75 percent of the project cost for a period of time up to 30 years. The borrower must contribute at least 25 percent of the project cost. A loan guarantee application is submitted to the DOE San Francisco Operations Office.

- HUD-Block Grant Program

HUD allocates block grants to local governments to pay for community development activities such as district heating/cooling systems. Spending priorities are determined at the local level. Smaller cities, not automatically entitled to funds, may receive funds on a competitive basis.

- Farmers Home Administration Community Facility Loans

  The FmHA program is authorized to make loans to develop community facilities for public use in rural areas and towns not to exceed 10,000 people. Loans are available for public entities such as municipalities, counties, and special purpose districts. Funds may be used to construct, enlarge, extend or improve community facilities that provide essential service to rural residents, and to pay necessary costs connected with such facilities.

There are a number of debt and equity sources in the private sector which may also be considered (Anderson and Lund, 1979), including:

- Commercial banks
- Savings banks
- Savings and loan associations
- Insurance companies
- Trusts and pension funds
- Commercial finance companies
- Personal finance companies
- Mortgage bankers
- Investment banks
- Equity investors
- Small business investment companies
- Leasing companies

5.2 Legal and Regulatory Requirements

The lands within and adjacent to the most prospective geothermal area are part of the lands withdrawn for the Army Ammunition Depot, public lands administered by the Bureau of Land Management, and private lands.

5.2.1 Leasing Procedures

- Privately Owned Lands

Developers generally enter into contracts with the private owners to explore a property and develop the resources found there for an annual rent or royalty. There are no regulatory constraints as with Federal lands. Each lease must be negotiated separately with the landowner. Generally, these leases name the substances for which the lessee may explore and develop. Most are for a term of 10 years, which is normally time enough for the developer to explore, test and begin production. The lessee is generally given the right to extend the lease beyond this period if the well remains productive. Royalty rates for geothermal wells average around 10 percent of the value of the energy produced.

- Publicly Owned Lands

Federal lands under the jurisdiction of the Bureau of Land Management are part of the prospective geothermal area. The Geothermal Steam Act of 1970 and the Regulations on Leasing Geothermal Leases allow private and public entities to acquire rights to develop geothermal resources on public lands. A prospective lessee may file a Geothermal Lease Application with BLM for up to 20,480 acres in the State. Presently an applicant must file on all the available Federal acreage in any one section with no more than 2,560 acres in any one lease. Leases run for a primary term of 10 years, with extensions which are dependent upon actively producing geothermal energy from the lease. A ten percent royalty on the value of the energy produced must be paid to the Federal government. For non-producing leases, there is an annual rental of $1.00 per acre per year through the fifth year. From the sixth year through the tenth year, or until the lease becomes productive, the rental is increased $1.00 per acre per year. Costs of certain types of exploratory and development activity by the lessee are accepted in lieu of the escalating portion of the rentals.

Table 5.1 summarizes the leasing procedures for private lands. The Federal regulatory process (pre-lease activities) for competitive (not applicable in this area) and non-competitive leasing is illustrated in Figure 5.1. A flow diagram showing required applications and regulatory processes for development on Federal geothermal leases is shown in Figure 5.2.

5.2.2 State Procedures and Regulations for Acquisition of Water Rights

- Application to Appropriate Water.

An application must be filed with the State Engineer, Division of Water Resources. The application form should be accompanied by a $100.00 filing fee and a supporting map prepared by a licenced State Water Rights Surveyor.

Notice of an application is published once a week for four weeks in a newspaper with general circulation in the county where the applicant proposes to appropriate water. Formal protests against granting a permit may be filed during this period and up to thirty days after the last date of publication. If no protests have been filed, and if approval will neither impair or injure any prior appropriator, nor be detrimental

