DOE/ET/28440--

GEOTHERMAL SPACE/WATER HEATING FOR CITY OF MAMMOTH LAKES, CALIFORNIA

1316 8-1

DRAFT FINAL REPORT
SEPTEMBER 1977

PREPARED FOR
THE UNITED STATES ENERGY RESEARCH
AND DEVELOPMENT ADMINISTRATION

UNDER CONTRACT NO. EY-76-C-03-1316
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THE BEN HOLT CO.
ENGINEERS & CONSTRUCTORS

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ABSTRACT

This report presents the results of a study to determine the technical, economic and environmental feasibility of geothermal district heating for Mammoth Lakes Village, California.

The geothermal district heating system selected is technically feasible and uses existing technology in its design and operation.

District heating can provide space and water heating energy for typical customers at lower cost than alternative sources of energy. If the district heating system is investor owned, lower costs are realized after five to six years of operation, and if owned by a nonprofit organization, after zero to three years. District heating offers lower costs than alternatives much sooner in time if co-generation and/or ERDA participation in system construction are included in the analysis.

During a preliminary environmental assessment, no potential adverse environmental impacts could be identified of sufficient consequence to preclude the construction and operation of the proposed district heating system.

A follow-on program aimed at implementing district heating in Mammoth is outlined.

INTRODUCTION

Mammoth Lakes Village is a winter and summer recreational resort located in the eastern Sierra Nevada Mountains of California at an elevation of 8,000 feet. About eighty-five percent of space and water heating demands for up to 17,000 Village visitors are now provided by electric resistance heating. Utilization of such an expensive and highly refined energy resource as electrical energy for heating suggests that alternative energy sources be examined.

Magma Energy, Inc. owns a geothermal resource on a 90 acre parcel at Casa Diablo Hot Springs, about three miles east of Mammoth. Eight geothermal wells were drilled on this property in the years 1959 to 1962. The wells have produced fluid with temperatures in excess of 340°F.

This report presents the results of a one-year study to determine the technical, economic and environmental feasibility of utilizing the Casa Diablo geothermal resource for district heating in Mammoth Lakes Village. The concept studied was to heat a fresh water loop with geothermal brine, circulate the fresh water to the Village where it would provide space and water heating energy via hydronic heaters located in individual buildings, and return the fresh water to the geothermal area for reheating and reuse.

The Ben Holt Co. was the prime contractor for this study. Holt was assisted by Southern California Edison Company (SCE), Ayres Associates (Ayres) and Magma Energy, Inc. (Magma).

SUMMARY

The primary results and conclusions of the work discussed in the following sections of this report are summarized in this section.

Using data from industry studies, and their own internal records, SCE estimated the electric space and water heating demand and energy use for Mammoth Lakes Village in the year 1980. The projected 1980 peak demand for electric space heating is 41 MWe, and for water heating is 8 MWe. Estimated eletrical energy use in 1980 for space and water heating are 53 million kwh and 24 million kwh respectively.

In order to validate the data used to estimate 1980 electric heating demands and energy use, SCE installed metering equipment on space and water heaters in eleven buildings within the Village. The metering equipment provided data to determine the percentage of total electric energy consumption attributable to heating, which in turn provided an indication of total heating energy consumption in the Village. Results of the metering work confirmed the above energy and demand estimates.

A survey was undertaken to determine the numbers and types of space and water heating units currently in use in the Village. It was found that approximately 88 percent of the space heating capacity and 74 percent of the water heating capacity depends upon electric resistance heating. The remaining capacity is almost exclusively fueled by LPG. An estimated 84 percent of all space and water heating load in the Village uses electrical energy.

The 1980 Village peak demands for all space and water heating were estimated using the above survey results to be 47 MWt and 11 MWt respectively. Estimates of growth in visitor population for Mammoth were used to estimate the growth in heating demand through the year 2000. The heating demand was projected to grow from 58 MWt in 1980 to 84 MWt in 1990 and to its ultimate demand of 122 MWt in 2000.

An analysis of the Casa Diablo geothermal reservoir was completed. The analysis was based on results of geothermal well testing in the 1960's and assessments by the U. S. Geological Survey of the heat storage and recoverable energy in the Long Valley area. The reservoir analysis concluded that the Casa Diablo geothermal area has the capacity to provide for the space and water heating needs of the town of Mammoth Lakes. USGS estimates suggest the potential of a 200 year supply of heating energy beneath the 90 acre Casa Diablo Site. Well and heat exchanger testing have provided flow and temperature data for a number of the existing Casa Diablo Wells. Wellhead temperatures of 330°F to 340°F and flow rates of 300,000 lb/hr to 500,000 lb/hr per well have been measured during short-term testing. These temperatures and flows are well in excess of peak space and water heating demand for the entire town of Mammoth Lakes.

While the USGS estimates and flow test results are encouraging, they are by no means conclusive as to the Casa Diablo geothermal area's capacity or longevity. Additional long-term reservoir data need to be provided before a large scale district heating facility can be built on the site.

Magma intends to drill and test a deep production well at Casa Diablo in late 1977. The reservoir information gained as a result of this deep well and associated testing should provide sufficient information for going ahead with a large district heating installation on the site, assuming the technical, economic and engineering feasibility of the heating system itself has been proven.

In order to implement geothermal district heating in the Village, the electric and LPG heating systems in existing buildings must be retrofit to hydronic heating and new building construction should include hydronic heating. Rough designs and cost estimates were prepared for installing hydronic heating systems in buildings considered typical of existing and new construction in the Village. The mechanical engineering firm of Ayres Associates was employed to prepare the designs and cost estimates for hydronic systems using water at either 200°F supply temperature (low-temperature system) or 300°F supply temperature (high-temperature system). Ayres also prepared cost estimates for installing electric and LPG heating systems in new buildings.

Building hydronic heating systems using a high-temperature district heating loop were shown to be 7 to 78 percent more costly than hydronic heating using a low-temperature district heating system, depending upon the type and size of building under consideration. The main contributor to the increased cost of high-temperature hydronic heating is the heat exchanger required in each customers building. The low-temperature systems do not require building heat exchagners as the district heating water can be used directly in hydronic heaters located within each building.

Installed cost estimates for LPG and electric heating systems in new buildings were consistantly lower than the cost of installing hydronic systems in the same buildings.

Based upon Village heating demand characteristics and information on the Casa Diablo reservoir, conceptual design were prepared for alternate high- and low-temperature district heating systems to supply a 52 MWt peak heating demand. Differential capital and annual cost estimates were prepared for each system configuration, and the results were compared. The capital and annual costs of district heating using a low-temperature loop were estimated to be $4 million and $700,000 per year less than using a high-temperature system. Therefore, subsequent design work was limited to the less costly low-temperature district heating system.

A preliminary design and capital cost estimate were prepared for a low-temperature geothermal district heating system to serve the Village. Main components of the system design are pumped geothermal wells, geothermal brine/fresh water heat exchangers, fresh water circulation and booster pumps, hot water storage tanks, and underground hot water piping. The estimated capital cost for the system in 1977 price level is $14.6 million. Approximately 62 percent of the capital cost involves the cost of purchasing and installing the 280,000 feet of preinsulated hot water distribution and return piping necessary to provide district heating service in the Village.

The geothermal district heating system capital cost estimate was compared with cost estimates for new electric power plants which could be used to provide heating energy as an alternate to district heating. The district heating system can be installed for approximately 80 percent of the cost of a combined cycle electric power plant, and 45 to 50 percent of the cost of a coal or nuclear power plant.

Annual costs for heating typical buildings in the Village with geothermal district heating were compared with the costs to heat the same buildings with LPG or electricity. The annual heating costs using geothermal district heating are higher than with conventional energy sources when the system is first installed. However, after a maximum of six years of operation, an investor owned district heating system can provide less costly heating for all typical buildings investigated. If the district heating system is owned by a nonprofit organization, its costs are less than LPG or electric heating after three years. The estimated cost of energy delivered to a typical customer from the district heating system in 1977 price level is 4.3¢/kwh(t) with an investor owned system, and 2.9¢/kwh(t) with nonprofit system ownership.

The economics of district heating can be improved further through the use of co-generation. In this concept, geothermal brine provides heat to an electric power generation cycle before being used to provide heat for the district heating system. The cost of producing electric and thermal power in this manner is estimated to be 0.4¢ to 1.0¢/kwh lower than the cost of geothermal district heating alone.

SCE prepared a preliminary environmental assessment of constructing and operating the geothermal district heating system. The assessment addressed environmental impacts in the categories of biology, archaeology, population, transportation and aesthetics. No potential adverse environmental impacts could be identified of sufficient consequence to preclude construction and operation of the system.

Two models were designed, built and shipped to ERDA-Washington which illustrate the use of geothermal energy. One model illustrated a geothermal district heating system for Mammoth, and the other represented a geothermal-electric power plant.

A phased program leading to full scale utilization of geothermal energy for district heating in the Village was outlined. If the program is implemented, district heating service can be operational in a portion of the Village by the winter of 1979-1980, and a 52 MWt peak demand could be served by 1988.

LITERATURE REVIEW

Papers, reports and other references containing information on district hydronic heating systems, both conventional and geothermal, were obtained and reviewed. Information relevant to the project was cataloged and put on file for ease of access. The references which were reviewed are listed in Table 1.

In order to obtain additional background on geothermal space heating, project personnel visited the Geo-Heat Utilization Center at Oregon Institute of Technology and toured the geothermal heating systems at OIT and in the town of Klamath Falls. The OIT campus employs hot water coils in forced air heating systems, baseboard convectors for perimeter space heating and water to water heat exchangers for domestic hot water heating. The space and water heating systems proposed for Mammoth Lakes Village are similar to the OIT systems.

In addition, the study manager visited the district heating system in Reykjavik, Iceland. Technical information gained was subsequently applied to the district heating system design for Mammoth Lakes Village. The trip was financed jointly by Magma Energy, Inc. and The Ben Holt Co.

TABLE 1

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LOAD SURVEYS

At the present time, approximately 85 percent of the space and water heating energy in Mammoth Lakes Village is provided by electrical energy from Southern California Edison Company (SCE). In order to determine the characteristics of the heating loads and heating systems currently in use in Mammoth Lakes Village, SCE has conducted various load surveys and prepared energy and demand estimates. The results of this work are presented below.

A. PRELIMINARY HEATING ENERGY AND DEMAND ESTIMATES--1980

Estimates were prepared for the monthly electrical energy consumption and peak electrical demand for space and water heating in Mammoth Lakes Village for 1980. The monthly energy consumption was estimated first, followed by a demand estimate.

1. Monthly Electric Heating Energy

A tabulation of monthly electrical energy consumption by various categories was made using SCE Document MR 367. This document records energy consumption in kwh and number of meters for various customer classifications (i.e., residential, commercial power, commercial lighting, industrial, street lighting, etc.), and for specifical geographic areas. The period from June 1974 through October 1975 was investigated as that period was more typical in terms of ambient temperature, load growth and skier activity, than the 1975-1976 season which experienced an unusually warm winter.

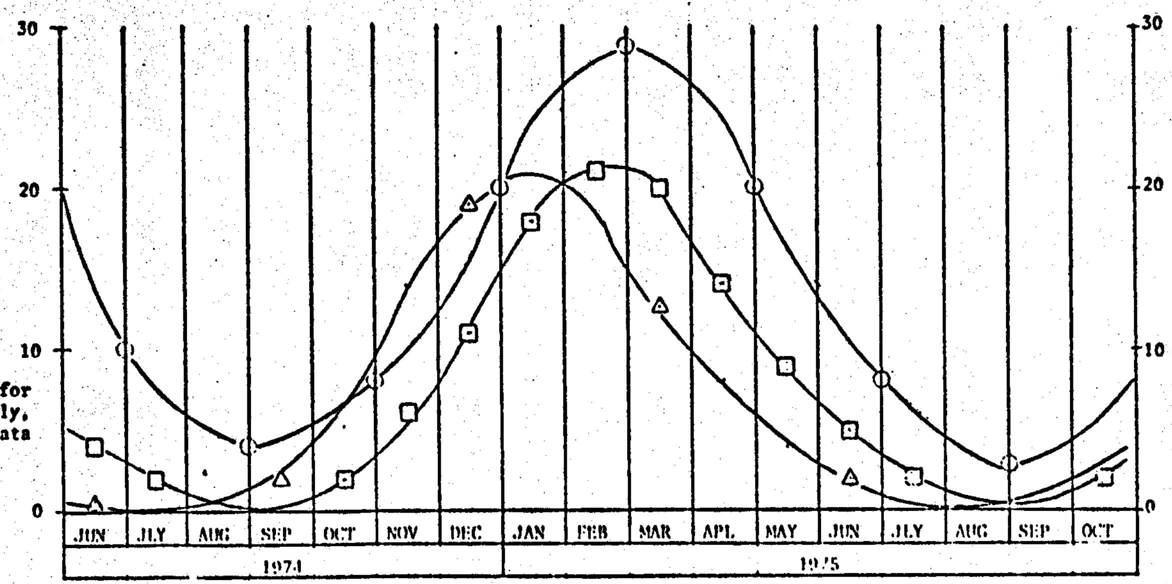
As a first step in determining that portion of the total load which is attributed to heating, the rate categories from the "MR-367's" which have no heating associated with them such as Residential Lighting, Commercial, Industrial and Public Authority Power (which is 3 phase power) and Street Light loads were neglected. Secondly, those loads which were very small compared to the total were neglected to simplify the analysis. The remaining kwh/month were tabulated as item 1) on Figure 1. Item 2) in the tabulation indicates the number of meters for which the energy consumption rates were recorded. The average kwh/meter/month was calculated, tabulated as item 3), and plotted using a "O" symbol in Figure 1.

Estimates of the energy used in 1974-1975 for space heating were taken from a previously completed internal SCE study of multiple unit dwellings which used temperature data from

FIGURE 1
MONTHLY ELECTRICAL ENERGY FOR SPACE AND WATER HEATING
MAMMOTH LAKES, CALIFORNIA

	JUN	JLY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APL	MAY	JUN	JLY	AUG	SEP	OCT
1) Recorded Energy (KWH X 1000)	4103	1192	3822	452	2919	1915	5271	8281	11149	7063	8288	6748	4157	2242	1920	1806	2666
2) Number of Meters	3629	3629	3822	3639	3655	3679	3856	3865	3864	3866	3866	3868	3870	3874	3874	3876	3882
3) Average Energy Use (KWH/Meter) ○	1130	328	1000	124	798	520	1367	2143	2885	1837	2144	1745	1074	578	495	465	686
4) Calculated Space Heating (KWH/Meter) △	58	0	0	0	530	1395	1874	2101	1404	1143	612	279	58	0	0	0	530
5) Shifted Space Heating (KWH/Meter) □	400	150	0	0	200	550	1100	1800	2100	2000	1400	900	500	200	0	0	300
6) Average Occupancy (People/Unit)	1	1	1	1	1	2	5	7	7	6	2	1	1	1	1	1	1
7) Calculated Water Heating (KWH/Meter)	250	250	250	250	250	330	580	750	750	660	330	250	250	250	250	250	250
8) 1980 Village Space Heating (KWH X 1000)	1924	722	0	0	962	2645	5291	8658	10101	9620	6737	4329	2405	962	0	0	2405
9) 1980 Village Water Heating (KWH X 1000)	1203	1203	1203	1203	1203	1587	2770	3608	3608	3175	1587	1203	1203	1203	1203	1203	1203

Monthly Energy Use
(KWH/Meter X 100)



NOTE: Symbols (○ △ □) are for curve identification only, they do not designate data points.

Bishop, California. Bishop is located about 40 miles southeast of Mammoth Lakes. Mammoth Lakes is approximately 5,000 feet higher in elevation than Bishop, therefore, the average ambient temperatures may be in the order of 10°F cooler than Bishop. It appears, however, that this does not introduce a significant error in estimated heating loads. When the calculated space heating loads using the warmer Bishop temperatures are plotted and the resulting curve is aligned with the total load curve previously estimated, the calculated values appear to be very reasonable. The calculated space heating values from the Bishop study were tabulated as item 4), and plotted using a "Δ" symbol. After this curve was aligned with the 1974-1975 season total load curve, the resulting monthly kwh space heating values were retabulated as item 5).

Estimates of the electrical energy used in 1974-1975 for water heating were based on data from the Association of Edison Illuminating Companies (AEIC) (1). This report tabulates annual kwh consumption for hot water heating as a function of family size (unit occupancy).

The average number of occupants per unit was somewhat arbitrarily estimated. A large majority of the installed meters in Mammoth served condominiums. It is our understanding from discussions with local residents and review of the Mono County plan (2) that many of the condominiums are often unoccupied during the summer season and filled to capacity with relatively large groups during the ski season. Thus the assumed occupancy ranged from 1 to 7 people per unit as tabulated as item 6) of Figure 1.

Based on the unit occupancy estimates above, monthly kwh use for water heating was estimated from AEIC data, and tabulated as item 7) in Figure 1. The maximum electrical energy consumption for hot water is in the order of 750 kwh/month.

The estimated 1974-1975 monthly space and water heating loads were multiplied by 1.3 to obtain an estimate for 1980 monthly energy consumption. The multiplier is based on the ratio of the recorded peak load for Mammoth Lakes in 1975 to the estimated peak load of 1980. The 1980 per unit energy rates were multiplied by the average number of units in 1974-1975 to obtain the total 1980 estimated rates as tabulated as items 8) and 9) in Figure 1.

The estimated rate of load growth is the most uncertain parameter in estimating the 1980 heating loads. The development of Mammoth is a strong function of many variables such as economic conditions, environmental restraints, water availability, weather and winter sports popularity. Depending upon the magnitude of changes in these variables, the electric load growth estimate can vary substantially.

The estimated monthly electrical energy heating requirements for Mammoth Lakes Village in 1980 are summarized below, and shown graphically in Figure 2.

	SPACE HEATING (kwh x 1,000)	WATER HEATING (kwh x 1,000)
JAN	8,700	3,600
FEB	10,000	3,600
MAR	9,600	3,200
APR	6,700	1,600
MAY	4,300	1,200
JUN	2,400	1,200
JUL	1,000	1,200
AUG	0	1,200
SEPT	0	1,200
OCT	2,400	1,200
NOV	2,600	1,600
DEC	5,300	2,800

2. Peak Electric Heating Demand

Two independent approaches were utilized to estimate peak electrical space heating demand for Mammoth Lakes. In the first, studies from the AEIC which provide demand versus temperature relationships for residential resistance heating were used (1). Based on a temperature differential of 50°F (outside ambient of 20°F and an inside temperature of 70°F), the AEIC data suggest an average electric space heating peak demand of approximately 8.5 kw per customer.

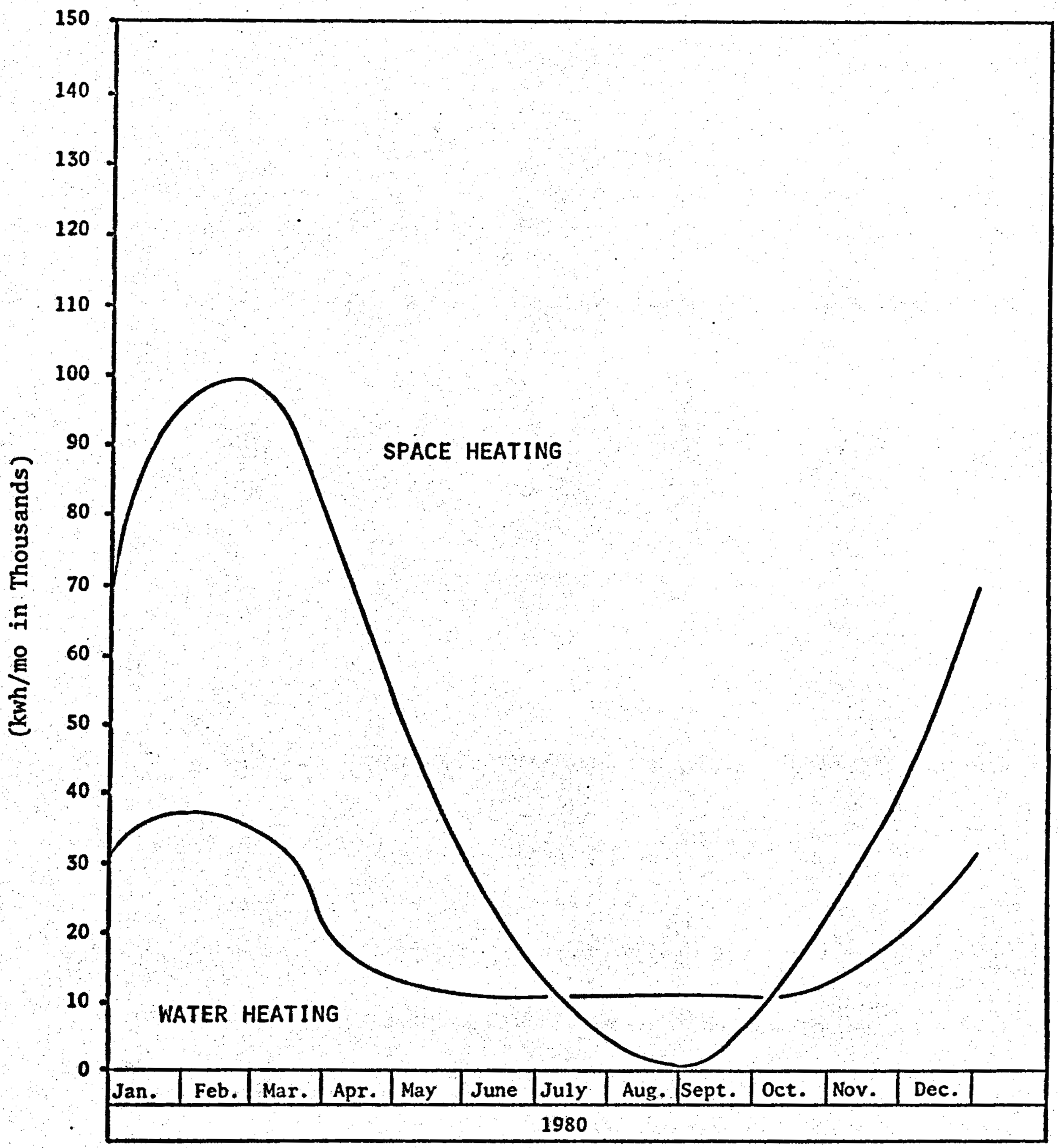
During the 1974-1975 winter peak (which was more "typical" in terms of weather and unit occupancy due to winter sports activities than subsequent winters) SCE records indicate there were approximately 3,700 residential customers in Mammoth Lakes. Multiplying the average 8.5 kw heating demand per customer by 3,700 customers yields approximately 31 MWe. This compares to a total peak of 41 MWe recorded at SCE's Casa Diablo Substation which essentially serves Mammoth Lakes exclusively.

Load studies indicate that the relationship between energy use and demand is a linear one. This relationship was used to re-estimate the peak space heating demand and thus provide a check on the figure calculated above. Thus, using figures from the peak month, February 1975:

FIGURE 2

ESTIMATED MONTHLY HEATING ENERGY

MAMMOTH LAKES VILLAGE - 1980



$$\frac{\text{Heating Peak Demand}}{\text{Total Peak Demand}} = \frac{\text{Heating Energy/Month}}{\text{Total Energy/Month}}$$

where,

Heating Peak Demand	= (to be determined)
Total Peak Demand	= 41 MWe recorded at Casa Diablo Substation
Heating Energy/Month	= 11,149,000 kwh estimated from SCE records of major loads in Mammoth associated with heating, Feb. '75
Total Energy/Month	= 14,238,000 kwh from SCE records. Mammoth, Feb. '75

$$\text{Therefore, } \frac{11 \times 10^6 \text{kwh/mo}}{14 \times 10^6 \text{kwh/mo}} (41 \text{ MWe}) = 32 \text{ MWe}$$

This estimate of 32 MWe corresponds quite closely with the 31 MWe calculated above utilizing the AEIC studies.

As noted above, a figure of 1.3 is used to escalate demand and energy figures from 1974-1975 to 1980. This results in an estimate of peak electric space heating demand of 41 MWe in 1980.

Residential electric water heating load curves from AEIC studies indicate that an average peak water heating demand per customer is 1.5 kw. Multiplying 1.5 kw by the 3,700 customers in Mammoth yields a total peak of approximately 6 MWe for electric water heating.

Applying the growth estimate of 1.3 as above, the estimated 1980 peak electric water heating demand becomes approximately 8 MWe.

Based on the above, the following breakdown of peak electric load demand for Mammoth Lakes in 1980 was used in this feasibility study.

Space heating	41 MWe
Water heating	8 MWe
Other	5 MWe
Total	54 MWe

B. SATURATION SURVEY

SCE personnel made a saturation survey in Mammoth Lakes with the objective of developing definitive estimates of the number and types of space heating and water heating units currently in use. These estimates were used to determine the potential market for retrofitting from gas or electric to geothermal heating, and in sizing the geothermal district heating system.

Data were gathered from three sources: a "door-to-door" survey, the Mono Plan, and SCE billing records. In the door-to-door survey, three SCE Energy Services representatives interviewed the owners and/or managers of 122 commercial, residential and institutional facilities and recorded the following data at each location:

WATER HEATING

Number of Water Heaters
Manufacturer
Model No.
kw or Btu/hr Rating
Size (gallons)

SPACE HEATING

Number of Rooms
Number of Heaters
Location
Type
Manufacturer
Model No.
kw or Btu/hr Rating

Of the 122 sites surveyed, 12 were residential units and 110 were commercial and institutional facilities. This 110 figure represents approximately half the total number of commercial/institutional facilities in town.

The 12 residential units are representative of the 2,800 condominium units in town which are very similar in terms of sizes and types of heating systems.

Information contained in the Mono Plan was used as a basis for characterizing the community in terms of absolute numbers of condominiums, single family homes, commercial and institutional facilities (2). Much of the Mono Plan was based on a 1972 general census. SCE records were used in some cases to update Mono Plan data, particularly in estimating the total number of condominiums and small businesses which have been built since 1972.

Using these sources of data, it is estimated that Mammoth Lakes Village was comprised of the following facilities in 1976:

2,800	Condominium units in 60 developments
1,200	Motel/Lodge rooms in 40 developments
1,200	Single Family Homes
24	Restaurants
150	Other Commercial/Institutional Facilities

The only industrial type facilities observed in Mammoth were several automotive garages, the County Water District Sewage Treatment Plant and the ski lift company machine shop.

In order to characterize the Village in further detail, it was divided into four discrete areas as shown in Figure 3, Heating District Areas. The Village was divided in this manner as each discrete area will probably be served by a different branch of the geothermal district heating system. Area 1, which comprises the main commercial area of town, would probably be the first to be served by the heating system, followed by Areas 2, 3 and 4 in that order.

The data collected during the door-to-door survey, and obtained from the Mono Plan are presented in Table 2 by geographic area of town. Data from the survey are presented first, while Mono Plan data are found at the end of each area tabulation, designated by a name in all capital letters. The space and water heating loads associated with the condominiums identified from the Mono Plan were estimated based on survey data for similar condominiums. Liquid Petroleum Gas fueled heater ratings are given in thousand Btu per hour (MBH) input, and electric heater ratings are in thousands watts (kw) input.

The total connected heating loads for each Area were then computed, and the results are shown in Table 3, Estimated Connected Heating Loads by Area. To facilitate comparison, the gas fueled connected load estimates have been converted to equivalent thermal megawatt (MWt) ratings using typical values for gas heater efficiency and derating for altitude. As mentioned previously, survey data were taken for 110 of the approximately 200 commercial establishments in the Village. In order to account for the loads associated with the 90 establishments which were not surveyed, load data from the 110 establishments surveyed were approximately doubled. Table 3 does not include the heating load for single family homes, as this diverse load could not be surveyed within the scope of this study. However, it is estimated that the connected load for single family home heating is about 24 MWt.

The statistics presented in Table 3 indicate that about 88 percent of the space heating capacity in Mammoth Lakes Village is electric.

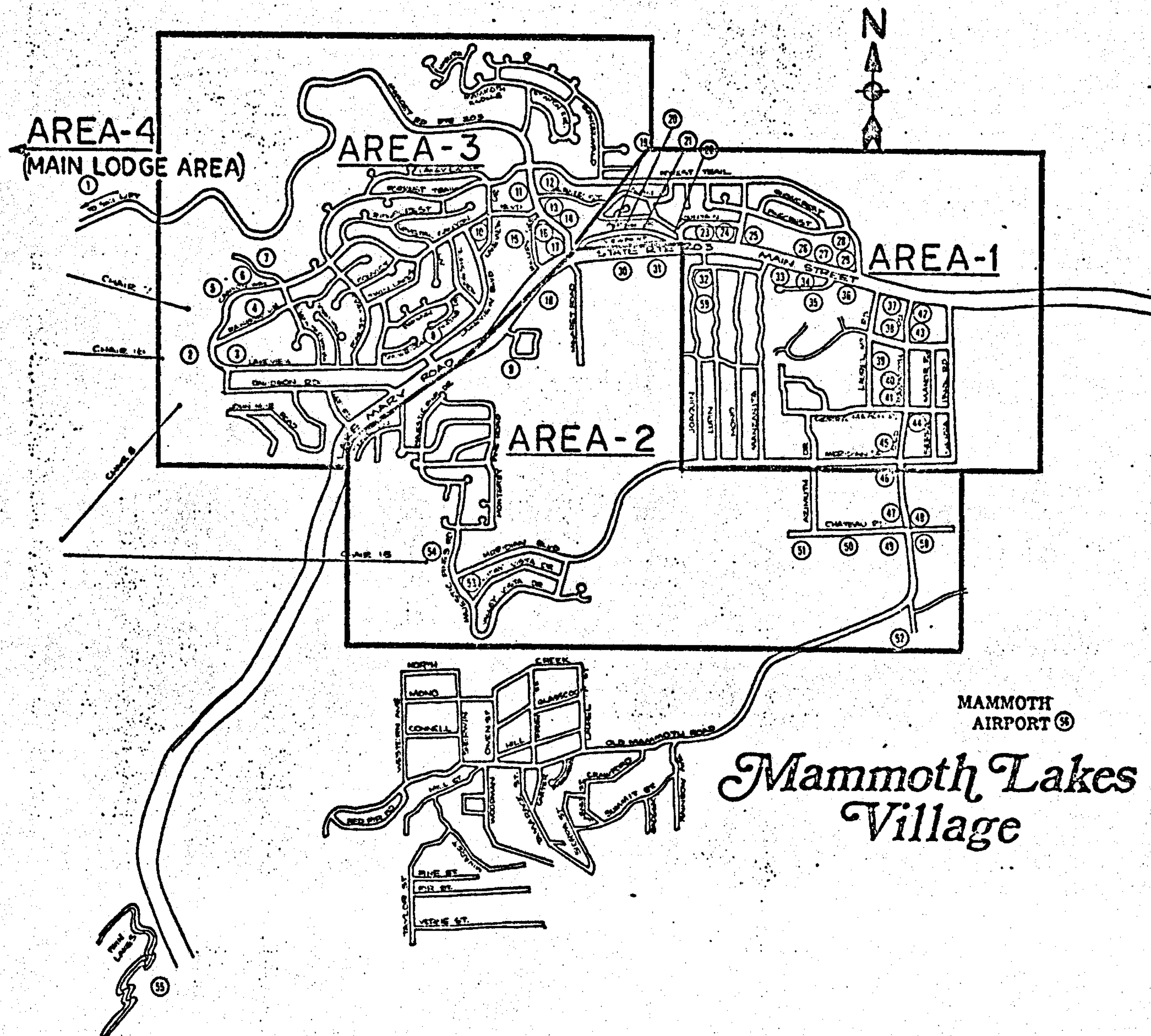


FIGURE 3
HEATING DISTRICT AREAS

TABLE 2

GEOGRAPHIC TABULATION OF COMMERCIAL AND CONDOMINIUM FACILITIES AND HEATING LOADS MAMMOTH LAKES

LEGEND

Areas:

1 - Commercial Area, USFS, High School, Motels

2 - Meridian Village Area

3 - Mammoth Slopes, Warming Hut No. 2

4 - Main Lodge Area

Heater Types:

W - Wall Heater

CS or C - Ceiling Suspended

FA - Forced Air

F - Floor

BB - BaseBoard

RC - Radiant Ceiling

GH - Gas/Hydronic Floor Coils

FC - Electrical Floor Cable

OH - Oil/Hydronic

SB - Steam Boilers

WBB - Wall and/or BaseBoard

TABLE 2 - continued

AREA 1 COMMERCIAL CENTER ET AL

#	Name	Gas (MBH) Space	Gas (MBH) Water	Electric (kw) Space	Electric (kw) Water
1	Sandy's Ski Rentals	w 24.5	---		
2	Mammoth Day Care Center	w 45.0	36.0 30 gal	c 2	---
4	Wildwood Inn	---	520.200g.	W 112	30 ,220g.
6	Moostachie Pete	w 70. FA 160	197.100g		

29	The Winery	--	---	FA 19	---
30	Lloyd Dennees (Furn.)	---	---	FA 17	---
31	Safeway	---	---	?FA 195	36 , 125 gal
32	John Taft Elect	---	---	FC 16	---
33	Century Const	---	---	FC 16	---
34	John Taft Elect	---	---	FC 12	---
35	F. Shakespeare	---	---	FC 16	4.5, 30
36	John Taft Elect	---	---	FC 16	4.5, 30
40	Sierra Nevada Inn	---	---	W 400	63, 1400
41	Mamm. Lks, Laundrymat	CS,125	1190,270g	---	---
42	Comstock Lode	FA,260	188,100g	---	---
43	PeaSoup Andersons	---	200,168	FA 133	---
44	Shotz Bakery	CS,600	---	---	6,40g
45	Phils Rest.	---	---	FA,45	5 , 120g
46	FireStation	CS,720	240,100	BB,30	---
47	Kittredge Arhey & Sport Goods	FA,200	36 ,30 gal	W, 2	---
48	Mammoth Villa	---	---	W,57	14 , 210g
49	Austrian Chalet	---	---	RC,80	24 , 480g
50	Pinecrest Lodge	W,300	200 ,500g	W, 18	
51	Mammoth Liquors	FA 150	---	---	1.5 , 5g.
52	Stump Alley Rest.	---	---	RC, 18	4.5, 50
53	Market Platz	C, 525	38, 40g	---	---
54	Laplander Lodge	---	---	W,66	27, 492g
58	Village Center Mall	---	---	W, 71	11 , 50g
59	Cont. Telephone Relay	FA,353	---	---	4.5, 20g
60	Shotz Rest.	W, 5	66 , 60g		
61	Hot to Go	---	---	W, 12	4.5 , 50g
64	Mamm. Chevron	CS,260	---	---	1.5, 6
65	Mamm Texaco	FA,140	20 , 20g	CS, 4	
66	Post Office	FA,160	---	---	2 , 12g
67	Inyo-Mens Bank	FA,268	20,20g	W, 15	---
69	Village Liquor	FA, 200			2 , 20g
74	Las Montanas	W, 135 FA,150	50,65g	---	65,6g
75	The Continental	---	---	W,58 RC, 50	40 , 120g
79	Mamm Union 76	CS,130	---	---	1.5 ,6g

TABLE 2 - continued

AREA 1 - continued

#	Name	Gas (MBH) Space	Gas (MBH) Water	Electric (kw) Space	Electric (kw) Water
80	KFC of Mamm.	CS,75	240 ,100g	---	---
81	The Outfitter	---	---	RC,10	---
		---	--	BB,28	---
92	Breeze Ski	---	---	RC,12	4.5 ,30g
94	B of A	---	---	FA,57	4.5 , 30g
95	Mamm Cty Water Dist.	---	---	FA,84	4.5, 52g
		---	--	CS,70	---
96	Mamm Pharmacy	---	---	FA,35	4.5, 30g
97	Nicolosis	---	150 ,100g	FA,17	1.5, 20g
100	USFS Visitor Center	FA,292	100 ,100g	---	---
101	Norco Gas Station	---	---	W,4	4.5 , 40g
102	Shakey's	FA,120	---	---	4.5, 100g
104	Pow Wow	---		w,16	4.5, 52g
105	Swiss Chalet	---	---	W,72	27,360g
106	Sears Catalog	---	---	W,8	1.5, 6g
107	Kittle Printing Co.			CS,15	1.5, 6g
108	Swensons Ice Cream	FA,150	80 ,67g	---	---
109	Mogul Steak House			W,26	20 ,60g
113	Corner Hardware Store			CS,30	1.5, 6g
	SHERWIN VILLAS (70U)			WBB,700	320
	ST. MORITZ VILLA (80U)			WBB,800	360
	LA RESIDENCE (96U)			WBB,960	430
	SIERRA PARK VILLAS (100U)			WBB,1000	450
	TAMARACK (40U)			WBB,400	180
	KRYSTAL VILLA (86U)			WBB,860	390
	THE HERITAGE (18U)			WBB,180	80
	TIMBERLINE (52U)			WBB,520	230
	VIEWPOINT (56U)			WBB,560	250

TABLE 2 - continued

AREA 2 MERIDIAN VILLAGE & SHERWIN PLAZA

#	NAME	GAS SPACE	GAS WATER	ELECTRIC SPACE	ELECTRIC WATER
5	Arlberg Chalet	FA680	408 300gal	---	---
8	Royal Pines Resort	F 192	390 200	W 48	---
	---	W 24	160 Jacuzzi	---	---
9	White Stag Inn	---	700 400gal	W 84	---
37	US Post Office	---	---	W 18	1.5 ,10g
38	The Stove	FA 120	---	---	10,45
39	The Tavern	Oil/Hyd.	800	(250 gal Hot water Heater)	
63	Mamm Properties	---	---	w k4	3.3, 52g
68	Perrys Pizza	W 75	36,30g	---	---
70	Holiday Haus	W885	805 ,580g	BB 16kw	---
71	Filsons Sports	?FA,100	---	---	---
72	Mill City Laundry	---	800 ,760g	---	---
73	Dai-San Rest.	---	---	W,4.5	4.5,50g
111	Mono Cty Plumbing			CS,12	4.5 ,40g
112	County Liquor			w,9	
				w,12	4.5,40g
	CHATEAU BLANC CONDOS (60U)			WBB,600	270
	CHATEAU DE MONTAGNE (48U)			WBB,600	216
	MAMM. CREEK CONDOS (60U)			600	270
	LA VISTA BLANC (80U)			800	360
	CHATEAU SANS NOM (38U)			WBB,380	171
	VILLA DE LOS PINOS (80U)?			800	360
	HORIZONS IV (92U)			WBB,920	400
	SUNSHINE VILLAGE (80)			WBB,800	360
	THE SUMMIT (110)			WBB,1100	400
	SUMMIT II (100)			WBB,800	
	WOODSTOCK (108)			WBB,1080	450
	CHATEAU D'OEX (18)			WBB,180	81
	TYROLEAN VILLAGE (56)			WBB,560	260
	HIDDEN VALLEY (80)?			800	360

TABLE 2 - continued

AREA 3 MAMM SLOPES, HUT #2

#	NAME	GAS SPACE	GAS WATER	ELECTRIC SPACE	ELECTRIC WATER
7	Warming Hut #2	---	---	F/A 812	186 ,350g
11	Engelnof Lodge	w360	226 ,280gal	BB 6	19 ,268g
12	Whiskey Creek	FA1260	200 ,100gal	---	9 ,100g
14	Eckert, MD	---	---	RC,24	9 ,800g
15	Bergers Burgers	---	---	RC 9	4.5 60
16	Der Alpenkoff	F 240	600 ,500gal	BB 90	---
17	Minaret Lodge	F 120	400,/00	---	---
18	Mamm. Realty	W240	---	---	---
		---	---	w 6	1.6 5
19	Austria Hof	---	600, 300	w 52	---
		---	---	BB 15	---
20	Host Motor Inn	---	---	BB 183	102 ,960g
		---	---	w 20	72 Jacuzzi & Pool
21	Seasons 4 Rec Hall	---	345 Jacuzzi	BB 20	---
		---	548 Pool	w 6	---
		---	200,200g	---	---
22	Mamm. County Yard	GH 1,000	150,50g	---	---
		C 200	---	---	---
24	Alpine Lodge	GH 910	1090,1300g	w 24	---
		---	261,Pool	BB 12	---
25	Comstock II	w 60	100,100g	BB 2	
26	Forest Trains Comm Center	---	---	w 24	4.5, 52g
27	Innsbruck Lodge	w 315	540,240g	w15	---
		FA 160	---	---	---
28	Div. of Hwy	C 300	---	C 5	10 ,130g
		---	---	w 6	---
93	Mamm. Minaret Corp	---	---	FA 544	12 , 82g
	Maint. Garage	---	---	---	---
98	Mamm Mtn Chalets	---	---	w,280	63 , 1150g

CHAMONIX CONDOS (100)	WBB,1000	450
CONESTOGAS (17)	WBB,170	75
DISCOVERY 4 (64)	WBB,640	290
MAMMOTH POINT (32U)	WBB,550	140
TIMBERIDE (54U)	WBB,540	240
THE 1849 (PT1) (100U)	WBB,1000	450
ST. ANTON (84)	WBB,840	380
SNOWBIRD (24)	WBB,240	110
MAMMOTH WEST (43)	WBB,430	200
MAMM SKI & RACKET (133)	1330	600
COURCHEVEL (600)	WBB,600	270
WESTERN SLOPE VILLAS (22)	WBB,220	100
SEASONS IV (100U)	WBB,1000	450
MAMMOTH ESTATES (78U)	WBB,780	350
LAKEVIEW VILLAS (31U)	WBB,310	140
CHATEAU ENCHANTE (80)	800	360
MAMMOTH FIRESIDES (30)	WBB,300	140
VAL D'ISTERE (46)	WBB,460	210

TABLE 2 - continued

AREA 4 MAIN LODGE AREA

#	NAME	GAS SPACE	GAS WATER		ELECTRIC SPACE	ELECTRIC WATER	
55	Main Lodge	Unknown Cap.			SB,720	732	,--g
	Minaret	---			W,200	---	
56	Ski Lift Apts.	---	750	,2500gal	W,693	140	,2500g
57	Mamm.Mtn Inn	---	---		FA,300	360	,12000g
		---	---		w,180	---	
		---	---		FA,150	---	
110	Yodler Rest.	---	---		FA,69	9	,120g
		---	---		w,16	---	

TABLE 3

ESTIMATED CONNECTED HEATING LOADS BY AREA IN THERMAL MEGAWATTS (MWt)

	AREA 1	2	3	4	Total
SPACE HEATING					
Gas					
Forced Air	2.0	0.3	0.5	NA	2.8
Other	1.3	0.4	1.3	NA	3.0
Total	3.3	0.7	1.8	--	5.8
Electric					
Forced Air	1.2	0	2.7	0.5	4.4
Other	10.3	10.4	15.3	2.3	38.3
Total	11.5	10.4	18.0	2.8	42.7
Total Space Heating	14.8	11.1	19.8	2.8	48.5
WATER HEATING					
Gas	2.1	1.5	2.0	0.2	5.8
Electric	4.2	4.1	7.1	1.2	16.6
Total Water Heating	6.3	5.6	9.1	1.4	22.4
TOTAL CONNECTED LOAD	21.1	16.7	28.9	4.2	70.9

NA = Information not available

However, of the forced air heating units, which will probably be the most convenient and economical to convert, only 61 percent are electric. In addition, about 74 percent of the water heating load in the Village is electric. Of the total estimated connected heating load of 70.9 MWt, about 84 percent uses electric energy.

C. LOAD GROWTH ESTIMATES

Estimated growth in the peak heating load has been estimated using the results of the Saturation Survey presented above, and population growth estimates for Mammoth Lakes Village projected in the Mono Plan (2). The estimated peak electric load demand for the Village in 1980 as derived in Part A of this section is presented below.

Space Heating	41 MWe
Water Heating	8 MWe
Other	5 MWe
Total	54 MWe

The Saturation Survey indicated that electric heating is used for 84 percent of the total connected heating load in Mammoth. This breaks down to 88 percent of the space heating load and 74 percent of the water heating load. Using these percentages, the estimated 1980 peak heating demand for electric and gas heating units was calculated. The results are presented below in terms of thermal megawatts.

Space Heating	47 MWt
Water Heating	11 MWt

The Mono Plan estimated that Mammoth Lakes Village would reach its maximum weekend population of 43,000 in 1995. A recent conversation with the Mono County Planning Director indicates that the maximum is more likely to be reached in the year 2000 as recent warm winters and a water shortage have temporarily caused a reduction in the population growth of Mammoth.

If the maximum weekend population does climb to 43,000 in the year 2000 from an estimated 17,000 in 1975, the average growth rate in population would be 3.8 percent per year. Assuming that the peak heating demand increases at the same rate as peak weekend population, the projected heating loads for 1985, 1990, and 2000 were calculated, and are given in Table 4 below.