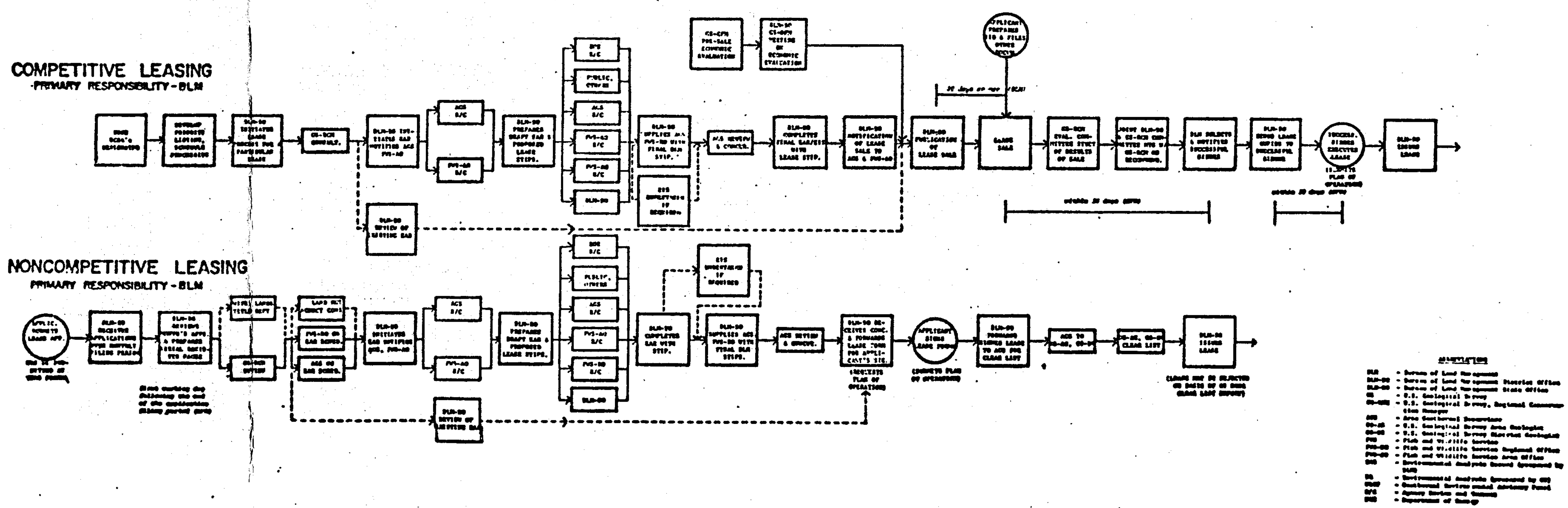
TABLE 5.1 Procedures for leasing of private and Nevada State lands

	Actions Required	Time Frame
PRIVATE LANDS	Negotiated between private individuals	Depends on how fast individuals can reach agreement
STATE LANDS	Under aegis of State Land Registrar	
	·Contract between private party and state officials negotiated via Attorney General's Office - all is negotiable	
	·Public notice of contract	Simple press release for five (5) weeks, Notice of Intent
	If challenged could lead to public hearing	Indeterminate time
	If no challenge	Permit can be issued in 1-2 weeks
		A total of nine (9) weeks to several years for State leasing

FIGURE 5.1 GEOTHERMAL REGULATORY PROCESS

(COMPILED FROM GEOTHERMAL STEAM ACT OF 1970, FEDERAL RULES AND REGULATIONS 43 CFR PART 3000 AND 30 CFR PARTS 270 & 271, AND MEMORANDUM OF UNDERSTANDING FOR THE GEOTHERMAL PROGRAM - USGS, BLM, FWS)

PRE-LEASE ACTIVITIES



to the public welfare, the permit will be granted.

If a protest is filed, the State Engineer conducts a field investigation, and if justified, will hold a hearing at which time a determination is made on the application.

Specific dates for the commencement and completion of drilling are established, and proof of beneficial use of water must be filed on a date specified by the State Engineer. There are also additional documents, such as Proof of Completion ($10.00) and Proof of Beneficial Use ($10.00) which are required.

When a water right certificate is granted, perpetual right to the use of a specific amount of water, for a specific purpose, and at a defined site, is guaranteed.

In undesignated basins, such as Walker Lake, property owners may drill prior to receiving a permit to appropriate water, but do so at the risk that such a permit may not be obtained.

5:2.3 State Well Drilling and Completion Regulations

- Notice of Intention to Drill

  This document is required by the State Engineer's Office prior to drilling, deepening, or repairing a well.