TABLE 4

ESTIMATED PEAK HEATING DEMAND
MAMMOTH LAKES VILLAGE

Year	Estimated Peak Load (MWt) Space Heating	Water Heating	Total
1980	47	11	58
1985	57	13	70
1990	68	16	84
2000	99	23	122

In order to establish the heating demand which a geothermal district heating system should be designed to meet, an estimate of district heating system demand growth was prepared. The projected growth in space and water heating for the entire Village, which was derived above, is plotted as the upper curve of Figure 4.

The following assumptions were made to estimate how much heating demand could be provided by geothermal district heating.

1. The district heating system will begin operating in 1980 at which time it will provide 10 percent of the Village space and water heating demand.

2. Of the new heating loads installed from 1980 to 1985, 75 percent will use district heating.

3. All new heating loads installed from 1986 to 2000 will use district heating.

4. Of the heating load in place in 1980, 35 percent will be converted to geothermal district heating by 1985, and 75 percent by 1990. No additional conversions will take place after 1990.

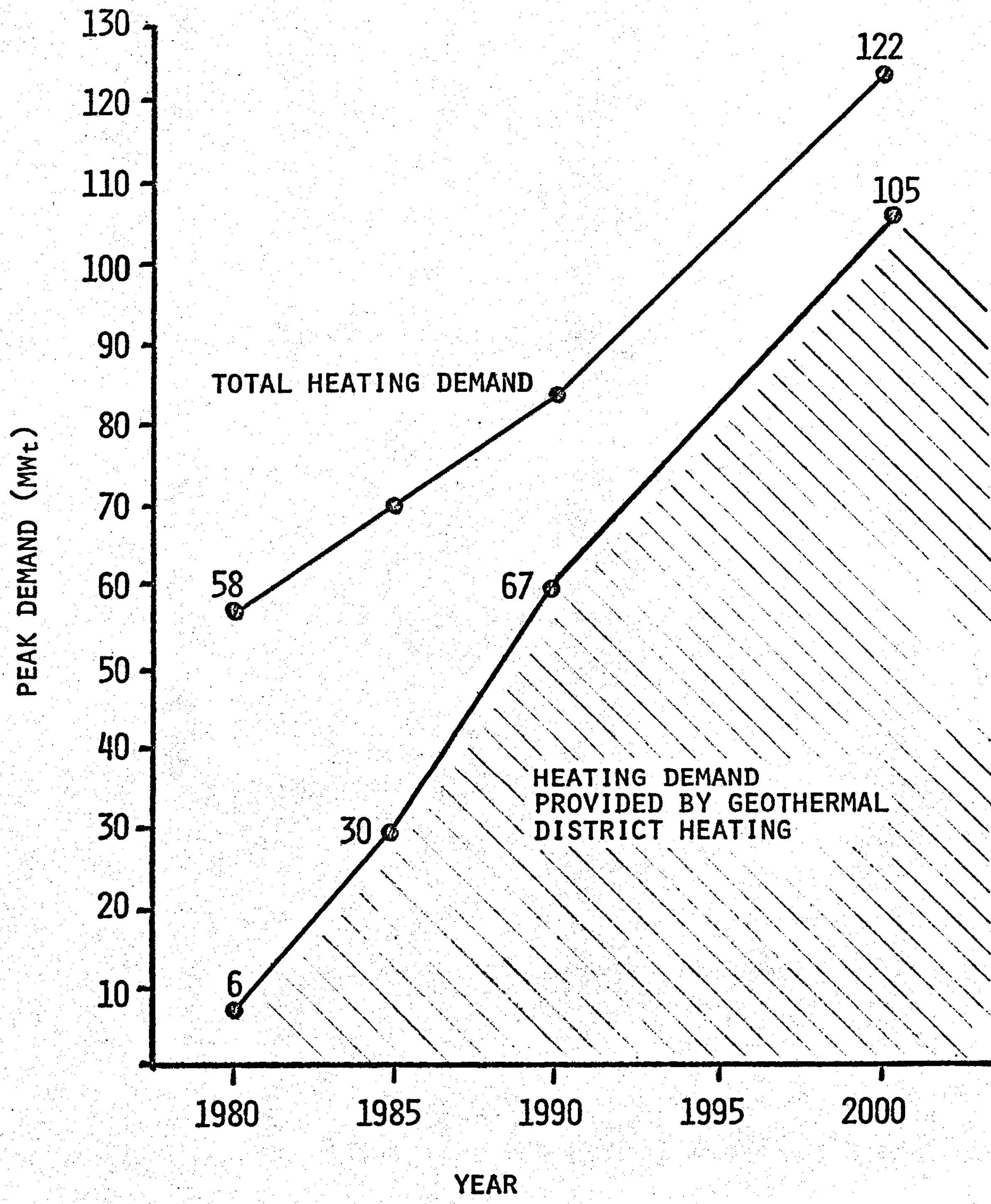
By applying the above assumptions to the projected peak Village heating demand, an estimate of peak demand which could be provided by district heating was obtained. This estimate is plotted as the lower curve of Figure 4.

D. METERING

As an early step in preparation for the design of the district heating system, the peak heating demand of Mammoth was estimated using data from previous studies, local substation electric demand data and Southern California Edison Company billing records (see Part A of this section). This estimated peak demand, together with

FIGURE 4

PEAK HEATING DEMAND PROJECTIONS
1980-2000



assumed growth rates and market penetration factors, served as a basis for sizing the district heating system.

In an effort to check the validity of the estimated heating loads, a field metering program was implemented. The objective of this program was to measure the percentage of the total electric energy consumption attributable to heating for various types of buildings. These percentages, when applied to the total load of the town as recorded at SCE's Casa Diablo Substation, yield an indication of the total heating load of the town.

A total of 57 elapsed time indicators have been installed on space and water heaters in five condominium units, one single family home, two offices, one pharmacy, one restaurant and one commercial garage. Table 5 has a listing of these meter installations. The elapsed time meters record the number of hours that each of the heating units at a given facility is energized. Figure 5 contains photographs of typical installations. Readings from these meters are recorded on a monthly basis by SCE's Bishop District personnel, and are reduced to kilowatt hours per day figures for each recording period, for each facility. Similarly, total kwh consumption is being recorded from SCE's billing records for each of the same ten facilities. These figures are also reduced to kwh per day for comparative purposes.

The average kwh per day heating and total energy consumption figures over each metering period for each facility are then compared, and the percentage of total energy consumption per day attributable to space and water heating is calculated. The results of this procedure are tabulated in Table 6 below.

TABLE 5

METER INSTALLATIONS

LOCATION NO.	TYPE OF FACILITY	METER NO.	IN SERVICE	RATING (KW)	TYPE HEATER	ROOM
86	Sing.Fam.Home	8	2/17 9:30A	4.0	W	L
		33	10:00A	4.5	W	L
		40	10:30A	4.5	WH	Upper element
		58	10:35A	2.5	WH	Lower element
		34	11:00A	3.0	W	B
		37	11:20A	3.0	W	B
		21	11:40A	3.0	W	B
87	Condo	1	2/8 2:00P	1.5	BB	H
		11	2:15P	4.5	WH	Upper
		15	2:45P	2.5	WH	Lower
		2	3:15P	2.5	BB	L
		3	3:30P	1.5	BB	L
		4	3:45P	1.5	BB	B
		5	4:00P	2.0	BB	B
		6	4:15P	2.0	BB	B
89	Condo	7	2/9 8:15A	2.5	BB	L
		9	9:30A	4.0	W	L
		10	10:00A	2.0	BB	B
		17	10:15A	4.5	WH	
		16	10:15A	2.5	WH	
90	Condo	12	2/9 2:20P	2.0	BB	L
		13	2:45P	1.5	BB	D
		14	3:15P	4.0	W	L
		18	3:30P	1.5	BB	B
		20	3:45P	2.0	BB	B
92	Business Office	52	2/17 3:00P	10	FA	Office
		55	3:10P	10	FA	Lobby
		36	3:30P	4	Wall	Lobby
96	Pharmacy	24	2/18 11:00A	17.3	FA	
		25	11:30A	17.3	FA	
		72	11:45A	2.5	WH	
		66	11:50A	4.5	WH	
97	Restaurant	64	2/18 1:45P	17	FA	

TABLE 5 - continued

LOCATION NO.	TYPE OF FACILITY	METER NO.	IN SERVICE		RATING (KW)	TYPE HEATER	ROOM
91	Condo	38	3/7	2:30P	4.5	W	L
		28		3:00P	4.5	W	B
		59		3:20P	4.5	W	B
		67		3:40P	4.5	WH	Upper
		65		3:45P	2.5	WH	Lower
95	Offices	42	3/4	11:45A	45	FA	
		43		12:00N	45	FA	
		29		2:00P	2.5	WH	Lower
		39		2:00P	4.5	WH	Lower
95	Garage	27	3/3	5:00P	10	FA	
		26		9:00A	10	FA	
		46		9:30A	10	FA	
		45		10:00A	15	FA	
		19		10:45A	15	FA	
		35		11:00A	4.5	WH	Upper
		43		11:15A	2.5	WH	Lower
116	Condo	22	3/7	10:00A	2.8	W	Hall
		32		10:20A	2.8	W	B
		23		10:45A	2.8	W	B
		53		11:00A	2.5	WH	Lower
		70		11:20A	4.5	WH	Upper
		44		11:30A	2.8	W	B
		41		11:45A	4.5	W	L
		30		12:00N	4.5	W	L

FIGURE 5 - TYPICAL METER INSTALLATIONS

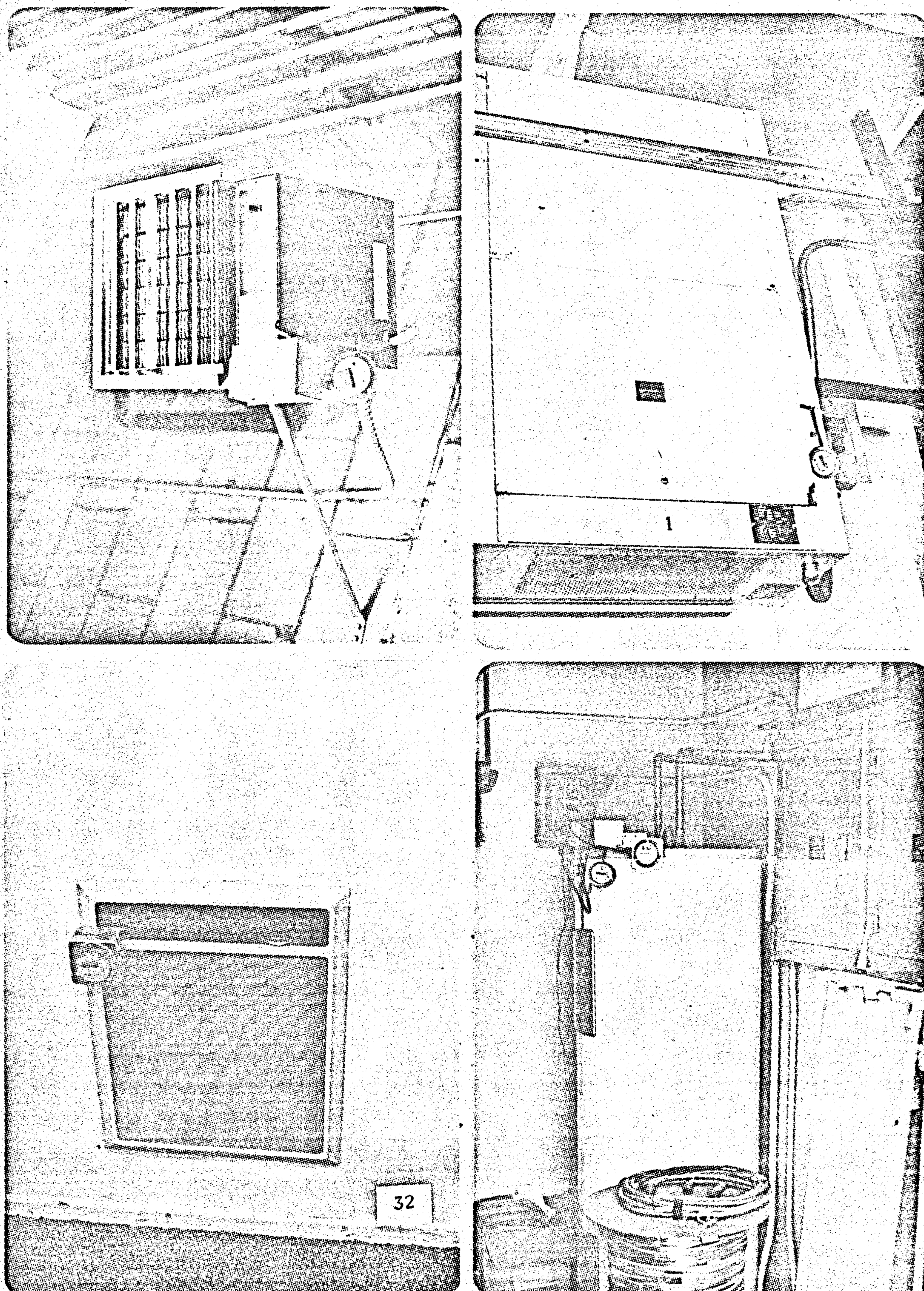


TABLE 6

PERCENTAGES OF TOTAL ELECTRIC ENERGY ATTRIBUTABLE TO SPACE AND WATER HEATING

5 Condominiums and 1 Single Family Home

Unit No.	Feb.	Mar.	Apr.
1.	57	50	50
2.	55	46	46
3.	88	92	94
4.	63	68	74
8.	--	100	100
10.	--	100	100
Average	66	76	77
3 Commercial Buildings			
5.	26	20	16
6.	17	16	14
9.	--	82	100
Average	22	39	43

The data and analysis performed to date generally confirm the assumed parameters used in sizing the system. The curves shown in Figure 6 represent the percentages of total monthly electric energy attributed to heating, which were originally assumed in sizing the system. These same percentages apply to monthly peak demands (due to the linear relationship between energy consumption and peak demands). This curve shows a peak value of 91 percent of total demand attributed to heating during the coldest winter months; this value falls off to nearly 30 percent during the warm summer months.

The data points derived from the metering program to date (from Table 6) are superimposed on the original graph of assumed percentages. Only the condominium data were included as these data represent the majority of the Village electric load. Including the commercial loads at this point would unfairly weight their contribution. It is noted that while the March and April data points fit the assumed curve fairly closely, the measured February heating percentage is low. This is due to the unseasonably warm weather experienced during February as illustrated in Figure 6, Temperature Data. Figure 7 shows daily maximum, minimum and mean temperatures, as well as heating degree-days per month tabulated across the bottom. These data were accumulated by an SCE's Temperature recorder installed for this study, and from the U. S. Forest

FIGURE 6

PERCENTAGES OF TOTAL KWH CONSUMPTION ATTRIBUTABLE TO SPACE HEATING, WATER HEATING, AND SPACE PLUS WATER HEATING

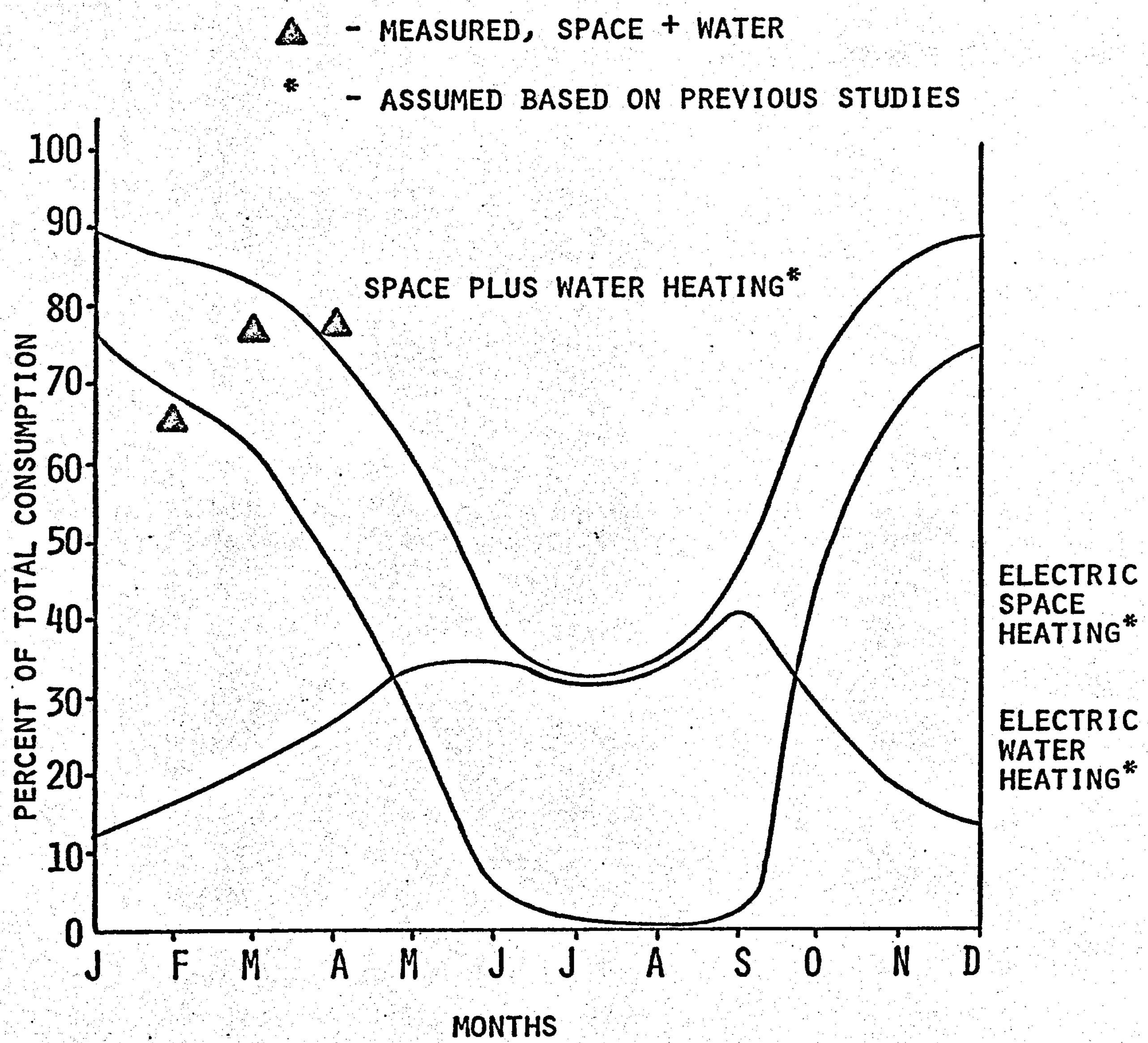
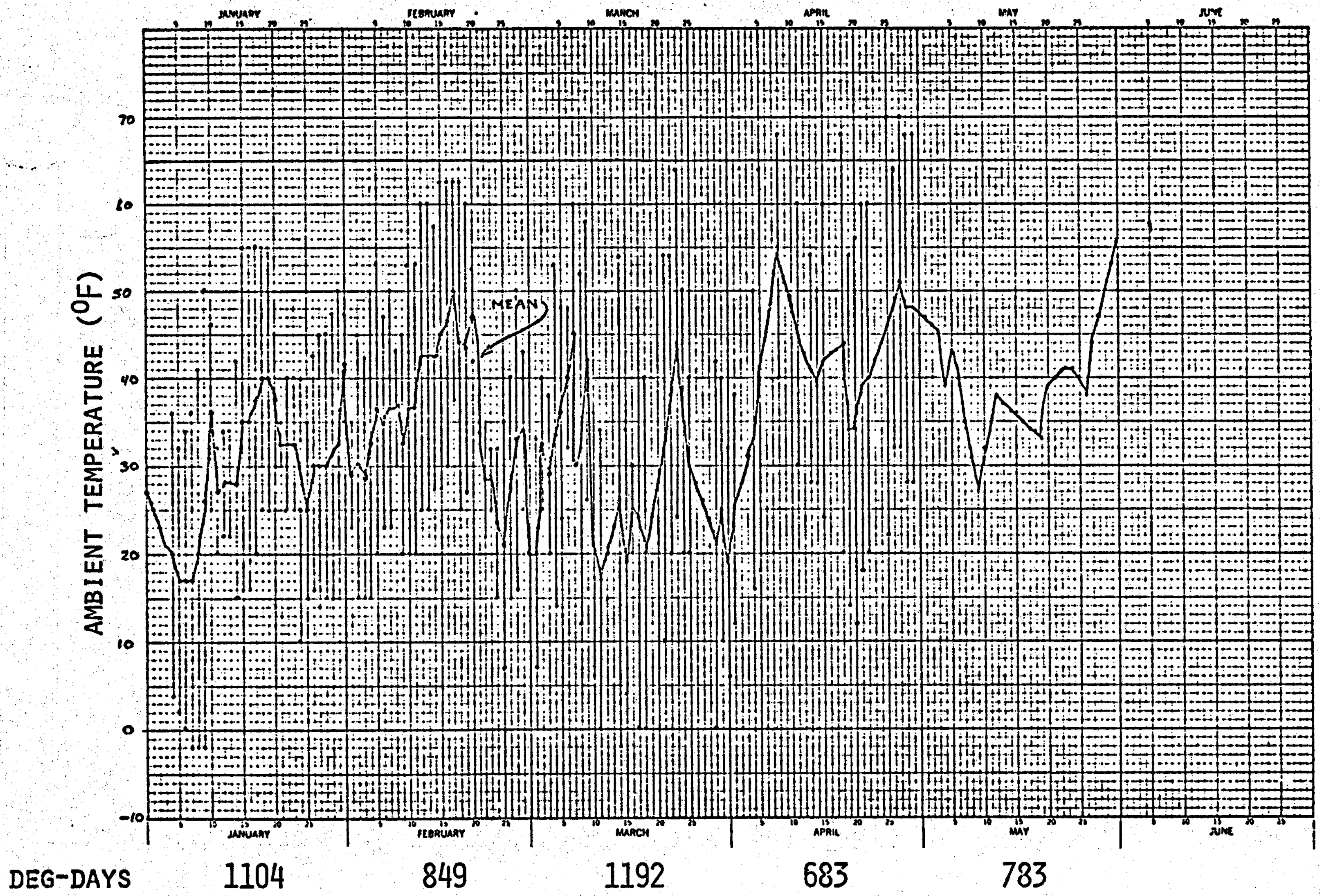


FIGURE 7 - TEMPERATURE DATA
MAMMOTH LAKES VILLAGE, 1977



Service and Caltrans recorders. This relatively warm winter at Mammoth resulted in unusually light snowfall and thus a low visitor occupancy factor in the Village, as well as a lower heating load. The effect on electrical peak demands of unusually warm weather over the last two seasons is illustrated in Table 7 below which lists yearly peak demand at Casa Diablo Substation. The annual peak demand grew quite rapidly until the last two winters, during which time it decreased.