- Waiver of Well Drilling Regulations

  A request to waive any well drilling regulations may be made in writing to the State Engineer's Office and will be considered if good cause is shown. Approval or denial of the request is made in writing to the well owner.

- General Construction Regulations

  Regulations have been determined by the State Engineer for casing, sealing, and other materials to be used in drilling a well. All wells must be cased and constructed so that no contamination can occur because of surface conditions. In addition, permits issued to appropriate ground water for irrigation, municipal and industrial purposes, require the driller to provide an opening near the top of the casing at least two inches in diameter so a measuring device can be inserted to measure the distance to the water surface.

. Well Log

When drilling a water well, a log is required for the State Engineer's Office. The log includes:

1. Well location and ownership
2. Driller and drill rig type
3. Rock strata penetrated; thickness and depth
4. Water-bearing zones
5. Test results
6. Water level and temperature
7. Well design and completion description

5.2.4 Other State Permits and Certificates

A water Pollution Control Permit will be necessary for disposal of the geothermal water by:

- Well injection,
- Infiltration trenches
- Evaporation ponds, or
- Surface discharge

The Water Pollution Control Section of the Nevada Division of Environmental Protection issues these permits. The basic information requested by the agency pertains to the: supply rates, water quality, use of the water, and mode of disposal. Ninety to 120 days is the normal time for processing applications. The cost is $100.00 for a single discharge (injection well) location. If more than one well is used in the immediate area, $25.00 is charged for each additional discharge point.

Injection of the geothermal water must be made into geologic formations which have water of similar quality to the injected water.

The district heating alternatives described in this study are all closed-loop systems, which do not deal with extraordinary or potentially deleterious fluids, gases, or temperatures. It will not be necessary to obtain permits which regulate or control air quality, noise, or land disturbance.

5.2.5 Public Utility Regulation

Under the jurisdiction of the Public Service Commission, geothermal resource developers will be regulated as public utilities only if they sell heat, water or power. There are two exceptions:

1. Municipalities which construct, lease, operate, or maintain energy facilities do not need the commission's approval, but are under their general jurisdiction.

2. Geothermal General Improvement Districts were established by the 1979 Nevada State Legislature. GID's may develop geothermal resources and provide heat without utility regulation.

A General Improvement District (as outlined in NRS 318) can be established to develop natural resources to furnish space heating.

The forming of a GID is initiated by either a resolution by the County Commissioners or a petition by any property owner in the proposed GID.

A statement requesting the ordinance creating a GID will show that the district is:

a. A Public convenience and necessity,

b. Economically sound and feasible,

and include a Service Plan showing - a financial survey; preliminary engineering or architectural survey for services to be provided and financed; map of proposed GID showing boundaries, population and assessed value; describe facilities to be provided and an estimate of costs. The Service Plan processing fee is $200. The fee is waived if the request for the GID is made by the County Commissioners.

A hearing will be scheduled on the creation of the GID. The County Clerk will mail written notice to all property owners within the GID. Any property owner within the district may protest against the establishment of the GID. If a majority of property owners file a signed written protest, the district is automatically not established. If a majority of property owners do not file a protest, the County Commissioners will decide at the hearing if a GID will be established. Appeals may be made within 30 days of the County Commissioners decision.

After establishing a GID the County Commissioners act as a temporary Board of Trustees setting up:

a. Accounting practices and procedures.

b. Auditing practices and procedures.

c. Budget.

d. Management standards.

The County Commissioners shall appoint five members to the Board of Trustees to oversee the GID.

The GID can be paid for by a general tax on property in the district, bonds, borrowing from the State of Federal Government, or special assessments.

5.3 Environmental Considerations

Geothermal resources are a relatively benign source of energy. Available information was reviewed to identify any significant environmental problems that would be likely to occur at Hawthorne as a result of geothermal development.

5.3.1 Water

Water quality is the primary environmental consideration in hydrothermal energy development. The mineral content tends to be higher than ordinary ground water, and certain elements may be present that are harmful to humans, animals, and/or plant life. Prevention of pollution by chemicals in the geothermal fluid in a district heating system can be accomplished by several means:

1. Chemical treatment of the fluid to change the chemical composition.
2. Removal of selected elements.
3. Confinement of the geothermal fluid in a closed system.

After the heat has been extracted from the geothermal fluid, it may either be injected into the geothermal reservoir by means of disposal wells, or water quality permitting, it may be disposed of at the surface. The manner of disposal must be approved by the Nevada Division of Environmental Control.

5.3.2 Air

A closed-loop district heating system such as the one proposed for Hawthorne would not allow any noxious gases which might be present in the geothermal fluid to be emitted. Hydrogen sulphide is the most noticeable gas generally associated with geothermal waters, but is normally in higher temperature systems.

Dust from vehicular traffic and construction activity may also pollute the air temporarily. Preventing this requires little more than sprinkling water during such activities. The

State Air Quality Control Division is charged with assuring that air quality standards are met, and with issuing permits for discharging pollutants into the air.

5.3.3 Land

Land subsidence may occur with the long-term removal of geothermal fluids from the geologic formations (the reservoir) at depth. This phenomena is dependent upon the character of the formations, and the quantity, and rate of fluid removal. The likelihood of subsidence can be anticipated to a large extent, from previous experience in the area, where water wells have been producing. A usual preventive measure is to inject the fluid back into the same reservoir.

It is possible that injection of geothermal fluids could stimulate seismic (earthquake) activity. Considering the shallow depth of injection, this does not seem likely to happen.

Soil erosion from construction and vehicular traffic would be no more detrimental to the environment than a well and distribution system for cold water.

5.3.4 Noise

Although noise has been a problem at The Geysers power generation site in California, because of steam being vented to the atmosphere periodically, hot water in a closed-loop system at Hawthorne would be essentially noise-free. The most significant noise problem would be the short-lived drilling of the production and injection wells.

5.3.5 Ecological Relationships

The area likely to be affected by the well sites and the distribution system, outside of the immediate townsite, has little cultivated vegetation. The natural vegetation which would be disturbed in limited areas is largely low-growing sage and grasses.

The long-term impact on the indigenous wildlife present at the periphery of the community would be essentially nil, since most of the system would be buried.

5.3.6 Water Availability

The availability of water is a key concern surrounding geothermal resource development in all Nevada basins. Removal of thermal waters would not be allowed if it constitutes a threat to prior water appropriations. In the case of Hawthorne, injection of fluids would constitute non-consumptive use.

5.3.7 Socio-Economic Impacts

Because of Hawthorne's limited work force, construction crews would probably be brought in for most of the well drilling, pipeline construction, and facilities retrofit. Since the town is somewhat remote, the workers might prefer to live near the construction site, rather than commuting. If so, a number of temporary housing units (mobile homes and recreation vehicles) could be located in the area.

6.0 DEVELOPMENT PLAN

To develop geothermal energy requires a number of different types of activities. One necessary activity is to arrange funding for the capital costs of development. The financing procedure will be different for the private well developer than for the county. However, financing will generally be in the form of a direct front-end allocation from existing savings or budget surplus, or it may be in the form of bonds or loans to be repaid over a period of time.

Another necessary activity is the drilling of the geothermal wells. One completed well already exists close to Hawthorne, however, additional wells will be required if Alternative III is selected. If insufficient resource information is available, then an exploration program should be conducted prior to further well development. An exploration program may include a mix of geological, geophysical, geochemical, and temperature gradient hole surveys, followed by drilling and well testing. Some of these activities are already underway at Hawthorne by the State Resource Assessment Team.

Once the reservoir is evaluated, a development plan would be developed. Final engineering design will take into account the amount of fluid available, its quality and temperature. The actual number of wells required to meet the energy demand will depend upon these resource parameters. The materials for the district heating system will be compatible with the chemistry and temperature of the fluid.

After the engineering design is completed and final cost estimates are made, then bid documents can be prepared, bids solicited, and contractors selected. Work can then proceed on the production and injection wells, the distribution system, and the retrofit of the existing buildings in the city.