TABLE 7

YEARLY PEAK DEMAND
CASA DIABLO SUBSTATION

Year	MWe
1969	9.6
1970	13.2
1971	15.6
1972	21.6
1973	30.0
1974	34.8
1975	41.0
1976	37.0
1977	28.0

The metering work performed to date has served to confirm the parameters derived in Part A of this section to size the district heating system for the feasibility study.

RESERVOIR ANALYSIS

To determine if a sufficient quantity of geothermal energy is available to serve the heating needs of Mammoth Lakes Village, an analysis of the Casa Diablo reservoir has been completed. The results of the analysis are summarized below.

A. INTRODUCTION

The Casa Diablo geothermal area is a 90 acre parcel of land located at the intersection of U. S. Highway 395 and California State Highway 203, about three miles east of the town of Mammoth Lakes, Mono County, California. The Casa Diablo site is owned in fee by the Magma Power Company of Los Angeles, California.

Casa Diablo is located within the Long Valley portion of the Mono-Long Valley Known Geothermal Resources Area (KGRA) established by the Secretary of Interior under the Geothermal Steam Act of 1970 (30 UCS 1001-1025 (1970)). Long Valley lies in a large caldera, about 150 square miles in area, formed 700,000 years ago and filled with up to 12,000 feet of rhyolite flows, tuffs and volcaniclastic sediments (3). The Casa Diablo site is adjacent to KGRA lands currently being considered by the Department of Interior for geothermal leasing in 1977.

Eight geothermal wells have been drilled on the Casa Diablo property. The date each was drilled, and its depth are listed in Table 8 below.

TABLE 8

GEOTHERMAL WELLS AT CASA DIABLO

Well	Date Drilled	Depth
Endogenous #1	30 July 1960	630'
Endogenous #2	31 Aug. 1960	810'
Endogenous #3	12 Sep. 1960	570'
Endogenous #4	2 Nov. 1961	805'
Endogenous #5	26 June 1962	405'
Endogenous #6	27 July 1962	756'
Endogenous #7	28 Aug. 1962	670'
Mammoth #1	25 Nov. 1959	1,063'

The wells are cased to a maximum depth of about 400 feet, with open hole (i.e., no casing) for the remainder of well depth.

B. USGS ASSESSMENT

The U. S. Geological Survey has made assessments of the geothermal heat storage and recoverable energy in the Long Valley area (4). They report maximum surface temperature from springs and fumaroles of 94°C (201°F) and geochemically inferred reservoir temperature of 219°C - 238°C (426°F - 460°F). Based on the above, geologic data they have collected and analysed, and the data from the Casa Diablo geothermal wells, they have published the following reservoir assumptions for Long Valley.

TABLE 9

RESERVOIR ASSUMPTIONS-LONG VALLEY
(From USGS Circular 726)

Subsurface Temperature	220°C (428°F)
Subsurface Area	225 km^2 (87 mi^2)
Thickness	2 km (1.2 mi)
Heat Content	5.5×10^{19} cal (2.2×10^{17} Btu)

Given the reservoir assumptions of Table 9, the USGS calculated the electrical energy generation potential of Long Valley after deriving a ratio of recoverable electrical energy to stored energy of 0.025 for a hot-water reservoir with 200°C to 250°C (392°F to 482°F) subsurface temperature. This calculation yields an estimated electrical energy production potential of 1,825 megawatt (electric) - centuries (MWe - cent) for Long Valley.

For purposes of comparison, USGS's recoverable energy estimates for other geothermal reservoirs are tabulated below.

TABLE 10

RECOVERABLE ENERGY ESTIMATES
(From USGS Circular 726)

Long Valley	1,825 MWe - cent
The Geysers	477
Salton Sea	836
All Identified Reservoirs*	7,966

*All U. S. geothermal resources with reservoir temperature above 150°C (302°F).

From Table 10, it becomes clear that the Long Valley geothermal resources compose a very large percentage of the total high-temperature geothermal resource base of the U. S. By additional comparison, the recoverable electrical energy estimate for Long Valley of 1,825 MWe - cent would be sufficient to supply 9 times the entire 1975 electric energy consumption of the State of California (5).

Assuming all portions of the Long Valley KGRA are homogeneous with respect to recoverable energy, the 90 acre Casa Diablo geothermal area would have a recoverable electrical energy potential of about 300 MWe - years. Based on a typical conversion efficiency of 15 percent for geothermal to electrical energy, the Casa Diablo geothermal area may contain about 2,000 megawatt (thermal) - years (MWt - yr) of recoverable thermal energy. Load survey estimates derived in the previous section indicate that 2,000 MWt - yr is sufficient energy to heat all space and domestic water in the town of Mammoth Lakes for over 200 years at the current usage rate.

C. WELL FLOW TESTING

In addition to reservoir estimates by the USGS, well test data exist for seven of the eight wells which have been drilled at Casa Diablo (6, 7). In 1960, well flow and temperature testing was conducted by Middleton for Endogenous Well Nos. 1 to 3 and Mammoth Well No. 1. Although the flow testing was only run for a short time, less than 1 day per well, an indication of the maximum capabilities of wells was determined as tabulated below.

TABLE 11

1960 WELL TEST RESULTS
(Data from Middleton)

WELL	MAXIMUM FLOW RATE	MAXIMUM WELLHEAD TEMPERATURE
Endogenous No. 1	531,000 lb/hr	364°F
Endogenous No. 2	287,000 lb/hr	357°F
Endogenous No. 3	349,000 lb/hr	314°F
Mammoth No. 1	495,000 lb/hr	270°F

Subsequent well testing, performed in 1962, provided additional flow and temperature data for Endogenous Well Nos. 1, 2, 4, 5 and 7. A summary of the data obtained during the six week testing period follows.

TABLE 12

1962 WELL TEST RESULTS
(Data from Middleton)

Well	WELLHEAD CONDITIONS Pressure (psig)	WELLHEAD CONDITIONS Temperature* (°F)	WELL FLOW RATES Water (lb/hr)	WELL FLOW RATES Total (lb/hr)	TOTAL Flow Time (wks)
Endogenous 1	70	343	123,000	---	3
Endogenous 2	56	341	206,500	---	3
Endogenous 4	52	331	250,000	330,000	1 1/2
Endogenous 5	70	324	524,000	550,000	1 1/2
Endogenous 7	50	(Only one measurement taken, data questionable)			1

*Static conditions, maximum temperature

Based on the data gathered in 1960 and 1962, Middleton concluded that the geothermal fluid flow and temperatures which could be expected from the Endogenous Wells are as follows.

TABLE 13

PREDICTED WELL CAPACITIES
(From Middleton)

WELL	FLOW RATE @ 50 PSIG (lb/hr)	PRODUCING TEMPERATURE (°F)
Endogenous 1	450,000	360
Endogenous 2	450,000	360
Endogenous 3	300,000	320
Endogenous 4	400,000	300
Endogenous 5	700,000	340
Total	2,300,000	Average 340

A producing rate of 2,300,000 lb/hr with a temperature of 340°F yields an instantaneous production rate of between 200 MWt and 800 MWt, depending upon the quality of the well flow. If all the well flow were liquid, 200 MWt would be produced; if all steam, 800 MWt would be the production rate. This compares to a projected peak space and water heating demand for all of Mammoth Lakes of about 58 MWt for the year 1980.

D. HETU TESTING

An additional set of tests was conducted on the Casa Diablo wells in 1974. Magma Power Company pumped geothermal waters from Endogenous Well No. 2, through a Heat Exchanger Test Unit (HETU) and injected the cooled geothermal water into Endogenous Well No. 1. The purpose of these tests was to determine the scaling properties of the geothermal water. However, temperature measurements recorded during testing provide an indication of reservoir temperature.

The HETU tests took place between August 8 and October 13, 1974. Two runs of 23 and 25 days were undertaken. The geothermal liquid temperature at the wellhead as monitored throughout the testing varied bewteen 330°F and 340°F. The geothermal liquid was being pumped at a rate of about 2,500 lb/hr.

E. CONCLUSIONS AND RECOMMENDATIONS

Based on the above information, the following conclusions and recommendations regarding the Casa Diablo geothermal area can be made.

The USGS estimates of reservoir capability and the well test results presented above indicate that the Casa Diablo geothermal area has the capacity to provide for the space and water heating needs of the town of Mammoth Lakes. USGS estimates suggest the potential of a 200 year supply of heating energy beneath the 90 acre Casa Diablo site. Well and heat exchanger testing have provided flow and temperature data for a number of the existing Casa Diablo Wells. Wellhead temperature of 330°F to 340°F and flow rates of 300,000 lb/hr to 500,000 lb/hr per well have been measured during short-term testing. These temperatures and flows are well in excess of peak space and water heating demand for the entire town of Mammoth Lakes.

While the USGS estimates and flow test results are encouraging, they are by no means conclusive as to the Casa Diablo geothermal area's capacity or longevity. Additional long-term reservoir data need to be provided before a large scale district heating facility can be built on the site.

The following actions are necessary to provide the data necessary for a complete reservoir evaluation (8):

a. Drilling a deep production test well with appropriate logging.

b. Instrumenting the deep production well, an existing injection well and one or more existing production wells for pressure, temperature and flow measurement.

c. Logging of some of the existing wells.

d. Running a full production test on the new well for a period of time required to obtain steady state data.

e. Measurement of pressure drawdown during deep well production, pressure build-up during shut-in following flow tests, and injection pressures throughout the testing.

The Magma made application on August 20, 1976 to the Mono County Department of Planning and Building for permits to drill a 4,000 to 9,000 foot deep production well on the Casa Diablo property. Magma hopes to complete the well by the end of 1977 (9). The reservoir information gained as a result of this deep well and associated testing should provide sufficient information for going ahead with a large district heating installation on the site, assuming the technical, economic and engineering feasibility of the heating system itself has been proven.

BUILDING HEATING DESIGNS AND COST ESTIMATES

As discussed in the LOAD SURVEYS Section of this report, buildings in Mammoth Lakes Village rely almost exclusively on electricity and Liquid Petroleum Gas (LPG) for space and water heating. Should a geothermal district heating system be implemented for the Village, existing buildings will require retrofit to hydronic heating and new buildings should be constructed with hydronic heating systems. Rough designs and cost estimates have been prepared for installing hydronic space and water heating systems in existing and planned buildings. The details of this work are presented below.

The Saturation Survey summarized in the LOAD SURVEYS Section of this report characterized the Village in terms of building units and space and water heating types. These results were used to identify buildings which can be considered "typical" in terms of their heating systems. Buildings which were chosen to represent typical residential and commercial loads in the Village for both existing and planned construction are listed in Table 14, Typical Heating Systems.

The mechanical engineering firm of Ayres Associates was employed as a subcontractor to prepare rough designs and cost estimates for retrofitting these typical existing buildings with hydronic heating systems from a geothermal district heating system. In addition, designs and cost estimates were prepared for installing gas, electric or hydronic heating systems into the typical planned buildings. The designs and costs were prepared for hydronic heating systems utilizing either a high temperature or low temperature district heating system loop. Hydronic heating system flow diagrams using high and low temperature district heating loops are shown in Figures 8, 9 and 10.

By referring to Figures 8, 9 and 10, typical space and water heating systems using high temperature and low temperature district heating can be compared. In Figure 9, high temperature water at 300°F enters a shell-and-tube heat exchanger where it gives up some of its heat to a closed loop hydronic building heating system, and is returned at 200°F to the district heating system. Building heating system water at 180°F is pumped from the heat exchanger shell to a hydronic domestic water heater and a fan coil or unit-type space heater. After giving up some of its heat to the domestic water and air, the building heating system water returns to the shell-and-tube exchanger for reheating and reuse. Temperature controls are provided for the building heating system loop, air and domestic hot water temperatures.

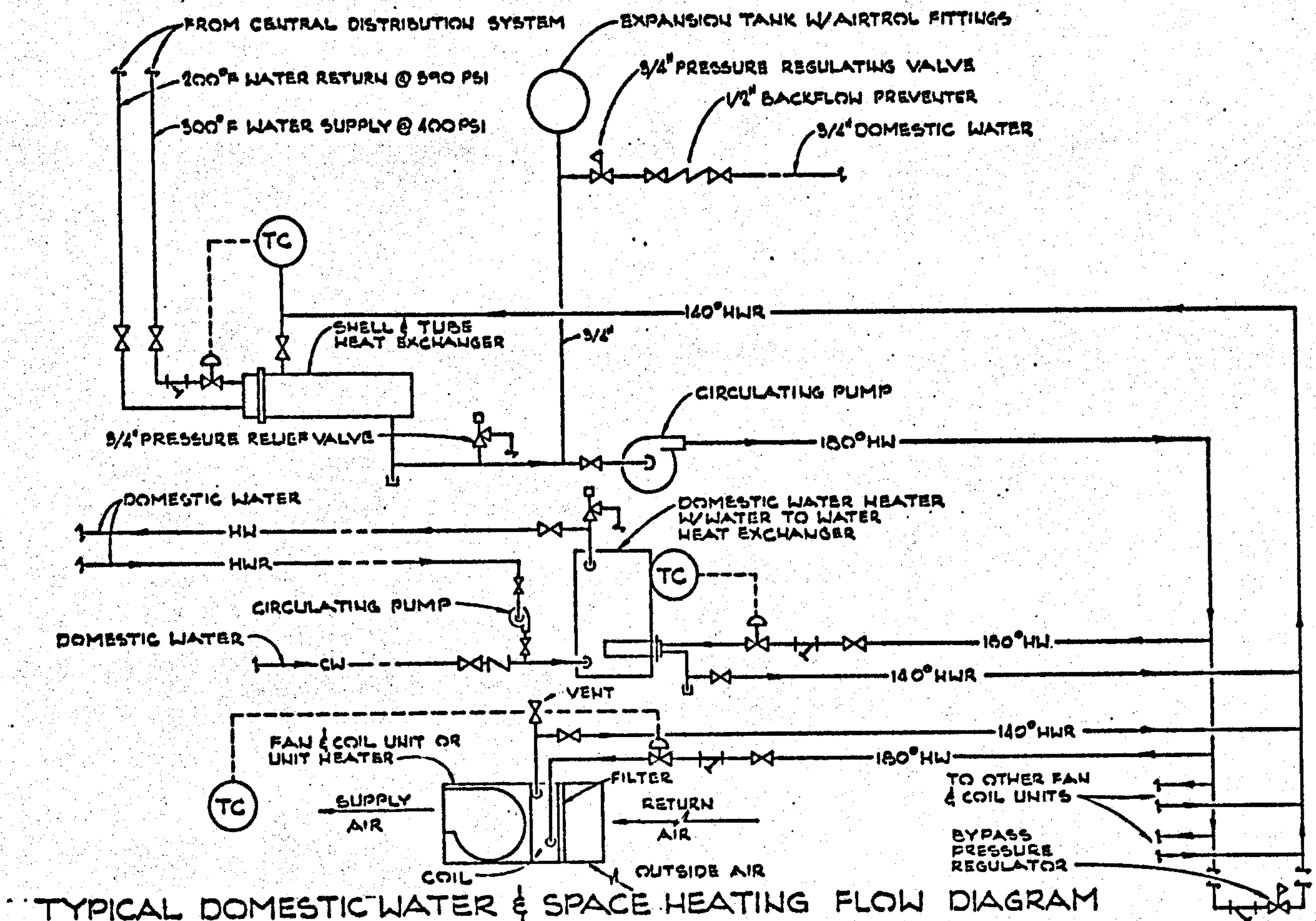
Figure 10, depicts a building hydronic heating system using low temperature district heating. This system is very similar to the high temperature system, except that no shell-and-tube heat exchanger is required.

TABLE 14

TYPICAL HEATING SYSTEMS

Category	Name	Space Heating Type	Water Heating Type
1. Existing Construction			
a. Commercial	USFS Visitor Center	Gas; Central Forced Air	Gas
	Mammoth Water District	Electric; Central Forced Air, Wall and Ceiling Suspended	Electric
	Wildwood Inn Motel	Electric; Wall Units	1 Gas, 1 Electric
	Pow Wow Shop	Electric; Wall and Ceiling Suspended	Electric
b. Residential	Season's Four Condominiums	Electric; Wall and Baseboard	Central Gas and Individual Electric
2. Planned Construction			
a. Commercial	Shakey's Pizza Parlor	Gas; Central Forced Air	Electric
b. Residential	Season's Four Condominiums	Electric; Wall and Baseboard	Central Gas and Individual Electric

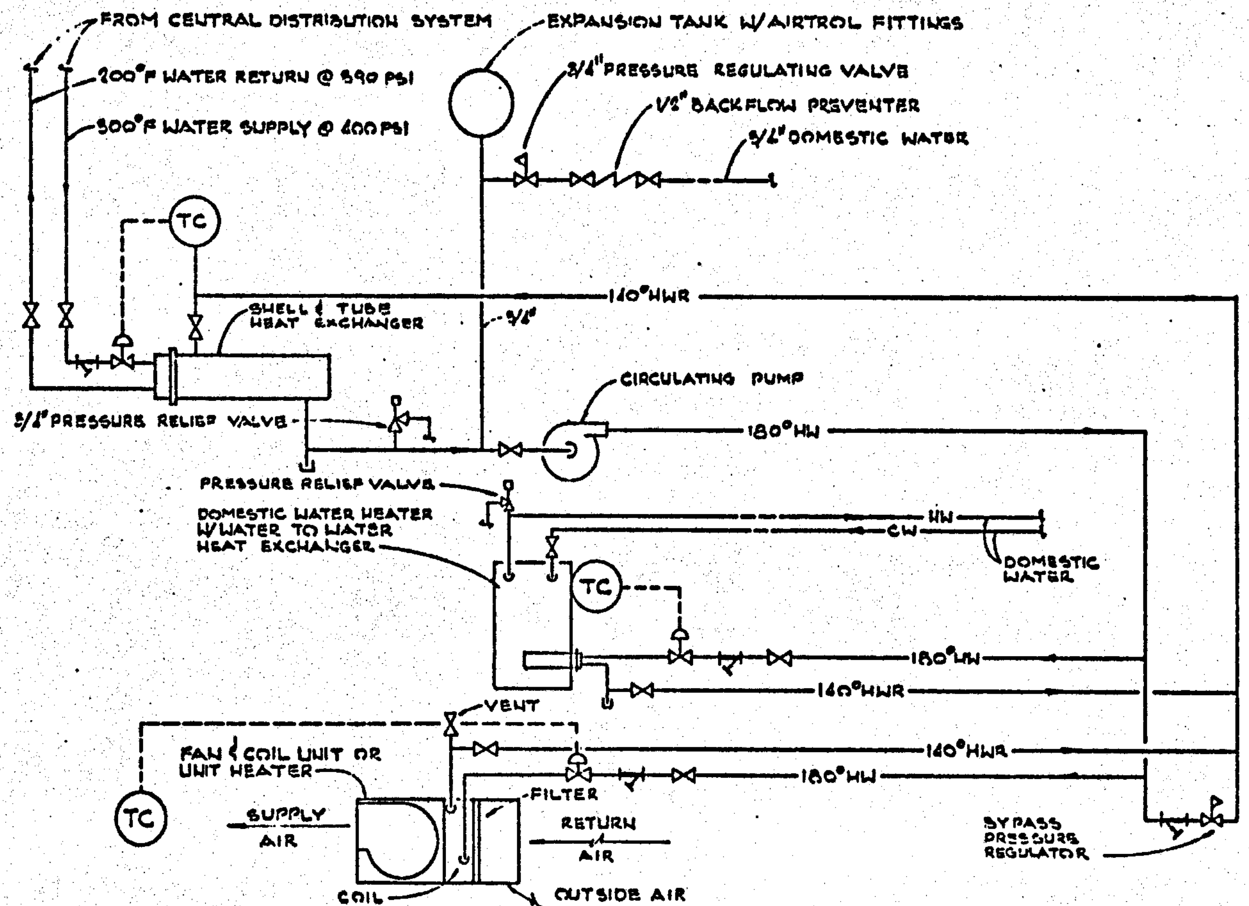
FIGURE 8



TYPICAL DOMESTIC WATER & SPACE HEATING FLOW DIAGRAM FOR MULTIPLE UNIT CENTRAL SYSTEM - HIGH TEMPERATURE

AYRES ASSOCIATES 1180 S. BEVERLY DR., LOS ANGELES, CA. 90035	CUSTOMER ERDA/MAMMOTH LAKES VILLAGE, CA/THE BEN HOLT COMPANY	DRAWN: GG DATE: 7-6-77	SHEET F-1

FIGURE 9



TYPICAL DOMESTIC WATER & SPACE HEATING FLOW DIAGRAM
FOR SINGLE RESIDENCE OR BUILDING - HIGH TEMPERATURE

AYRES ASSOCIATES 1180 S. BEVERLY DR., LOS ANGELES, CA 90035	CUSTOMER ERDA/MAMMOTH LAKES VILLAGE, CA./THE BEN HOLT COMPANY	DRAWN: GG DATE: 7-6-77	SHEET F-2

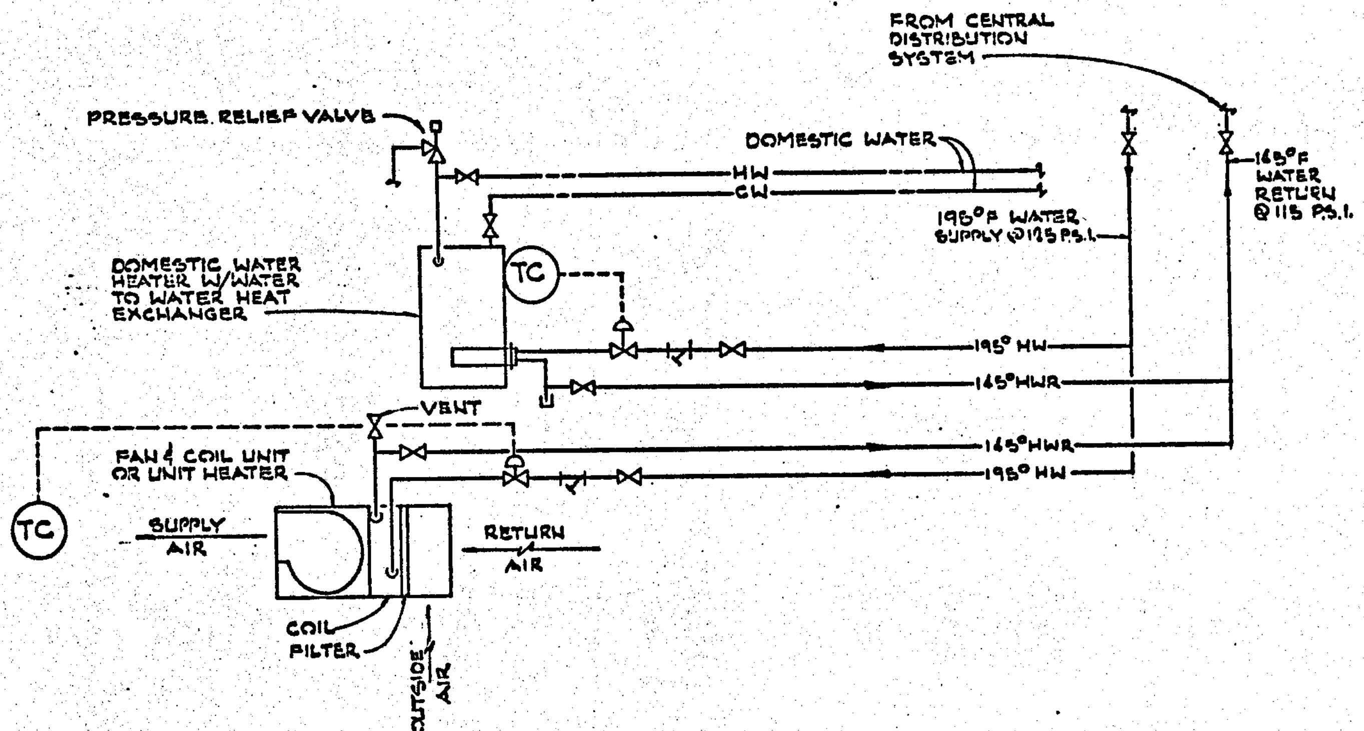


FIGURE 10

TYPICAL DOMESTIC WATER & SPACE HEATING FLOW DIAGRAM
FOR SINGLE RESIDENCE OR BUILDING - LOW TEMPERATURE

AYRES ASSOCIATES 1150 S. BEVERLY DR., LOS ANGELES, CA. 90035	CUSTOMER ERDA/MAMMOTH LAKES VILLAGE, CA/THE BEN HOLT COMPANY	DRAWN: GG DATE: 7-6-77	SHEET F-3

The district heating system water is used directly in the hydronic domestic water heater and fan coil or unit heater. Controls are provided for the air temperature and domestic hot water temperature. The building heating system supply temperature is kept constant by the district heating system controls.