Prior to each step in the resource development and engineering process, the necessary legal steps must be taken. For geothermal development, either outright ownership or geothermal leases are needed, both for the surface to be used and for the mineral and/or water rights as dictated by the site ownership characteristics. Certain permits and licenses are required, also as dictated by the site characteristics. In order to determine these permit requirements and the general acceptability of a project, an appraisal of the environmental conditions at a particular site is required. The following pages describe each of the primary development activities that might apply to Hawthorne. A time-line chart shows all of the various activities required, the approximate time required for each, and the relationship of these activities to each other.

6.1 Financing

- Formation of a geothermal General Improvement District, described above in 5.2.6 Public Utility Regulation, appears to provide a good avenue for the city to develop the resource to furnish energy for space heating, without utility regulation.

Before a geothermal district heating system project at Hawthorne can begin, developers need to be assured that they can afford to pay for it. After a second production well is drilled and the engineering design and cost estimates are completed, revenue bonds could be issued by the county to obtain financing for the distribution system. Although the bond issuance program can very enormously, for the purposes of this study, it is assumed to require six weeks for the actual issuance only, not including preparation time.

6.2 Resource Exploration and Production

Appropriate drill site locations must be selected prior to the drilling of additional production wells. A standby production well for Alternative I and II is recommended, and additional production wells for Alternative III are necessary. Systematic exploration will provide the basis for optimal site selections. The program is estimated to take a minimum of two to three months.

Once the well sites have been selected, bid documents can be issued, bids accepted, and a contractor selected. Then the drilling can begin. Although difficulties in the contracting process (such as a shortage of available drilling rigs), or in the drilling itself could cause the drilling to take much longer, a six month period is estimated for the time required for issuing requests for bids, contracting and drilling the new wells.

Prior to drilling for production purposes, where either the surface or mineral rights (or both) are Federal, geothermal leases must be obtained. The previous section describes how leases are obtained.

Several permits are also needed prior to drilling. A water appropriation application should be filed with the Nevada State Engineer, along with a Notice of Intent to Drill. If there is sufficient water available to be tapped, water rights may be appropriated.

An air quality permit must also be obtained from the Air Quality Control Division of the Nevada Division of Environmental Protection prior to beginning construction of a well. A fluid discharge permit will probably also be required from the Nevada Division of Environmental Protection in order to reinject the spent geothermal fluids into reinjection wells.

After proper publication of the application to appropriate water and the project filing period has passed, the water rights certificate can be granted.

6.3 Engineering Design

Design of the distribution piping must be carried out by a competent engineering firm in order to determine final design details. Such details include the size and location of all piping necessary to transport the geothermal fluid, the pipe insulation thickness, number and size of expansion loops, anchor and support requirements, and other pertinent details. This work must also address the supply and injection pumping systems, and also issues relating to scaling or corrosion of the pipe. The engineering must also include an estimate of all construction costs, as well as operation and maintenance costs, for the final design. This work can probably be accomplished in 12 weeks.

The engineering firm selected for this project must also prepare bid documents and specifications, so that competitive bids can be obtained from qualified contractors to complete the construction. The process of reviewing the bids and selecting the contractor should include participation from the engineering firm which does the design.

6.4 Construction

Construction of the Hawthorne geothermal district heating system might consist of two separate major activities: the well supply system and the distribution system. Because different ownership is likely to be involved for the two portions of the complete system, the developer may choose to conduct the design efforts, the bidding processes, and the construction as separate activities and possibly at separate times.

For purposes of this development plan, however, it is assumed that the developer and the distributor will elect to integrate their design and construction activities. The value of such integration and coordination would be both time and cost effective in the implementation of the entire system. The development plan, outlined in Tables 6.1, 6.2, and 6.3, show that the three alternate geothermal development plans for Hawthorne could be accomplished in two to four years, assuming that each of the tasks can be accomplished in a timely manner.