Using the design concepts discussed above, and heating system layout sketches prepared during field inspections of each building, cost estimates were prepared for installing heating systems in existing and planned buildings. These costs are summarized in Table 15. The costs presented were used to compare the economics of high temperature versus low temperature district heating systems. The results of that comparison are presented in the SYSTEM DESIGN AND COST ESTIMATE Section of this report.

The capital cost estimates presented in Table 15 were also used to determine the economics of district heating versus conventional propane and/or electric heating systems. That evaluation is contained in the ECONOMIC ANALYSIS Section of this report.

Rough designs and cost estimates were also prepared for district heating of swimming and jacuzzi pools. A flow diagram of a typical installation is shown on Figure 11. The sketch is applicable to both high and low temperature systems. District heating system water flows to a shell-and-tube heat exchanger where it gives up some of its heat to raise the temperature of filtered return water from the pool. The heated water is then piped back to the pool.

The estimated capital costs of installing swimming and jacuzzi pool heating systems in new or existing construction are given in Table 16.

TABLE 15

CAPITAL COST ESTIMATES
HEATING SYSTEMS IN TYPICAL BUILDINGS

Facility and Description	CAPITAL COST ESTIMATE ($/ft²) HT Hydronic	LT Hydronic	Propane	Electric
A. Retrofit of Existing Construction				
1. Season's Four Condominiums				
a. Manager's Office & Game Room (2,000 ft²)	2.70	1.60	-	-
b. Typical Condominium Unit (1,000 ft²)	4.80	2.70	-	-
2. Pow Wow Shop (1,150 ft²)	4.70	2.90	-	-
3. Wildwood Inn Motel, 36 units (16,000 ft²)	3.20	3.00	-	-
4. USFS Visitor Center (14,000 ft²)	0.75	0.53	-	-
5. Mammoth County Water District				
a. Truck Repair Garage (5,600 ft²)	1.30	0.94	-	-
b. Office Building (5,000 ft²)	0.92	0.47	-	-
B. Planned Construction				
1. Season's Four Condominums				
a. Manager's Office & Game Room (2,000 ft²)	2.60	1.50	0.66	0.74
b. Typical Condominium Unit (1,000 ft²)	4.50	2.50	1.30	1.40
2. Shakey's Pizza Parlor Restaurant (2,080 ft²)	2.50	1.60	1.10	1.20

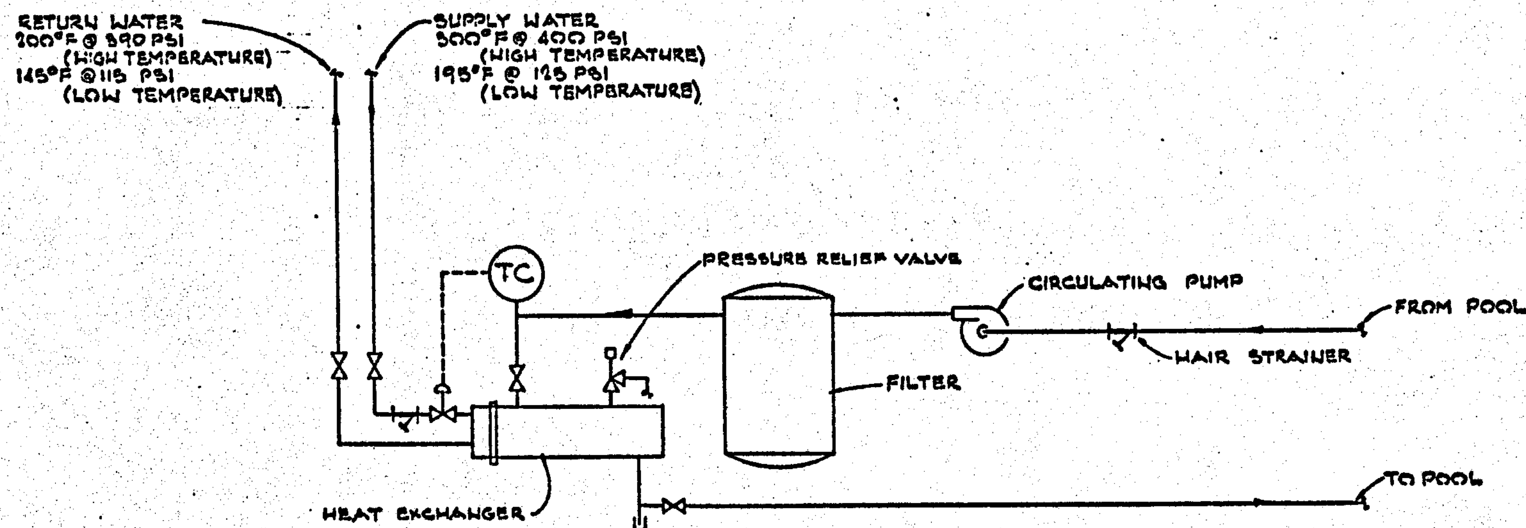


FIGURE 11

TYPICAL SWIMMING POOL OR JACUZZI POOL HEATING FLOW DIAGRAM
HIGH TEMPERATURE OR LOW TEMPERATURE SUPPLY

	CUSTOMER		SHEET
AYRES ASSOCIATES 1180 S. BEVERLY DR., LOS ANGELES, CA. 90035	ERDA/MAMMOTH LAKES VILLAGE, CA/THE BEN HOLT COMPANY	DRAWN: GG DATE: 7-6-77	F- 4

TABLE 16

CAPITAL COST ESTIMATES

POOL AND JACUZZI HEATING SYSTEMS

Facility and Description	CAPITAL COST ESTIMATE ($) HT Hydronic	LT Hydronic
A. Retrofit of Existing Construction		
1. Season's Four Condominiums		
a. Swimming Pool	3,200	2,300
b. Jacuzzi Pool	3,000	2,100
2. Wildwood Inn Motel		
a. Swimming Pool	2,200	1,200
b. Jacuzzi Pool	2,000	1,000
B. Planned Construction		
1. Season's Four Condominiums		
a. Swimming Pool	3,100	2,200
b. Jacuzzi Pool	2,900	2,000

DISTRICT HEATING SYSTEM DESIGN AND COST ESTIMATE

A preliminary design was prepared for a geothermal district heating system to serve the Village. High-temperature and low-temperature district heating systems were compared and the selected system was optimized, resulting in the preliminary design. A capital cost estimate was then prepared for the preliminary design. The results are presented in this section.

A. DESIGN

1. Trade-off Studies

Conceptual designs were prepared for two alternate district heating systems: one using low-temperature water (200°F), and one using high-temperature water (300°F). These alternate systems were sized to supply the 1988 projected peak demand of 52 MWt as shown on Figure 4 in the LOAD SURVEYS Section of this report. The 1988 demand corresponds to approximately one-half of the ultimate projected district heating demand of 105 MWt.

Base case preliminary piping and instrumentation diagrams (P&ID's) were prepared for each alternate system. Drawing No. 7622-E-3201 depicts the high-temperature system. The high-temperature system consists of a closed loop in which fresh water is heated by 340°F geothermal brine to 300°F in Brine/Fresh Water Heat Exchangers (E-1A, B and C). After leaving E-1A, B and C, the high-temperature water is pumped by Circulation Pumps (P-1A, B and C) to the lower elevations of Mammoth Lakes Village, and by Booster Pumps (P-5A, B and C) to the higher elevations within the Village. Once in the Village, the high-temperature water flows through distribution piping to individual buildings where it passes through a building heat exchanger, providing heat to the low-temperature (about 200°F) hydronic heating systems located in each building. Spent district heating system water flows from the building heat exchangers through a collection system and returns by gravity to E-1A, B and C for reheating and reuse. The high-temperature water is kept from flashing and allowed to expand and contract through the use of Pressurization Tanks (T-2A, B, C and D) and a nitrogen pressurization system. Water in the system may be drained into the Water Storage Tank (T-1) during maintenance activities, or make-up water may be pumped from T-1 to the heat exchangers E-1A, B and C by Make-up Pumps (P-2A and B).

The low-temperature system is shown schematically on Drawing No. 7622-E-3202. The system is similar to the high-temperature system, with the following exceptions. The low-temperature is not a closed loop, but is open to the atmosphere at the Hot Water Storage Tanks (T-1, 2 and 3). Therefore, the maximum hot water supply temperature corresponds to boiling at atmospheric pressure in the Village which is about 197°F. Because of its low supply temperature, the water can be used directly in building hydronic heating units without the need for an intermediate building heat exchanger.

The design features of each alternate system are summarized in Table 17.

TABLE 17

DESIGN PARAMETERS

		LT System	HT System
1.	Main Supply Pipeline Diameter	16"	12"
2.	Hot Water Peak Flow Rate	5,900 gpm	3,800 gpm
3.	Geothermal/Fresh Water Heat Exchanger Surface Area	18,000 ft^2	54,000 ft^2
4.	Geothermal Brine Peak Flow Rate	2,900 gpm	3,900 gpm
5.	Number of Building Heat Exchangers Required	NONE	500
6.	Differential Temperature Supply-Return	50°F	100°F

On the basis of the above P&ID's, and rough system pipeline routing and major equipment arrangements, differential capital cost estimates were prepared for the high and low-temperature systems. The results are shown in Table 18.

TABLE 18

CAPITAL COST COMPARISON
(Thousand Dollars)

		LT System	HT System
1.	Piping Mains	$1,800	Base
2.	Wells	Base	200
3.	Well Pumps	Base	300
4.	Heat Exchangers	Base	700
5.	Tanks	Base	1,200
6.	Circulating Pumps	200	Base
7.	Building Heating Systems	Base	3,600
	TOTAL	Base	4,000

The increased peak hot water flow rate associated with the low-temperature system resulted in a $1.8 million capital cost penalty for larger piping and a $200,000 penalty for larger hot water circulating pumps. However, these cost penalties were more than offset by the costs for additional well pumps to provide higher geothermal brine flow rates, larger geothermal/fresh water heat exchangers, pressurized expansion tanks, and individual heat exchangers in each customer's building necessary in the high-temperature system.

An annual cost comparison was also prepared, the results of which are shown in Table 19.

TABLE 19

ANNUAL COST COMPARISON
(Thousand Dollars/Year)

		LT System	HT System
1.	Carrying Charges on Capital	Base	800
2.	Operating Costs		
	Labor and Material	Base	40
	Electric Power	120	Base
	TOTAL	Base	720

The annual carrying charges on capital cost were calculated at 20 percent which is a typical value for an investor owned utility. The differential power costs for pumping were based on an electric rate of 2 cents per kwh. Table 19 clearly shows that a low-temperature geothermal district heating system offers superior economics for the case of Mammoth Lakes Village.

In addition to its economic superiority, the low-temperature system has additional advantages. First, because the low-temperature system does not require the use of costly heat exchangers in each customer's building, the capital cost of the hydronic heating system within each building is reduced. This reduced capital cost to the customer is expected to increase the attractiveness of geothermal district heating. In addition, the low-temperature system has the potential for future addition of a topping cycle electric power plant. The high-temperature geothermal water could first be used for electric power production; then the lower temperature geothermal water rejected from the power cycle could be used to heat fresh water in the district heating system. As discussed below in the ECONOMIC ANALYSIS Section of this report, this co-generation concept appears to offer substantial economic advantages over district heating alone.

Once the low-temperature system's superiority was demonstrated, design parameters of the low-temperature system were traded off against one another in order to approach a more optimum system configuration.

Trade-off studies were performed which compared the economics of various hot water storage tank locations, the cost of hot water storage versus piping and pumping costs with no storage, and main pipeline pressure drop versus pumping costs. These studies resulted in selection of more nearly optimum storage tank locations and sizes as well as pipeline and circulating pump sizes. These optimized design parameters were used to determine the system configuration which served as a basis for the preliminary system design and cost estimate.

2. Preliminary Design

a. Piping and Instrumentation Diagram - As a first step in the preliminary design, a P&ID was prepared for the optimized low-temperature district heating system. The P&ID is shown on Drawing No. 7622-E-3203. Equipment and piping drawn with solid lines would be installed to serve the Village initially (in 1980), and the equipment which would be added as the system grows to its projected 52 MWt capacity by 1988 is shown with dashed lines.

The fully developed district heating system is designed to pump 2,550 gpm of brine at 340°F from geothermal wells to Brine/Fresh Water Heat Exchangers (E-1A, B and C), where the brine gives up its heat to the fresh water district heating loop. The wells are designed to provide a stand-by flow of 850 gpm, should one well pump be unavailable during peak demand periods. After passing out of E-1A, B and C, the brine is reinjected into the geothermal reservoir at a temperature of about 190°F.

Fresh water returns from the district heating system at about 140°F and passes through E-1A, B and C, where it is heated to 200°F. After leaving the exchanger, the supply water is pumped by the Hot Water Circulation Pumps (P-3A to -3G) to Hot Water Storage Tank (T-1). Pump P-3A is used during periods of low demand, P-3B, C and D during intermediate flow periods, and P-3E, F and G at peak demand periods. The peak hot water flow rate to T-1 is 5,960 gpm.

Supply water is stored in T-1 at atmospheric pressure and a corresponding saturation temperature of about 197°F. T-1 and other Hot Water Storage Tanks are designed to provide sufficient storage such that during a system peak demand period, hot water supply flow rates to the tanks are 80 percent of the flow out of the tanks to the heating loads. Incorporating this storage feature allowed a reduction in size of the entire supply system by 20 percent. From T-1 the supply water is divided into two streams. One flows by gravity to space and water heating loads in Area 1 of the Village, and the other is pumped via Hot Water Booster Pumps (P-5A to -5F) to Hot Water Storage Tanks T-2 and T-3. Pump P-5A is used during low demand periods, P-5B, C and D during periods of intermediate demand, and P-5E and F at peak demand. The peak hot water flow rate to T-2 and 3 is 3,540 gpm. Supply water is stored in T-2 and 3 from which it flows to heating loads in Areas 2 and 3, respectively.

Supply water passes through hydronic heating systems located in various buildings. After leaving the building systems at about 145°F, the water is collected in area return headers, and flows to a main return line which carries the water to exchangers E-1A, B and C for reheating and reuse.

During periods of peak flow, the flow from T-1, 2 and 3 exceeds the maximum supply flow rate to the tanks. During this period, return water splits into two streams at the Casa Diablo Area. One stream returning to E-1A, B and C, and the other to Main Water Storage Tank (T-4). When the peak demand period is over, water is pumped from T-4 via Storage Transfer Pumps P-4A, B and C to be heated and returned to T-1, 2 and 3. In this manner T-1, 2 and 3 are recharged with hot water in order to meet the next peak demand period.

The instrumentation and control system balances the three main areas by pressure control which automatically compensates for the differences in elevations and for dynamic pressure variations among areas.

Each area has an automatic control valve (PV-1, 2 and 3) in the return piping and located close to its junction with the other area returns. The valve "supports" the elevated column of spent water returning by gravity from the consumers of that area to the main plant. Each valve is operated by an area controller set to maintain constant pressure at a reference point high in the return collection header. The individual area control systems detect and accommodate for changes in consumer water demands in accordance with the effects these changes have on the return-side pressures. For example, an increase in demand tends to increase pressure at the reference point. The control valve then opens wider to restore the set reference pressure.

An additional reference point in the main return line downstream is held at constant pressure by a split-range control system operating valves PV-4A and -4B, located at the discharge of the circulation pumps P-3A to -3G and in the return line to the main storage tank (T-4), respectively. This system acts to adjust the water supply rate to meet variations in consumer demands since an exact match of supply-to-demand must be maintained in order to prevent cavitation in the main return line or suppressed flow to and drawdown of the hot water storage tanks.

A stable pressure at the reference point infers that the flows are matched. An increase or decrease in pressure indicates the demand is changing and the control system, by positioning valve PV-4A, readjusts the piping friction losses (hence, the delta P across the pumps) until the reference pressure is stabilized.

The split-range system is designed so that, during all but peak demand periods, the total return water is reheated and pumped directly back to upper storage tank

T-1. At the same time, amounts approximating the usage in areas 2 and 3 are continuously transferred from T-1 to tanks T-2 and T-3 by booster pumps P-5A to -5F.

During peak demand seasons there are short-term flow rates exceeding the capabilities of the circulation pumps. The split-range system then diverts the surplus return flow to the main storage tank T-4 to be held until nonpeak hours when it can be reheated and transferred back to the upper tanks.

It is generally unnecessary and undesirable to divert any return water to the main storage tank except as required during peaks. The split-range system is designed to open the diversion valve (PV-4B) only when the circulation valve (PV-4A) is wide open and a further increase in flow is called for. To prevent this from happening during normal seasonal operation, the position of the circulation valve is constantly monitored. As the valve closely approaches full opening, an alarm informs the operator that an increase in pumping capacity is in order.

All pumps are manually started and stopped from stations at the main control panel. The distribution of supply water to tanks T-2 and T-3 may be adjusted by means of a manual valve loading station also located at the main panel. This station operates control valve HV-1 at the inlet of the lower tank.

The choice of which circulation pumps to operate is made in accordance with a predetermined schedule calculated to obtain the best match between pump efficiencies and prevailing consumer demands.

Temperatures of the hot water entering the upper storage tanks, within the tanks, leaving the tanks and returning from each area are continuously recorded at the main panel. Seasonal differences in heat losses during the transfer of hot water to the upper tanks may be compensated by raising or lowering the setpoint of the hot water controller TIC-5.

All storage tank liquid levels are indicated on the control panel and the total water inventory may be determined by simple calculations. Make-up water can be added to the main storage tank and transferred at the operator's convenience.

Measurement and control signals are transmitted between the plant and remote locations by a telemetering system.

Automatic control valves are operated by electric motors which remain in fixed positions if power is interrupted.

b. Equipment - Based upon the P&ID discussed above, designs and specifications were prepared for major equipment.

The Brine/Fresh Water Heat Exchangers (E-1A, B and C) were sized such that any two of the three will provide sufficient heat exchanger surface to serve 80 percent of the 1988 projected heating peak of 52 MWt. The above capacity reduction was allowable because, as outlined earlier, the three Hot Water Storage Tanks have sufficient capacity to provide for up to 20 percent of the peak demand water flow rate. A spare exchanger was included to provide operating flexibility during peak demand periods. During final system design, consideration should be given to a design without a spare exchanger since peak demand periods are relatively short and exchanger maintenance could probably be deferred to off-peak periods. The performance and mechanical features of E-1A, B and C are provided on Heat Exchanger Specification in the DRAWING AND SPECIFICATIONS Section of this report.

The geothermal Brine Production Pumps are of the multi-stage, deep-well type. Each pump driver motor is located on a wellhead and the pump bowls are connected to the motor by a long drive shaft. A lubrication system injects water into a drive shaft enclosing tube to provide bearing lubrication. P-1A and B were designed for a 500 foot deep bowl setting in two existing 9-5/8 inch diameter well casings. Each pump will provide up to 425 gpm of 340°F geothermal brine at 350 psig, discharge pressure. P-2A, B and C were designed for settings of 700 feet in new production wells which will have 13-5/8 inch diameter casing. Each pump will provide 850 gpm of 340°F geothermal brine at 350 psig discharge pressure. The pump bowls are of cast iron and drive shafts of mild steel. Sufficient wells and pumps are provided so that the system peak demand can be met even in the event that a failure of P-2A, B or C occurs.

Hot Water Circulation Pumps P-3A to -3G were selected based on two basic criteria. First, pump capacity and differential pressure were specified so that smaller, less costly pumps could be installed initially, and larger pumps could be installed as the yearly system peak demand increases. Secondly, the pumps were sized to allow the use of different pumping units depending upon the instantaneous demand of the system (i.e., during low demand periods such as daytime in the summer, P-3A may be sufficient to provide heating energy, rather than using a larger pump and relying on a throttling valve to reduce flow and pressure). Specifications for Pumps P-3A to -3G may be found in the DRAWINGS AND SPECIFICATIONS Section.

Storage Transfer Pumps P-4A, B and C are required to refill tanks T-1, 2 and 3 during off-peak hours of peak demand days. As the system peak load is served, the levels in T-1, 2 and 3 decrease to make up the difference between customer heating demand and maximum system supply flow rate. The water removed from T-1, 2 and 3 during peak demand is diverted to T-4. During the late evening and early morning hours when heating demand is reduced, Pumps P-4A, B and C transfer water from T-4 to E-1A, B and C for heating and return to T-1, 2 and 3. In this manner, T-1, 2 and 3 are filled in order to meet the next day's heating peak demand.

Hot Water Booster Pumps P-5A to -5F were selected based upon the same criteria discussed above for P-3A to -3G. Specifications for these pumps are presented in the DRAWINGS AND SPECIFICATIONS Section.

As discussed previously, Hot Water Storage Tanks T-1, 2 and 3 were sized to provide for all district heating hot water demands greater than 80 percent of the 52 MWt peak. In addition to providing for peaks, the storage tanks can supply hot water to customers in the event of an outage of pumps P-3 or P-5. The tanks will provide service for 2.4 hours during a system peak, and up to 48 hours during periods of low system demand. Tanks T-1, 2 and 3 also provide nearly constant supply pressure to district heating system customers over a wide range of system flow rates. This reliance on static head for supply pressure rather than dynamic head from pumps aids in system control. The tanks vary in size from 40 feet in diameter by 36 feet high to 45 feet in diameter by 37 feet high. All are welded steel construction with 3" urethane insulation on the sides and roofs.

The Main Water Storage Tank, T-4, was sized to receive the total contents of T-1, 2 and 3. T-4 is all welded steel construction with 3 inches of urethane insulation on the sides and roof. It is 67 feet in diameter by 40 feet high.

c. <u>Preliminary Design Drawings and Description</u> - Drawing No. 7622-E-3204, Piping Routing Plot Plan is a layout of the main components of the proposed district heating system including; the proposed location of geothermal production and injection wells, the heating plant located at Casa Diablo Hot Springs, main supply and return piping, Hot Water Storage Tanks 1, 2 and 3, Village Areas served by each tank, the Booster Pump Station near tank 1, distribution headers from the tanks to heating loads, and return headers from the heating loads to the main return piping. The Plot Plan also indicates the character of different portions of the Village (i.e., location of houses, motels, condominiums, etc.).

The main supply line to T-1, 2 and 3, and the main return line from the Village to the Heating Plant were located underground, north of and adjacent to the main road to Mammoth (State Route 203). Distribution and return headers within the Village were buried adjacent to roadways where possible, and under road surfaces if necessary. All other district heating system water lines were located under road surfaces.

Drawing No. 7622-E-3205 is a plan of the Heating Plant. The plant site is within an area of approximately one acre and is fenced on all four sides. There is a 20-foot wide service roadway on three sides and 30-foot wide roadway which connects the site to County Road 346A (old U. S. Highway 395). A 30-foot by 80-foot single story building containing offices, electrical equipment, a control room and shop is shown near the northwest corner of the site. The mechanical equipment is located on the southeastern corner of the site, with the Main Water Storage Tank shown in the southwest portion of the plot. Fresh district heating water supply and return lines enter the site from the southeast. Geothermal brine supply lines enter from the northeast and southwest, and brine return lines leave from the northwest of the site.

Piping within the plant site is above ground and rests on pipe supports or sleeper supports. Piping which leaves the plant site does so underground as shown.

Drawing No. 7622-E-3206 shows a plan of the Booster Pump Station located near Hot Water Storage Tank T-1, and section drawings for both the Booster Pump Station and the main Heating Plant. The Hot Water Booster Pumps P-5A to -5F take suction from T-1 and deliver district heating water to tanks T-2 and T-3.

Drawing No. 7622-E-3207 contains details of the district heating system piping. All heating system piping will be underground with the exception of piping within the main Heating Plant, Booster Pump Station and directly adjacent to Storage Tanks T-1, 2 and 3. The piping selected in this preliminary design consists of a carbon steel service pipe, covered with urethane foam insulation and a reinforced polyester resin coating. This piping system is typically factory prefabricated in 20 and 40-foot lengths. Preinsulated fittings such as elbows and tees are also available from factories.

In the final design, consideration should be given to the use of asbestos-cement piping in those portions of the system where operating pressures do not exceed ratings for this type of pipe (about 150 psig at 200°F). Use of asbestos-cement piping in some parts of the system can be expected to reduce system costs.

The proposed 50 MWt district heating system will contain approximately 280,000 feet of fresh water piping. Table 20 lists the approximate quantities of piping by Village Area (see Drawing No. 7622-E-3204) and by pipe size. Table 20 does not include piping lengths for expansion loops, which were estimated separately.

Drawing Nos. 7622-D-3601, 3602 and 3603 are electrical single line drawings for the Heating Plant, Area 1 and Booster Pump Station, and Wells, respectively. Electric motor specifications for all system pumps may be found in the DRAWINGS AND SPECIFICATIONS Section of this report.

TABLE 20

DISTRICT HEATING SYSTEM
FRESH WATER PIPING SUMMARY

Nominal Line Diameter (inches)	Area 1 Piping (feet)	Area 2 Piping (feet)	Area 3 Piping (feet)	Main Supply & Return Piping (feet)	TOTAL
3/4	17,400	5,000	6,400	-	28,800
2	34,600	5,000	7,400	-	47,000
3	17,200	24,800	18,800	-	60,800
4	3,000	2,200	5,500	-	10,700
5	11,800	400	11,100	-	23,300
6	12,000	2,000	8,300	-	22,300
8	2,300	5,000	4,900	-	12,200
10	6,200	4,100	5,800	6,500	22,600
12	7,800	-	-	6,000	13,800
14	3,600	-	-	-	3,600
16	-	-	-	20,600	20,600
18	-	-	-	14,400	14,400
TOTALS	115,900	48,500	68,200	47,500	280,100

B. CAPITAL COST ESTIMATE

An installed cost estimate was prepared for the 52 MWt district heating system described in Part A of this report section. The estimate is shown by system component in Table 21.

TABLE 21

CAPITAL COST ESTIMATE
52 MWt DISTRICT HEATING SYSTEM

1.	Geothermal Wells & Pumps	$ 2,150,000
2.	Brine Piping	144,000
3.	Heating Plant	1,850,000
4.	Main Supply & Return Piping	3,752,000
5.	Hot Water Storage Tanks & Booster Pump Station	1,274,000
6.	Distribution & Return Lines in Areas	
	a. Area 1	2,448,000
	b. Area 2	1,006,000
	c. Area 3	1,533,000
7.	Subtotal	14,177,000
8.	Contingency	423,000
9.	Total	$14,600,000

The estimate was developed using current day (1977) prices. In arriving at the estimate, it was assumed that a single contractor would be responsible for design and construction of the system. Cost quotations were obtained from vendors for preinsulated system piping, heat exchangers, well pumps, and fresh water pumps. Potential subcontractors provided cost estimates for storage tank erection, well drilling and completion, and insulation of tanks and equipment. Material take-offs provided the basis for cost estimates of site preparation, piping, instrumentation and electrical construction. Labor rates were obtained from local union representatives, and the remote project location was taken into consideration in estimating field construction costs. More detailed explanation of how cost estimates were arrived at for each category of costs above follows.

Cost estimates for drilling new production and injection wells, and for preparing existing production wells for operation were obtained from Magma Energy, Inc. A new 4,000-foot deep production well was estimated to cost $330,000, a 4,000-foot deep injection well was estimated at $250,000, and the cost of preparing an existing well for production was estimated to be $10,000. A detailed breakdown of the production well cost estimate is included in Table 22. The system design includes three new and two existing production wells, and two new injection wells.

Geothermal well pump equipment quotations were obtained from pump vendors. The costs of material, labor and indirect charges were added to the equipment costs to arrive at an installed cost estimate for the pumps. Small, modular buildings were included over each production well and pump for protection of personnel and equipment during severe weather. Costs of electrical work assumed that SCE would provide one service near each of the existing wells and one for the new production wells.

The cost of brine piping to and from the wells and heating plant were based on material quotations from vendors of factory pre-insulated piping. Installation costs were based on the same assumptions as those discussed for the main supply and return piping below.

Costs for equipment within the heating plant were based on quotations from vendors heat exchanger and pump vendors. Installed equipment costs were estimated by adding material, labor and indirect costs to the vendor quotations. Costs for site preparation, concrete, piping, instrumentation, electrical and the control building were based on material takeoffs. An installed cost estimate for the storage tank was obtained from a tank erector. Costs to insulate the piping and process equipment were obtained from an insulation contractor.

Material quotations for the main fresh water supply and return piping and fittings were provided by a vendor on a material takeoff. The estimated cost of pipeline installation was derived based upon necessary trench widths and depths for various line sizes, the surface area of pavement to be broken and repaved, the number of pipe welds and insulation field closures to be completed, the type of construction equipment necessary to carry out trenching, backfilling and pipe placement, the quantities of native soil and sand to be excavated, screened, hauled and/or backfilled, an estimate of construction crew size and composition, and an estimate of contractor's overhead and profit.

TABLE 22

WELL COST ESTIMATE

AREA - Casa Diablo, California
WELL TYPE - Geothermal Hot Water
DEPTH - 4,000 feet
RIG TYPE - Rotary

1.	Roads and Drill Site		$ 4,000
2.	Drilling:		
	A.	Move in and out cost	32,000
	B.	Drilling 30 days @ $3,744 per day	112,320
	C.	Bits and Reamers	15,000
	D.	Drilling Mud (Gel-Lignite)	9,000
	E.	Miscellaneous Rentals	5,000
3.	Casing and Accessories:		
	A.	100' of 20" Conductor @ $18.00/ft	1,800
	B.	1,200' of 13-3/8" 54.5 #K-55 @ $17.50/ft	21,000
	C.	3,000' of 9-5/8" 36 #K-55 @ $13.25/ft	39,750
	D.	Casing Accessories	4,000
	E.	Wellhead Equipment	4,000
4.	Outside Services:		
	A.	Cementing	18,000
	B.	Trucking	9,000
	C.	Sub Surface Logging	15,000
	D.	Liner Slotting	3,000
5.	Supervision: 30 days @ $250/day		7,500
		Subtotal	$300,370
		Contingency	29,630
		TOTAL COST	$330,000

Capital cost estimates for the three Hot Water Storage Tanks and one Booster Pump Station were based on installed cost estimates from tank vendors and equipment quotations from pump vendors. Labor and indirect costs were added to the above costs to arrive at an installed cost estimate. Cost estimates for site preparation, concrete, piping, instrumentation and electrical were based on material take-offs.

Capital cost estimates for the distribution and return piping within Village Areas 1, 2 and 3 were prepared in the same manner as discussed above for the main fresh water supply and return lines.

A contingency of approximately 15 percent of the total field labor costs was added to the estimate any labor component of cost which may have been overlooked in this preliminary estimate. No contingency was added to equipment and material costs since these costs were obtained from suppliers.

ECONOMIC ANALYSIS

In order to determine the viability of the geothermal district heating concept for Mammoth Lakes Village, economic comparisons of district heating with alternate means of providing space and water heating were prepared. The results of these comparisons are reported below.

Capital cost estimates developed in the BUILDING HEATING DESIGNS AND COST ESTIMATES and DISTRICT HEATING SYSTEM DESIGN AND COST ESTIMATE Sections of this report were used in the analysis, along with system operating and maintenance costs estimated in this section. The costs of heating energy using electrical energy and LPG were derived based on established rate structures in Mammoth.

A. CAPITAL COST COMPARISON

Capital costs of alternatives which could provide for increased heating demands in Mammoth Lakes were determined. As electrical energy currently provides about 84 percent of the space and water heating energy in Mammoth, a percentage which is expected to remain constant or increase in the future, the capital costs of geothermal district heating were compared with the costs of generating electric power. Installed costs for generic electric power plants were obtained from Southern California Edison Company (SCE). These costs are tabulated below for plants with 1977 initial operating dates.

TABLE 23

COST ESTIMATES - GENERIC POWER PLANTS

POWER PLANT TYPE	CAPITAL COST $/kw
Combined Cycle	295
Coal	525
Nuclear	495
Fuel Cell	540

The capital costs above are work order level without owner's costs during construction for the power plant only and do not include fuel supply or electric power transmission facilities.

As reported in the DISTRICT HEATING SYSTEM DESIGN AND COST ESTIMATE Section of this report, the capital cost estimate for a 52 MWt district heating system, not including building heater units or fuel supply facilities (i.e., wells and well pumps), was estimated to be $12.4 million in 1977 price level, or $238/kw.

The estimated capital cost of the district heating system compares favorably with cost estimates for electric power plants which might be utilized to provide heating energy as an alternate to district heating. The district heating system can be installed at approximately 80 percent of the cost of a combined cycle power plant and 45 percent to 50 percent of the cost of a coal or nuclear power plant.

B. OPERATING COST COMPARISONS

The economic viability of geothermal district heating will be significantly influenced by the total annual costs that typical customers will be required to pay for district heating versus the costs of heating with LPG or electricity. Therefore, annual cost comparisons of heating typical buildings in Mammoth with alternative energy sources were made.

Costs to the customer for space and water heating were calculated in two parts; an energy delivery charge for the hot water, electricity or LPG to fuel the heaters, and an annual cost of installing hydronic, electric or gas heaters in typical buildings. The energy delivery charge was multiplied by annual heating energy used in each typical building to obtain annual energy costs. By adding the annual energy costs to the annual cost of the building heating system, a total annual cost attributable to space and water heating for alternative energy sources was obtained. These costs were then compared over a ten year period.

1. Energy Delivery Charges

a. District Heating System - The energy delivery charges were based upon two components of cost; a geothermal energy charge associated with providing geothermal energy to the Heating Plant, and an energy charge associated with the capital and operating costs of the district heating system. The geothermal energy charge was calculated assuming that the developer will require a 15 percent rate of return on investment after taxes.

The cost of geothermal energy in 1977 price level is 1.0 cents per thermal kwh. The escalation in cost assuming operating and maintenance costs escalate at the rate of 10 percent per year are shown in Table 24 below.

TABLE 24

ESTIMATED GEOTHERMAL ENERGY COSTS

YEAR	¢/kwh(t)
1	1.00
2	1.02
5	1.07
7	1.11
10	1.16

The energy charge associated with constructing, operating and maintaining the district heating system was calculated assuming investor ownership (i.e., SCE) or public ownership (i.e., Mono County) of the system. Data upon which the energy delivery charge was based are tabulated below.

TABLE 25

COST DATA - DISTRICT HEATING SYSTEM

1.	Capital Cost	$12,300,000
2.	Annual Carrying Charge Rate	
	a. Investor Ownership	0.20
	b. Public Ownership	0.10
3.	Operating Costs	$230,000/yr
4.	Maintenance Costs	$250,000/yr

The equivalent energy cost of the district heating system in 1977 price level was calculated to be 3.26 cents per thermal kwh for investor ownership and 1.89 cents per thermal kwh for public ownership. The above costs were escalated assuming a 10 percent per year increase in operating and maintenance costs, which resulted in the following costs for a ten year period.

TABLE 26

HEATING SYSTEM CHARGES

YEAR	¢/kwh(t) INVESTOR OWNERSHIP	¢/kwh(t) PUBLIC OWNERSHIP
1	3.26	1.89
2	3.31	2.00
5	3.47	2.17
7	3.58	2.29
10	3.76	2.49

The costs presented in Tables 25 and 26 were added to obtain a total cost of energy delivery to an average customer for both investor and public ownership of the district heating system. Private ownership of the geothermal wells was assumed for both cases.

TABLE 27

TOTAL ENERGY DELIVERY CHARGE

YEAR	¢/kwh(t) INVESTOR OWNERSHIP	¢/kwh(t) PUBLIC OWNERSHIP
1	4.26	2.89
2	4.33	3.02
5	4.54	3.24
7	4.69	3.40
10	4.92	3.65

b. Electrical Energy - Southern California Edison Company furnished electric rate schedules currently in effect in Mammoth Lakes Village for General and Domestic Service. These were used to calculate the energy charges associated with space and water heating with electric units.

The Domestic Service rate is currently 4.22 cents/kwh for the first 300 kwh/month, and 3.41 cents/kwh for energy use in excess of 300 kwh/month. The General Service rate varies from 7.05 cents/kwh for very low energy use to 2.38 cents/kwh for high use in a month. These rates were applied to the specific typical heating loads to obtain an energy cost estimate for each building.

c. LPG - Rates currently in effect in Mammoth for LPG were obtained from Turner Gas Co., Petrolane Gas Co., and Cal Gas Co., all of which serve the Village. The average domestic rate is currently 52 cents/gallon while the commercial rate varies from 48 cents/gallon to 44 cents/gallon depending upon the quantity of gas used annually.

An average gas appliance efficiency of 80 percent and a derating for altitude were applied to the above rates to obtain equivalent LPG costs per thermal kwh. The domestic cost is 3.17 cents/kwh and the commercial rate varies from 2.93 to 2.68 cents/kwh.

2. Annual Cost of Building Heating System

Installed cost estimates for hydronic heating systems which were presented in the BUILDING HEATING DESIGNS AND COST ESTIMATES Section of this report were utilized to determine the annual costs to typical customers of installing hydronic, electric and LPG heating systems. It was assumed that the capital cost of the heating systems would be financed as part of a 20-year building mortgage for new construction, and as a 20-year building improvement loan for existing building retrofit. The results appear in Table 28.

3. Total Annual Costs of Space and Water Heating

The total annual costs attributable to heating for the typical buildings selected were calculated by combining the annual energy costs and annual costs associated with installing the building heating systems.

The energy cost component of total annual costs was then escalated over a ten-year period for electric, LPG and district heating service. The effects of escalation on District heating costs is shown in Table 27. The LPG and electric energy costs were escalated at the rate of 10 percent per year as both are heavily dependent upon the cost of petroleum.

Figures 12, 13, 14 and 15 are graphical representations of total annual cost estimates for electric, LPG and hydronic heating over a ten-year period. Figure 12 is for a typical 1,000 square foot condominium which would be converted to hydronic heating in year 1. As Figure 12 indicates, after three or six years of operation (depending upon the ownership of the District Heating System), a hydronic system offers lower annual costs than electric even though the condominium owner had to bear the cost of retrofitting with a hydronic system in year one.

TABLE 28

ANNUAL COST ESTIMATES
HEATING SYSTEMS IN TYPICAL BUILDINGS

FACILITY AND DESCRIPTION	ANNUAL COST ESTIMATE ($/year) LT HYDRONIC	PROPANE	ELECTRIC
A. Retrofit of Existing Construction			
1. Season's Four Condominium Unit ($1,000\ ft^2$)	320	-	-
2. Pow Wow Shop ($1,150\ ft^2$)	390	-	-
3. Wildwood Inn Motel, 36 Units ($16,000\ ft^2$)	5,700	-	-
4. USFS Visitor Center ($14,000\ ft^2$)	760	-	-
5. Mammoth County Water District			
a. Truck Repair Garage ($5,600\ ft^2$)	620	-	-
b. Office Building ($5,000\ ft^2$)	280	-	-
B. Planned Construction			
1. Season's Four Condominum Unit ($1,000\ ft^2$)	290	150	170
2. Shakey's Pizza Parlor Restaurant ($2,080\ ft^2$)	380	260	280