TABLE 6.1 Geothermal Development Plan for Alternate I, Hawthorne

TASK	Duration of Task (months)	Project Milestone (month)
1. Secure funding for development of resource (assume private funds)	0	
2. Apply for and secure geothermal resource rights; lease: private	0	
federal	0	
3. Exploration of the geothermal resource		
(a) Select contractor(s)	0.5	1st
(b) Conduct exploration surveys: geological, geophysical, temperature gradient holes	0	
(c) Evaluate survey results: select production and injection well sites; well specifications	1	2nd
4. Drilling permits (temporary waiver)	0.5	2nd
5. Obtain water appropriation	0	
6. Development of the geothermal resource: drill production well(s) and injection well(s)		
(a) Select drilling contractor	1	3rd
(b) Drill, survey, pump test, and evaluate wells; complete wells	1 - 3	4th - 6th
7. District heating engineering design		
(a) Select design contractor(s)	1	7th
(b) Final design and cost estimates	8	8th - 15th
(c) Bid document preparation	3	15th - 17th

8. Permits

•Air quality permit	1	18th
•Land disturbance permit	0.5	18th
•Registration certificate and Operating permit	1 - 3	18th - 20th?
•Fluid discharge permit	3 - 4	18th - 20th (or 21st)

9. Issue revenue bonds	1.5	18th - 19th
10. District heating system construction		
(a) Select contractors	1	20th
(b) Construct wellhead and distribution system	6	21st - 26th
(c) Retrofit buildings	8	21st - 28th
11. Test the district heating system	1	29th

TABLE 6.2 Geothermal Development Plan for Alternate II, Hawthorne

TASK	Duration of Task (months)	Project Milestone (month)
1. Secure funding for development of resource (assume private funds)	0	
2. Apply for and secure geothermal resource rights; lease: private	0	
federal	0	
3. Exploration of the geothermal resource		
(a) Select contractor(s)	0.5	1st
(b) Conduct exploration surveys: geological, geophysical, temperature gradient holes	0	
(c) Evaluate survey results: select production and injection well sites; well specifications	1	2nd
4. Drilling permits (temporary waiver)	0.5	2nd
5. Obtain water appropriation	0	
6. Development of the geothermal resource: drill production well(s) and injection well(s)		
(a) Select drilling contractor	1	3rd
(b) Drill, survey, pump test, and evaluate wells; complete wells	1 - 3	4th - 6th
7. District heating engineering design		
(a) Select design contractor(s)	1	7th
(b) Final design and cost estimates	6	8th - 13th
(c) Bid document preparation	2	13th - 14th

8. Permits

•Air quality permit	1	15th
•Land disturbance permit	0.5	15th
•Registration certificate and Operating permit	1 - 3	15th - 17th?
•Fluid discharge permit	3 - 4	15th - 17th (or 18th)

9. Issue revenue bonds	1.5	15th - 16th
10. District heating system construction		
(a) Select contractors	1	16th
(b) Construct wellhead and distribution system	6	17th - 22nd
(c) Retrofit buildings	6	17th - 22nd
11. Test the district heating system	1	23rd

TABLE 6.3 Geothermal Development Plan for Alternate III, Hawthorne

TASK	Duration of Task (months)	Project Milestone (month)
1. Secure funding for development of resource (assume private funds)	3	1st - 3rd
2. Apply for and secure geothermal resource rights; lease: private	1	1st
federal	12	1st - 12th
3. Exploration of the geothermal resource		
(a) Select contractor(s)	1.5	2nd - 3rd
(b) Conduct exploration surveys: geological, geophysical, temperature gradient holes	3	4th - 6th
(c) Evaluate survey results: select production and injection well sites; well specifications	1	7th
4. Drilling permits (temporary waiver)	0.5	8th
5. Obtain water appropriation	2 - 4	8th - 10th (or 12th)
6. Development of the geothermal resource: drill production well(s) and injection well(s)		
(a) Select drilling contractor	1.5	8th - 9th
(b) Drill, survey, pump test, and evaluate wells; complete wells	3 - 6	10th - 15th
7. District heating engineering design		
(a) Select design contractor(s)	1	16th
(b) Final design and cost estimates	12	17th - 28th
(c) Bid document preparation	4	28th - 31st