FIGURE 12

ANNUAL COST OF HEATING ALTERNATIVES
TYPICAL CONDOMINIUM - RETROFIT

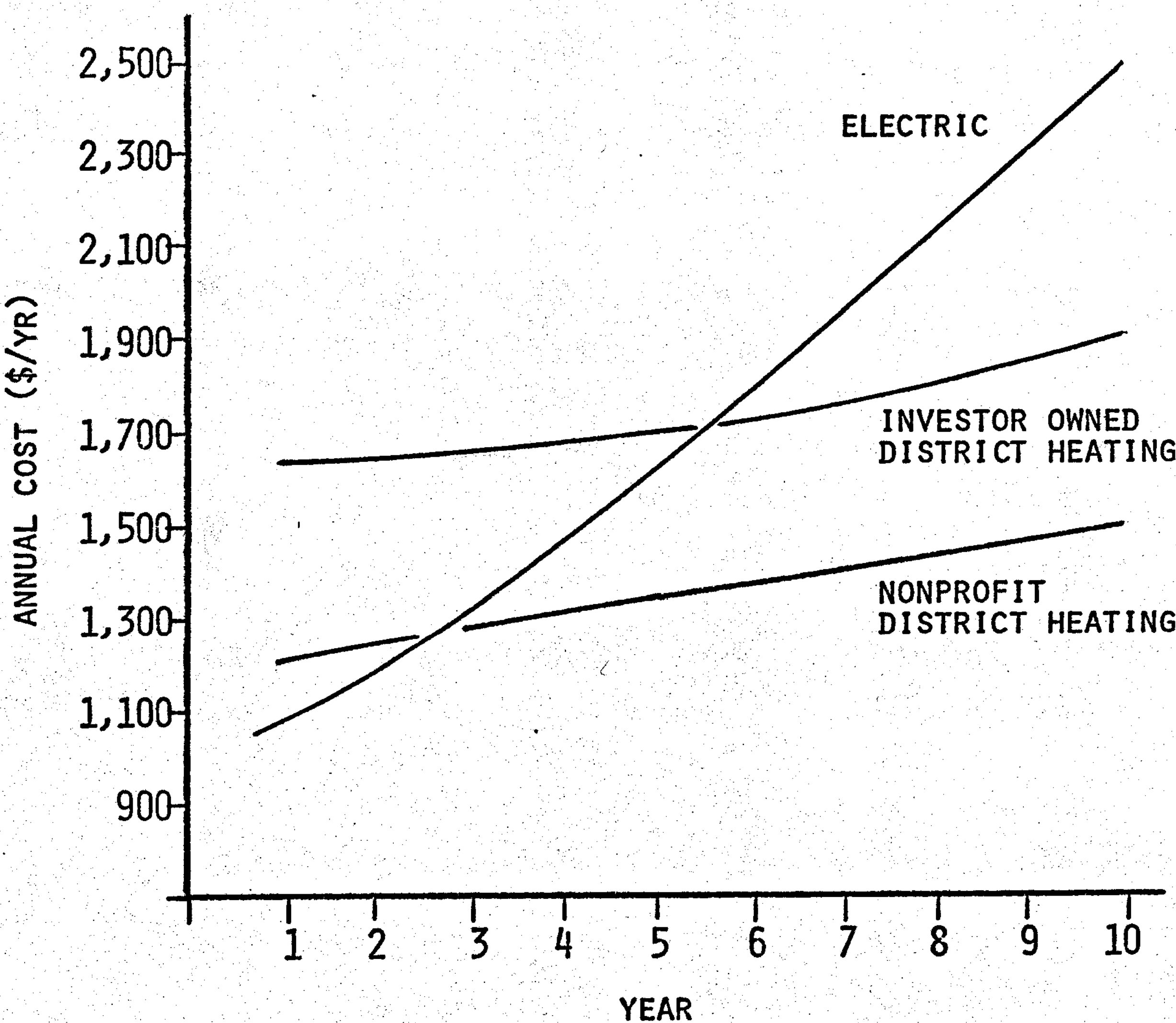


FIGURE 13

ANNUAL COST OF HEATING ALTERNATIVES
TYPICAL CONDOMINIUM - NEW CONSTRUCTION

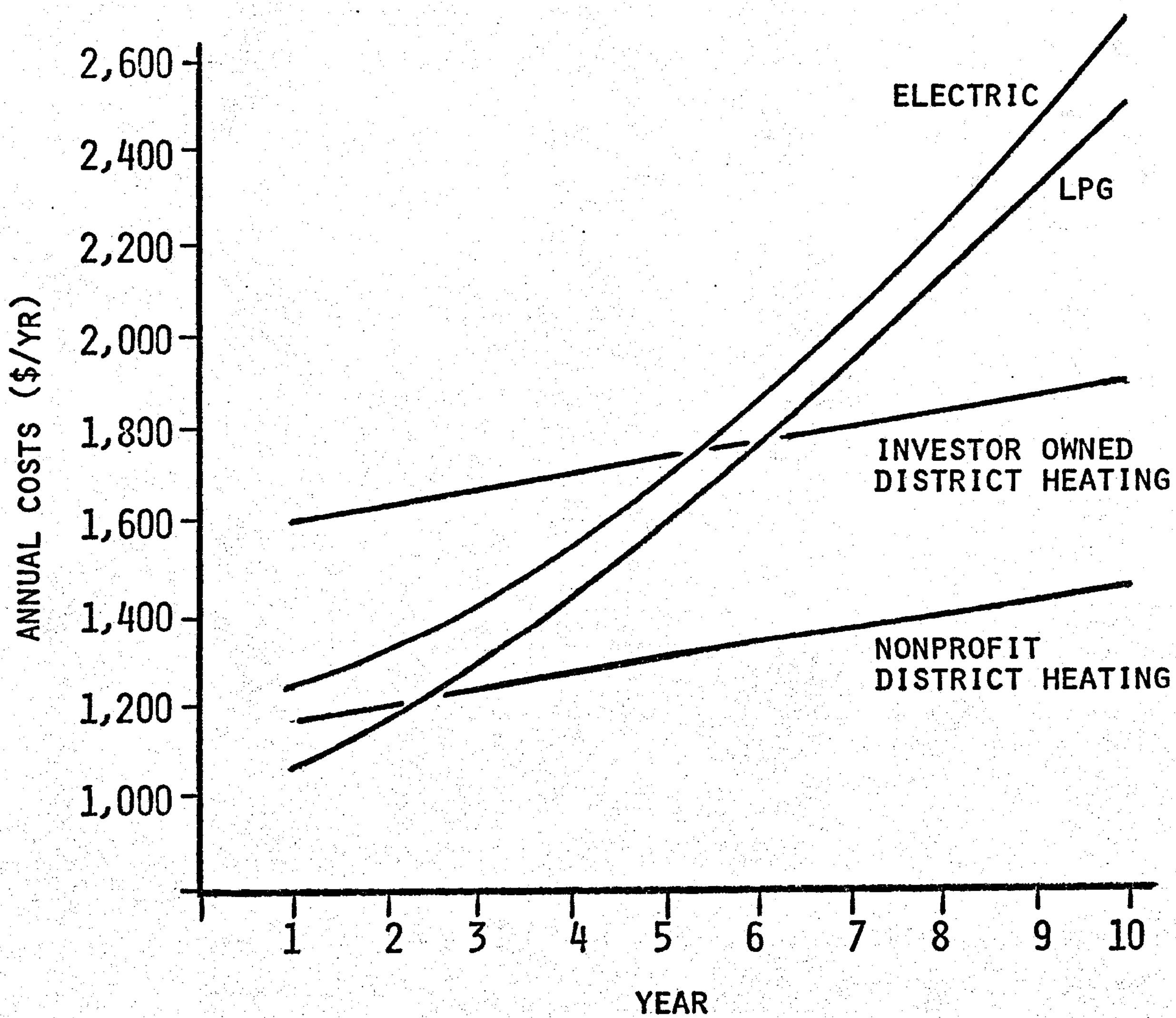


FIGURE 14

ANNUAL COST OF HEATING ALTERNATIVES NEW RESTAURANT

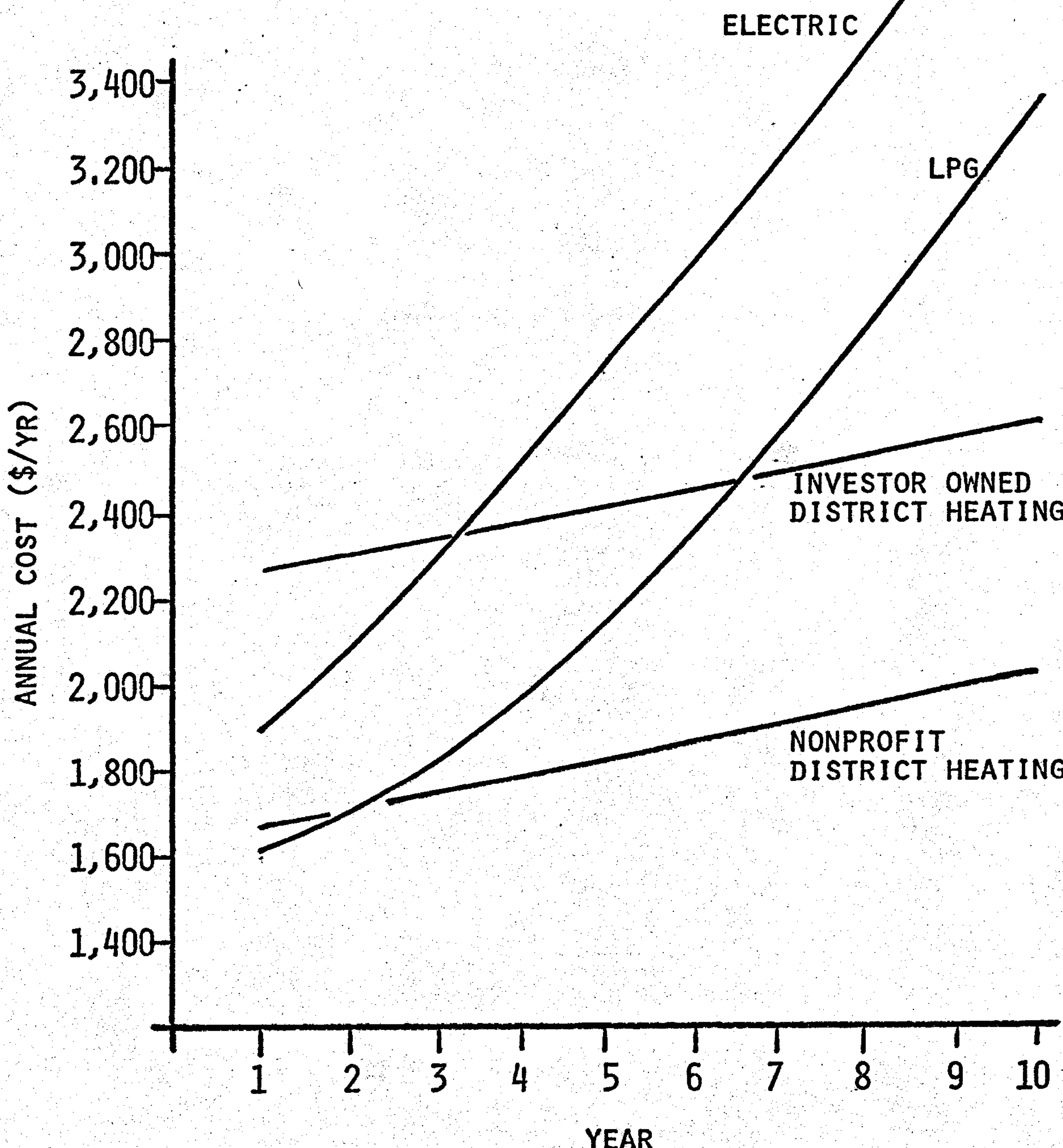


FIGURE 15

ANNUAL COST OF HEATING ALTERNATIVES
TYPICAL MOTEL - RETROFIT

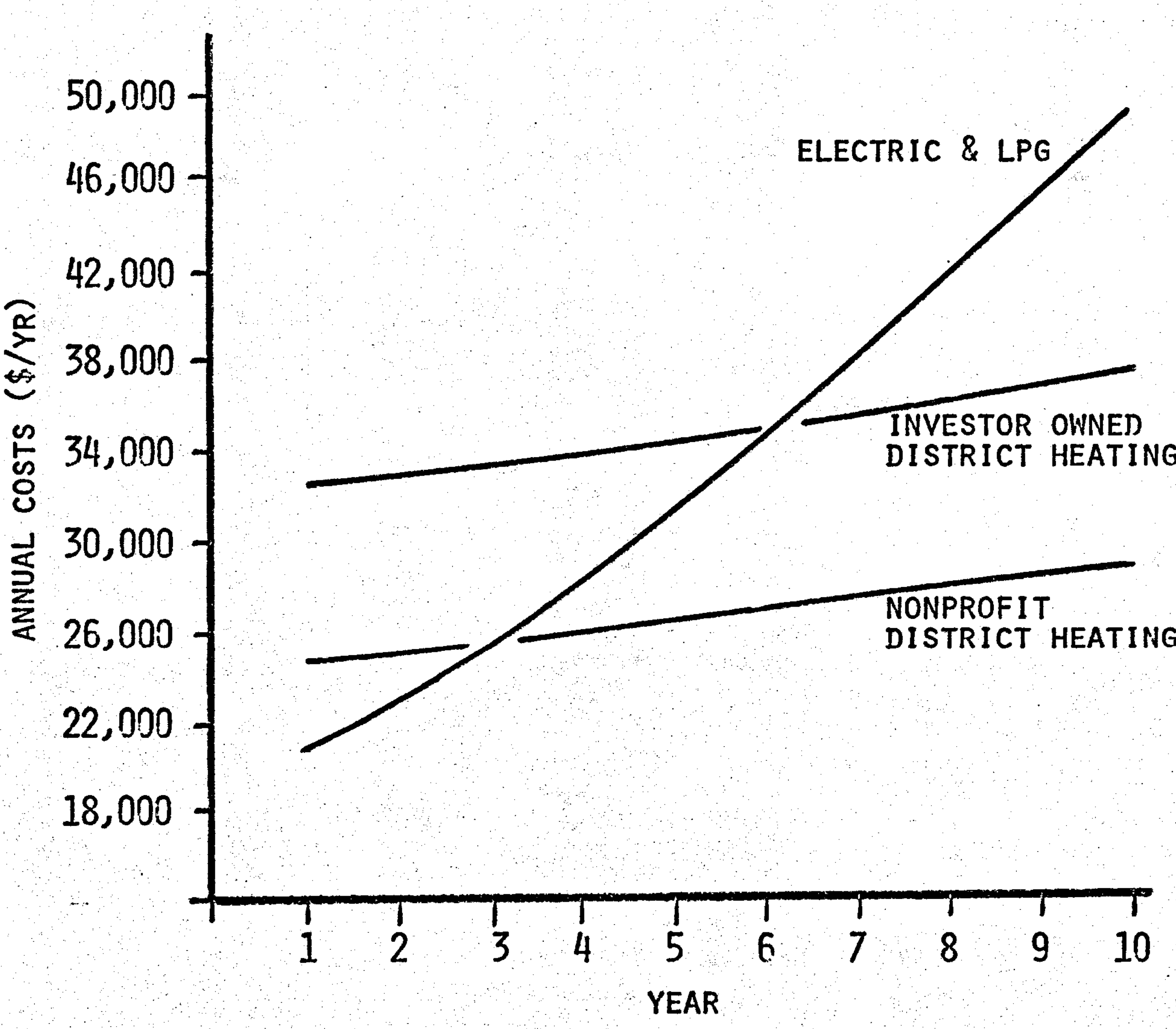


Figure 13 illustrates the costs of alternative heating systems in a typical new condominium unit. District Heating becomes less costly than LPG or electric heating after two or five years, again depending upon which assumption is made regarding District Heating System ownership.

Figure 14 shows projected annual heating costs for a newly constructed restaurant. Here, geothermal District Heating is less costly than electric heating initially for nonprofit ownership and after three years for investor ownership. However, district heating does not become less costly than LPG until after two or six years, depending upon ownership assumptions.

The costs shown in Figure 15 are for retrofitting an existing motel which uses LPG for water heating and electricity for space heating. District heating costs become lower after three to six years.

A 52 MWt district heating system in Mammoth, while not less costly when first installed, will provide lower cost space and water heating than using LPG or electricity within zero to six years. With cost improvements to be discussed below, district heating can become the lowest cost alternative much sooner in time.

C. ADDITIONAL IMPROVEMENTS IN ECONOMICS

The superior economics of district heating shown above can be improved further through a number of methods. Among these are the following; use of geothermal energy for co-generation, cost optimization of the district heating system design, participation by ERDA in the first implementation phase of the system through field experiments, and exploitation of a geothermal resource in closer proximity to Mammoth.

The co-generation concept appears particularly attractive for Mammoth. Co-generation would involve using geothermal waters to generate electric power with the high level heat, while providing district heating with the low level heat. A study of this concept is currently underway for SCE by Holt.

Preliminary heat balance calcuations indicate that a 32 MWe power plant would take the geothermal water from 340°F to 227°F, and the 52 MWt district heating system would reduce the brine temperature to about 200°F prior to injection. A conceptual capital cost estimate for a co-generation plant indicates that the 32 MWe of incremental capacity can be installed for about $675/kw. Assuming the power plant can operate at an 80 percent capacity factor, the electric energy production costs would be 2.9¢/kwh assuming investor ownership of the plant. The cost of producing electric and thermal power from a co-generation plant is estimated to be 3.3¢/kwh compared to the 4.3¢kwh calculated above for an investor owned district heating system only. If the power plant were under nonprofit ownership, the cost of producing both electric and thermal energy would be 2.5¢/kwh versus 2.9¢/kwh for a nonprofit district heating system only. These rates for electric energy production and co-generation are lower than the existing domestic rates for electric energy in Mammoth of 3.4¢ to 4.2¢/kwh. These preliminary costs indicate that co-generation at Mammoth may result in large cost savings for heating energy.

There are numerous optimizations which may be performed on the district heating system during detailed design in order to reduce overall heating costs, including the following. Decrease the system redundancy by removing spare exchangers, wells, and pumps, which will in turn decrease capital cost. Optimize the hydronic heater water temperature drop versus the total annual cost of heating for typical buildings. Investigate the use of asbestos-cement pipe in the low pressure portions of the district heating system supply and return lines in place of the welded steel piping used throughout the system in preliminary design work. Study the economics of using fossil fuels to provide the district heating systems with heat during peak demand periods.

The initial phase of the district heating system will include construction of all system facilities necessary to provide service to Village Area 1 only. This initial construction phase may qualify for support by ERDA as a field experiment. The initial phase is estimated to cost about $7.3 million. Should ERDA fund 50 percent of this amount, the capital cost of the system would be reduced by $70/kw and the energy costs would be reduced by about 0.8¢/kwh (or 19 percent) for an investor owned system, and 0.4¢/kwh (or 14 percent) for a nonprofit ownership. These reductions in cost through ERDA participation would greatly increase the economic attractiveness of geothermal district heating in Mammoth Lakes Village.

ENVIRONMENTAL ASSESSMENT

A preliminary environmental assessment has been prepared by Southern California Edison Company (SCE) for the geothermal district heating system design presented in the previous section of this report. Locations referred to in this section may be found on Drawing No. 7622-E-3204, Piping Routing Plot Plan.

In June of 1974, The Ben Holt Co. prepared a preliminary Environmental Impact Report for Magma Energy Inc. covering a geothermal power plant that Magma and Edison were considering for installation at Casa Diablo. The proposed geothermal heating system will be located on the site originally selected for the power plant. The previous preliminary report covers many of the significant environmental matters unique to the geothermal producing field and to the heat exchange facility and has been used in preparing this environmental assessment.

On April 25-26, 1977, SCE conducted a field investigation of the project site area to determine if there were any significant changes in the existing environment since the 1974 study was completed. On May 20, 1977, an additional reconnaissance of the proposed supply and return pipeline corridors was conducted. This assessment presents preliminary environmental data for the plant site, pipeline systems, and storage tank sites. The assessment addresses environmental impacts in the categories of biology, archaeology, population, transportaion and aesthetics in the following manner:

1. Defines status of the environment as it presently exists (incorporating the baseline data).

2. Identifies areas of the proposed facility which may have an impact on the environment.

3. Offers conceptual plans to minimize or eliminate identified adverse impacts.

A. BIOLOGY

The proposed geothermal project will be located on the eastern slope of the Sierra Nevada Mountains in an area characterized by variable associations of: Yellow Pine Forest, Big Sagebrush and Pinon Juniper Woodland vegetative communities. Thus, the area is an ecotone of two to several plant communities as described by Munz and Keck (10). The presence of several plant community types in the area is indicative of variable and diverse abiotic factors such as available moisture; edaphic or substraite factors such as soil type, depth, pH; wind conditions; slope exposure; etc.

The plant community variability in the project area contributes to an animal community higher in diversity than is generally typical of less diverse and complex habitats.

Within the general geographical areas of the geothermal field there are several areas that have been and are being impacted to varying degrees by man's activities. Man's impact upon an area inherently induces changes in the natural biotic communities. For example, disturbances to vegetation alters the habitat of the resident animals which in turn alters their population structure and dynamics to adjust to the new habitat condition.

A three-day biological survey was performed in July 1974 on and around the proposed project area. The proposed project site and surrounding area were found to have basic similarities in gross vegetative associations and faunal communities. For example, all sites are located within the Casa Diablo Deer Management Unit, and each has bitterbrush, and big sagebrush as an important vegetative community component.

A second set of biological surveys was performed in April and May 1977 to determine if any significant biological changes have occurred. The content of the following biological report is based upon data gathered during the above mentioned surveys.

1. Existing Vegetation

   a. Proposed Plant Site - The proposed site has been significantly disturbed. It is bordered on three sides by roads and on one side by a small two-building lumber yard. Approximately 50 percent of the site is void of vegetation and has piles of used lumber on it. The other half of the site is vegetated with moderately low growing perennial shrubs plus isolated patches of tall grass (*Poa* sp.). The following are the perennial shrubs identified on the site: Big sagebrush (*Artimesia tridentata*), bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus nauseosum*), groundsel (*Senecio* sp.), snowbush (*Ceanothus cordulatus*), and wild buckwheat (*Eriogonum compositum*, *E. ovalifluim*).

   b. Surrounding Area - The surrounding site area has been less impacted by man than the proposed site. However, significant disturbance has occurred at geothermal well locations. Vegetation in the surrounding area is similar to the proposed site area consisting of an understory of big sagebrush, bitterbrush, rabbitbrush, and snowbush. In addition, there are several species of grasses and rush (*juncus* sp.), small willow shrubs (*Salix* sp.), and a few isolated clumps of wild iris (*Iris missouriensis*) found in the surrounding area. The overstory consists of a light to moderate population of Jeffrey pine (*Pinus jeffreyi*), Pinon pine (*Pinus monophylla*), and Juniper (*Juniperus* sp.).

c. Pipeline Corridor - The biotic community between the project site and the Forest Service Visitor Center is essentially the same as that which occurs in the geothermal field area - Jeffrey pine overstory with an understory dominated by big sagebrush, bitterbrush, and rabbitbrush. Labrador tea (*Ledum glandulosum*), manzanita (*Arctostaphylos* spp.) and perennial bunch grasses are other important species of the understory. Along the road berm an impact zone is present due to road construction and vehicle use, which varies from approximately three to fifteen meters wide. Within this disturbed area, many of the plant species dominant in the undisturbed adjacent areas are less dominant and pioneering. Instead, invader species are more common; i.e., russian thistle, squirrel tail, and wheatgrass.

The pipeline corridor from the Forest Service Visitor Center to the proposed storage tanks, while entering the developed Mammoth Lakes Village transcends from the Jeffrey pine/big sagebrush biotic community to a more diverse pine fir woodland typical of increased altitude change.

From the Visitor Center to Storage Tank #1, the vegetative association has an overstory of Jeffery pine and white fir (*Abies concolor*). The understory, where present, consists of manzanita (*Arctostaphylos* spp.), tobacco bush (*Ceanothus velutinus*) and bitterbrush.

Between Storage Tank #1 and Storage Tanks #2 and #3, the vegetative composition is similar. The overstory is comprised of Jeffrey pine, lodgepole pine (*Pinus murrayana*), western white pine (*Pinus monticola*), white fir and red fir (*Abies magnifica*). The understory consists, generally, of manzanita, labrador tea, *Ceanothus* spp., and snowberry (*Symphoricarpos longiflorus*).

d. Storage Tank Area - Each storage tank is proposed to be located in an area close to existing roads and residences. Each specific tank location is relatively undisturbed, but moderate to heavy impact from urban development is present within 25 to 100 meters.

Storage Tank #1 will be located in an area with an overstory estimated at 50 percent consisting primarily of Jeffrey pine and white fir. The understory is moderate and primarily an association of manzanita, bitterbrush, and tobacco bush.

The area for location of Storage Tank #2 has an overstory roughly estimated at 75 percent and is comprised of Jeffrey pine, lodgepole pine, white and red fir, and western white pine. The understory is moderate in cover and is dominated by snowberry, manzanita, and Ceanothus spp.