8.	Permits		
	•Air quality permit	1	32nd
	•Land disturbance permit	0.5	32nd
	•Registration certificate and Operating permit	1 - 3	32nd - 34th?
	•Fluid discharge permit	3 - 4	32nd - 34th (or 35th)
9.	Issue revenue bonds	1.5	32nd - 33rd
10.	District heating system construction		
	(a) Select contractors	2	33rd
	(b) Construct wellhead and distribution system	12	34th - 45th
	(c) Retrofit buildings	12	34th - 45th
11.	Test the district heating system	3	46th - 48th

7.0 SUMMARY

Hawthorne, a community of 3,690, is the commercial hub of Mineral County mining activity and the adjacent Army Ammunition Depot. Also fundamental to the local economy are the tourism and entertainment industries.

Over a period of years, a dozen wells drilled for water on the military reservation by the Navy, and near the townsite by the Hawthorne water utility, have found thermal waters of 71° to 125°F. In 1980, the owners of the El Capitan Lodge and Casino drilled a 1,000-foot well, one and one-quarter mile southwest of town, which produced 700 gpm of 210°F water. Although a thermal area of no less than 30 square miles encompasses the town, the most prospective geothermal zone appears to include the El Capitan, NAD 1 (125°F), and NAD 5 (114°F) wells, which lie in a northwesterly line between Hawthorne and the Wassuk Range.

Additional resource evaluation, including geological, geophysical, geochemical, and/or temperature gradient hole surveys should be completed in order to properly site any additional production wells which may be necessary for a district heating system.

Potential applications of geothermal energy for existing facilities in Hawthorne are significant. The principal applications are for space heating and for domestic hot water heating of the county buildings, the public school buildings, a commercial lodge and club, and selected residential subdivisions. A possibility also exists for use by prospective future residential subdivisions. The present total heat load of six groupings of facilities in the study is 28.6×10^6 Btu/h (peak), or 44.5×10^9 Btu annually.

The six groupings of facilities includes:

- Courthouse, public safety, hospital and library
- Schools
- Mt. Grant subdivision
- Lakeview tract
- El Capitan subdivision
- El Capitan Lodge & Club

This grouping is Alternative I in the engineering and economics evaluations. Alternative II is the same grouping with Mt. Grant and Lakeview Tracts excluded. Therefore, the total annual heat load is 26.8×10^8 Btu. Alternative III would be Alternative I plus the remainder of the town of Hawthorne, including all other residential and commercial users. An estimate of the total energy consumption for the entire town is 168.9×10^9 Btu.

Assuming a resource temperature of 180°F, the existing well and pumping equipment are adequate for Alternative II, which requires a peak flow of 780 gpm. Substitution of a larger pump would produce the 991 gpm peak flow required for Alternative I. Alternative III would require the drilling of four additional wells of approximately the same delivery rate per well as the existing well, for a total peak delivery rate of 4,025 gpm.

Geothermal district heating system costs estimates for the three alternates are separated into two parts - the well supply system and the distribution system:

Alternate	Well Supply System	Distribution System
I	$154,000	$1,866,560
II	154,000	1,418,640
III	757,000	8,590,000

The life cycle cost analysis of the geothermal district heating system and the resultant prices of energy delivered to the various customers are determined by the capital and operating costs as well as by the ownership structure for the basic components of the system. The most practical structure appears to be for the well supply system to be privately owned and operated by the El Capitan Lodge, and for the distribution system to be publicly owned and operated by Mineral County.

A possible first year wholesale price from the supplier to the distributor was found to be $0.90 per MMBtu, while the retail price was ascertained to be $5.50 per MMBtu. The wholesale price would provide the supplier with a nominal 16.5% return on investment after taxes. The retail price charged by the distributor, when coupled with energy savings realized by the county, would provide a cash flow that would pay off its original cash investment plus interest in nine years, for Alternate II, and in sixteen years for Alternate III.

The financing options appropriate for geothermal development will, to a large extent, depend upon the total capital investment required. These options include budget appropriations, general obligation bonds, revenue and industrial development bonds, and assistance programs from another level of government.

Legal and regulatory requirements, well drilling regulations, permits and licenses required during exploration and drilling, public utility regulation, and environmental considerations are addressed as they may impact the geothermal district heating system.

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