Storage Tank #3 will be located in an area with a moderate overstory estimated at 50 to 75 percent consisting of Jeffrey pine, lodgepole pine, western white pine, and white and red fir. The understory is moderate in cover but low in diversity. Dominant understory species present are snowberry and pinemat (Arctostophylos nevadensis). Pinedrops (Pterospora andromedea) were also observed in this area.

2. Existing Wildlife

As part of the three-day biological survey of July 1974, two consecutive nights of live animal trapping were carried out in and around the proposed site area. As determined in the April 1977 biological survey, lack of observable change in the general biotic community indicates that there should be little or no significant change in wildlife of the project area.

The 1974 trapping survey represented 102 trapping nights. The trapping results do not allow a comparative evaluation of animal population densities for the proposed site and surrounding areas because of the relatively short trapping duration. The results do show, however, that the same small mammals were common to the site and surrounding areas.

The following rodents were trapped: Pinyon mouse (Peromyscus truei), deer mouse (Peromyscus maniculatus), western harvest mouse (Reithrodontomys megalotis), and lodgepole chipmunk (Eutamias speciosus). In addition, golden mantled ground squirrels (Cilellus lateralis) and beechey ground squirrels (Citellus beecheyi) were observed but not trapped.

Large mammals were not observed on any of the sites. However, tracks and scats of deer and coyotes were found. The project area falls within the area of the Casa Diablo Deer Management Unit, but lies outside primary summer and winter ranges. Deer do migrate through this area when moving from the summer range to the winter range.

The only reptiles observed in the area were the western fence lizard (Sceloporus occidentalis), sagebrush lizard (Sceloporus graciosus), and the side-blotched lizard (Uta stansburiana), and gopher snake (Pituophis melanoleucus).

Amphibians common to the eastern Sierra Nevada area, although not observed during field studies in the project area are;

great basin spadefoot (Scaphiopus intermontanus), western toad (Bufo boreas), and Pacific tree frog (Hyle regilla).

Birds observed in the area during the study are listed in Table 29. The list is not complete but gives an indication of the many bird species that inhabit and or migrate through the area.

3. Endangered and Threatened Species

The presence of endangered or threatened floral and faunal species may constitute major obstacles to siting of proposed projects. During the 1974 and 1977 surveys of the project vicinity, no endangered or threatened species were identified. However, listed below are those species that may be found in the Mammoth Lakes project area.

a. Vegetation - The California Native Plant Society (CNPS) (Special Publication No. 1, 1974) has established an inventory or rare and endangered vascular plants of California. Additionally, the Department of the Interior (DOI), U. S. Fish and Wildlife Service published a proposed list of threatened and endgangered flora of the United States in the Federal Register (7/1/75, Vol. 40:127). Plant species listed in these documents that may occur in the project area are listed below.

SPECIES	LIST	STATUS
Astragalus johannis-howellii	CNPS	Very rare and rare and endangered
Draba nivalis	CNPS	Very rare and rare and endangered
Eriogonum ampullaceum	CNPS	Very rare and rare and endangered
	DOI	Threatened
Pedicularis crenulata	CNPS	Very rare and rare and endangered
	DOI	Threatened
Penstemon papillatus	CNPS	Very rare and rare and endangered

In addition to the above listed species, others that occur in Mono County and on the CNPS list include:

TABLE 29

BIRDS OBSERVED IN THE GENERAL PROJECT AREA DURING THE JULY 1974 BIOLOGICAL SURVEY

COMMON NAME	SCIENTIFIC NAME	RELATIVE LOCATION
Mallard	Anas platyrhychos	Hot Creek
Red-Tailed Hawk	Buteo jamaicensis	Site
Sparrow Hawk	Falco sparverius	Site
Killdeer	Charadrius vociferus	Site, nests at Mono Lake
California Gull	Larus californicus	Site, Twin Lakes
Morning Dove	Zenaidura macroura	Site
White Throated Swift	Aeronautes saxatalis	Twin Lakes
Rufous Hummingbird	Sealasphorus rufus	Site
Red Shafted Flicker	Colaptes cafer	Site
Lewis' Woodpecker	Asyndesmus lewis	Site
Cassin's King Bird	Tyrannus vociferans	Airport
Hammonds Flycatcher	Empidonax hammondii	Site
Western Wood Penee	Contopus sordidulus	Site
Tree Swallow	Iridoprocne bicolor	Twin Lakes
Cliff Swallow	Petrochelidon phrrhonota	Site
Stellors Jay	Cyanocitta stelleri	Site
Clarks Nutcracker	Nucifraga columbiana	Mammoth
Black Capped Chickadee	Parus atricapillus	Site
Mountain Chickadee	Parus gambeli	Site
Plain Titmouse	Parus inornatus	Mammoth
Rock Wren	Salpinctes obsoletus	Site
Mocking Bird	Mimus polyglottos	Airport
Robin	Turdus migratorius	Site
Starling	Sturnus vulgaris	Site
Warbling Vireo	Vireo gilvus	Site
Yellow Warbler	Dendroica petechia	Site
Audubons Warbler	Dendroica auduboni	Site
Red-Winged Blackbird	Agelaius phoeniceus	Site
Brewers Blackbird	Euphagus cyanocephalus	Site
Western Tanager	Piranga ludoviciana	Site
Cassin's Finch	Carpodacus cassinii	Twin Lakes
House Finch	Carpodacus mexicanus	Site
Grey Crowned Rosey Finch	Leucosticte tephrocotis	Twin Lakes
Lesser Goldfinch	Spinus psaltria	Twin Lakes
Green-Tailed Towhee	Chlorura chlorura	Site
Vesper Sparrow	Pooecetes gramineus	Airport
Chipping Sparrow	Spizella passerina	Site
Song Sparrow	Melospiza melodia	Mammoth Creek
Brewers Sparrow	Spizella breweri	Airport
White Crowned Sparrow	Zonotrichia leucophrys	Twin Lakes

Astragalus greyeri	_Agropyron scribneri_
Draba quadricostata	_Arabis lignifera_
Eriogonum beatleyae	_Astragalus kentrophyta_
Eriogonum kearneyi	_Eriogonum gricilipes_
Glyceria grandis	_Eriogonum latum_
Hackelia brevicula	_Juncus abjectus_
Halimolobus virgata	_lupinus duranii_
Hesperolinon duranii	_lupinus inyoensis_
Sedum pineforum	_lupinus montigenus_
Puccinella lemmonii	

b. Wildlife - The species listed below and their respective status are predicated upon the listings in At The Cross Roads, 1976.

American Peregrin Falcon	- _Falco peregrinus anatum_ - Endangered
Southern Bald Eagle	- _Haliaeetus Leucocephalus leucocephalus_ - Endangered
Wolverine	- _Gulo luscus luscus_ - Rare
California Bighorn Sheep	- _Ovis canadensis californica_ - Rare

4. Impact of the Project

a. Vegetation - Construction of the geothermal heat exchange facility will result in the loss of approximately one acre of natural habitat on the proposed site. Since the site is already heavily impacted by man, this is not considered to be a significant impact.

Construction of underground pipelines from the plant to production wells and reinjection wells will result in the removal of a strip of vegetation perhaps ten feet wide and the length of the lines. This could, conceivably, result in the loss of several acres of productive habitat. If, however, the pipelines are buried below the existing unimproved roads in the area, the impact will be minimal, and natural re-vegetation will take place after initial disturbance.

For that segment of supply and return pipelines that parallels State Route 203 from the plant to the Mammoth Lakes Village, impact upon vegetation will be minimal since the pipelines have been routed under the roadside berm which is a previously impacted zone.

The remaining network of supply and return pipelines within the Mammoth Lakes Village should have an insignificant impact on vegetation due to the existing impact from urban development.

There may be low to moderate impact at the storage tank sites as these are relatively undisturbed areas. Impacts to vegetation will be limited to construction of relatively short access roads (about 1,000 feet from existing roads to exact site locations) and to the removal of vegetation on the site of each storage tank. Wherever possible, including access roads, vegetation will not be removed nor its root systems destroyed to allow for natural recovery with time.

If deemed necessary, re-vegetation utilizing native plant species will be employed in areas where removal of existing vegetation cannot be avoided.

b. <u>Wildlife</u> - The faunal community in the project area is diverse, particularly in mammals and birds. The avifauna is particularly rich during migratory seasons. Game species occurring in the project vicinity include dove, quail, fowl, rabbit, sage grouse, deer, and fish.

Of particular concern are those species sensitive to construction activities and other human related activities. Thus, game and recreational related species, plus endangered and threatened species are of primary concern.

Within the project area only deer and fish constitute viable hunting and fishing experience. Since the geothermal project is proposed to be a closed system, fish should not be affected by the project. The Casa Diablo Deer Herd summers north and east of Mammoth. The winter range is located generally east of Mammoth; thus, migration routes of deer to and from the seasonal ranges pass through the project area. Additionally, deer have been observed in the vicinity year round. Due to the high level of year round human activity along U. S. Highway 395 and in Mammoth; i.e., hunting, fishing, skiing, camping, etc., no long term impact on deer from the project is expected. The normal everyday activities of the Mammoth Lakes community will outweigh perturbations that may occur to the deer migrations attributed to the project.

Construction of the geothermal heat exchange facility on the proposed site will have minimal impact on wildlife since it is bordered on three sides by roads and on one side by operation of a small lumber yard. To further alleviate project impact on wildlife, all existing vegetation will be preserved to the greatest extent possible to maintain wildlife habitat. Areas that are temporarily impacted will be re-vegetated with native plant species, if deemed necessary, since these provide the best habitat for native wildlife.

B. ARCHAEOLOGICAL AND HISTORICAL SETTING

The general Mammoth area is a natural laboratory in the scientific investigation of human activities and cultural development of primitive peoples. Several studies have been made in the past and archaeological interest in the area remains high. These studies indicate that primitive people may have occupied this area beginning as much as 14,000 years ago (11, 12 and 13).

The Northern Paiute Indians lived along the western edge of the Great Basin - the area of land bounded on the west by the Sierra and on the east by the Rocky Mountains. Petroglyphs in this area indicate that Paiute groups lived near Mono Lake, Benton, and in the southern section of Long Valley (14). The Paiute Indians first encountered white men in the early 1800's when small groups of fur trappers came from the east to California. In the 1850's, mass movements of people came to the eastern Sierra seeking gold. White settlement of the Mammoth Lakes area took place after 1853 and by 1877 as many as 2,500 persons were making a living from mining there (14). However, mining soon declined and since the early 1900's both summer and winter recreational uses have become the major activities in the Mammoth area.

Several archaeological sites are presently recorded in the general Mammoth area, and it is almost certain that many more are present, but as yet unrecorded. Five of these sites have been excavated and are located along Hot Creek from its mouth to Casa Diablo Hot Springs. They are: Ca Mno 455 and 472, Mammoth Indian Cave, Mammoth Junction site, and the Hot Creek Hatchery site.

In July of 1974, a three-day archaeological reconnaissance was conducted on and around the proposed project area. A general field reconnaissance of the project area and approximate pipeline route as far west as the Forest Service Visitor Center was conducted on April 27-28, 1977. The reason for the latter reconnaissance was to determine whether there had been significant changes on the condition of the cultural resources in the project area since the original study in 1974, and to examine the general area of the pipeline route.

1. Present Conditions

a. Proposed Site - No archaeological resources were noted at this site.

b. Surrounding Area - Part of the surrounding geothermal area has a light to moderate scatter of obsidian flakes left from tool manufacturing activities. There is no indication of midden development or depth to the deposit.

c. Pipeline Corridor - No archaeological resources were noted along the pipeline corridor from the plant site to the Forest Service Visitor Center.

2. Project Impact

At present there are no known cultural resources of such significance as to endanger the project. Utilization of the proposed site would creat no impact on presently known archaeological resources. Pipelines from the geothermal plant to the production and reinjection wells could cause significant impact to scatters of obsidian flakes. Impacts from the pipeline into the Mammoth Lakes Village and to storage tank locations do not appear significant at this time. However, this cannot be confirmed until precise routes and locations of all project facilities are marked in the field and firm data on right-of-way widths and construction techniques are available.

C. POPULATION

1. Present Conditions

The closest community to the proposed site is Mammoth Lakes Village, which is about four miles away. The permanent population of the Village and surrounding area is about 2,900 (Special Enumeration, August 8, 1972; Sponsored by Mono County, Compilation by California State Department of Finance). During some weekends and holiday periods, this increases to about 18,000.

2. Project Impact

It is estimated that approximately 50 workers and their families will be associated with the construction of the project and less than 10 workers will be required to maintain and operate the plant. With the community of Mammoth Lakes geared to handle a visitor population of 18,000, it is extremely unlikely that the project will in any way create growth in the Mammoth Lakes area.

D. TRANSPORTATION

1. Present Conditions

Transportation in the Mammoth area is basically via private vehicle, although there is a small airport approximately nine miles southeast of the community of Mammoth Lakes. Highway 395 provides the main link between Mammoth Lakes and its major market area, Southern California. Average daily traffic volumes (ADT) through the Mammoth Lakes area, measured at Highway 395 and State Route 203, range from 7,000 ADT during peak month periods to 3,200 ADT. State Route 203 provides access to Mammoth Lakes from Highway 395; it is also the main thoroughfare in the community. Present traffic volumes measured at the intersection of State Route 203 and Minaret Summit Road range from a daily average of 10,000 vehicles during peak months to 6,400 vehicles during average periods (15).

2. Project Impact

During construction, delivery of equipment and supplies may have a minor impact on the traffic load on U. S. Highway 395 and State Route 203. However, this would be of short duration, possibly less than four weeks. Once the major equipment and materials are delivered to the site, the traffic load contribution of the project would not be significant. Underground placement of supply and return pipelines along road shoulders may have temporary impact on traffic loads.

E. AESTHETICS

1. Present Conditions

The dominant landforms in the Mammoth area are the Sierra Nevada and Long Valley. The interrelationship of the barren peaks and valley floor with the vegetation patterns, water features, and man-made features creates the visual character of the Mammoth area. The community of Mammoth Lakes is the focal point of man-made structures in the area. The community itself is a mixture of high and low density residential development, strip commercial operations, and the winter season resorts.

2. Project Impact

The proposed geothermal facility site is in the midst of a relatively flat open field at an altitude of approximately 7,300 feet above sea level. Two lumber storage buildings stand within 500 feet to the southwest of the site. Also visible are several tanks, piping, a small cooling tower and drilling mud ditches scattered over the area, giving evidence of geothermal field development. Therefore, the visual impact of the plant facilities will not be significant since the plant site area already has relatively low scenic value. It will be mainly visible at close range only from County Road 346A (old U. S. Highway 395), on which there is now relatively little traffic. The visual impact from the new U. S. Highway 395 should be minimal as it passes about 700 yards at the closest point from the proposed site. Since pipeline systems will be underground, there will be only minimal and temporary impact due to dust and noise during the construction phase.

F. SUMMARY OF RECOMMENDATIONS AND MITIGATION MEASURES

Vegetation - Wherever possible, including access roads, vegetation will not be removed nor its root systems destroyed to allow for natural recovery with time. If deemed necessary, re-vegetation utilizing native plant species will be employed as much as possible in areas where removal of existing vegetation cannot be avoided. To decrease removal of vegetation, pipelines will be buried underneath existing unimproved roads or underneath improved road berms wherever possible.

Wildlife - All existing vegetation will be preserved to the greatest extent possible to maintain natural wildlife habitat. Areas that are temporarily impacted will be re-vegetated, if deemed necessary, with native plant species since these provide the best habitat for native wildlife.

Archaeology - At present there is no known cultural resource of such significance as to impede the project. However, a complete cultural resources survey of all areas subject to project related impact will be necessary, preferably in time for inclusion in the project Environmental Impact Report. This survey cannot be conducted until precise routes and exact sites are marked in the field, and firm data on right-of-way widths and constructuion techniques are available. Once the survey is completed, small adjustments in individual routes and locations can be made to avoid resources identified during the survey, or firm plans for mitigation of impact can be developed. Professional archaeological monitoring of ground disturbing activities may be required for portions of the project.

Population - No mitigation measures are needed since the Mammoth Lakes Village is geared to handle large recreational crowds.

Transportation - Traffic problems can be alleviated by careful planning and delivery of equipment and supplies and scheduling of construction.

Aesthetics - Since pipeline systems will be underground, there will be only minimal and temporary impact due to dust and noise during the construction phase. To minimize visual impact of the project, it is planned to make use of architectural techniques to blend the project components with the surroundings.

MODELS

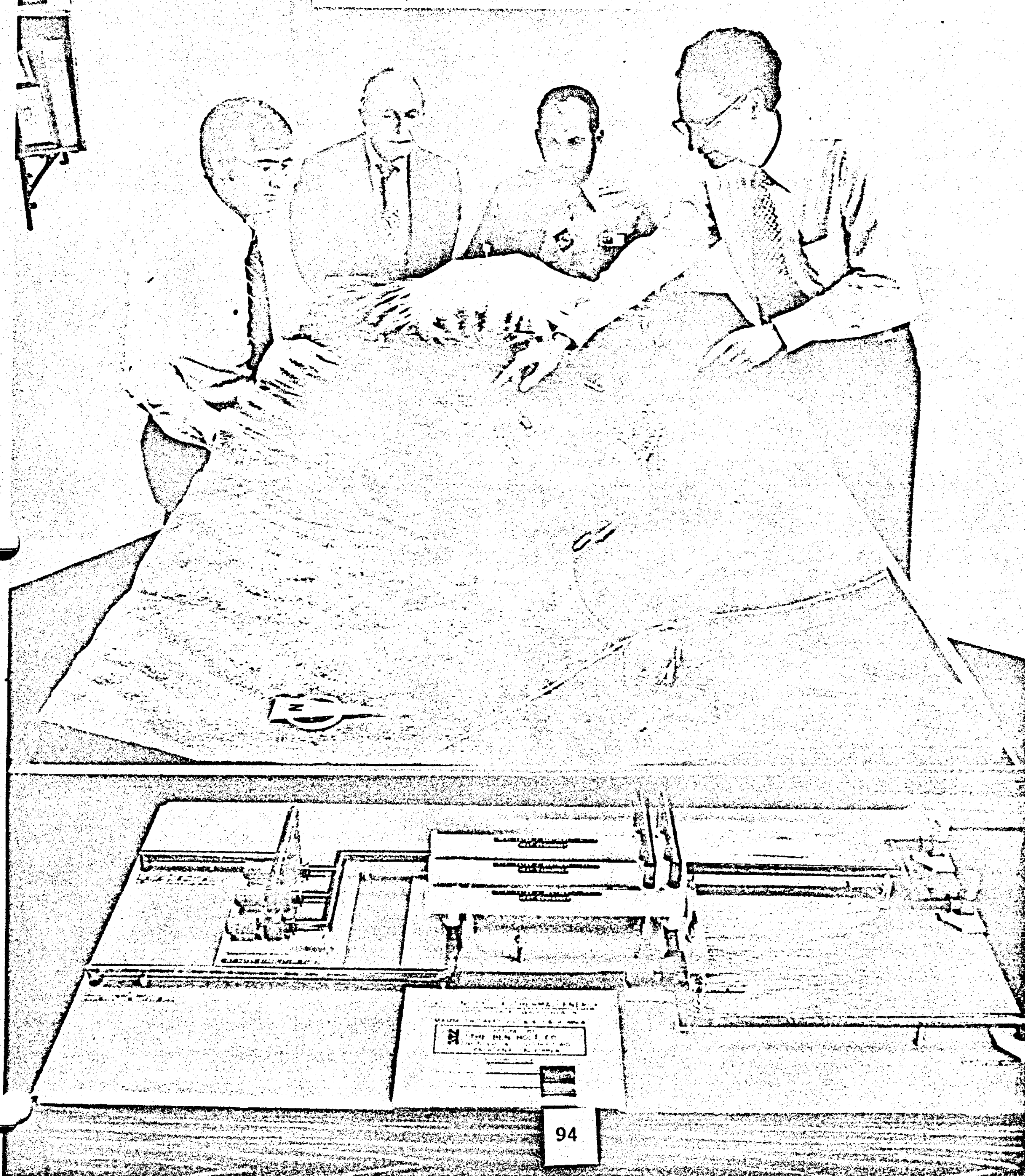
Two models were designed, built and shipped to ERDA-Washington which illustrate the use of geothermal energy. One model illustrated a geothermal district heating system for Mammoth Lakes Village, and the other portrayed a geothermal-electric power plant.

The Mammoth Lakes model consists of two parts. First, a three dimensional relief map showing the geothermal well locations, heat exchange equipment and pipelines, and the Village area. The second part is a "semiworking" model which illustrates the geothermal/fresh water heat exchange system using entrained air bubbles in water to simulate flow of geothermal water and fresh water. Figure 16 is a photograph of these models.

The geothermal-electric power plant model depicts the operation of a binary cycle plant. This model is also "semiworking"; that is, a concealed pump is used to circulate water with entrained air bubbles to simulate the flow of geothermal brine, hydrocarbon working fluid, and cooling water. Colored transparent tubing was used to differentiate the various streams.

FIGURE 16

DISTRICT HEATING SYSTEM MODELS



FOLLOW-ON PROGRAM

Completion of the feasibility study reported on in this work marks the first Milestone in an overall development program for geothermal energy utilization in Mammoth Lakes Village. As currently envisioned, that development program consists of the following Milestones.

TABLE 30

GEOTHERMAL DEVELOPMENT PROGRAM MILESTONES
MAMMOTH LAKES VILLAGE

	MILESTONE	DATE
1.	Complete ERDA District Heating Feasibility Study	9/77
2.	Complete SCE Co-generation Feasibility Study	12/77
3.	Complete ERDA District Heating Implementation Plan	3/78
4.	Drill and Test Deep Exploratory Well	6/78
5.	Construct and Test ERCDC Pilot Project	12/78
6.	Install Phase I District Heating System/ ERDA Field Experiment	12/79
7.	Install and Operate Full Scale District Heating System	1/81 to 1988

The second Milestone in Table 30 is a study being undertaken for SCE by Holt to investigate the feasibility of co-generation of electric power and district heating from geothermal brines. As discussed in the ECONOMIC ANALYSIS Section of this report, co-generation may significantly improve the economics of geothermal energy utilization in the Mammoth area. The results of Milestone two will help define the extent of that potential improvement.

In order to allow for construction and operation of a geothermal District Heating System in Mammoth as soon as possible, ERDA has authorized Holt to proceed with work on Milestone three, an Implementation Plan. This plan will involve defining the regulatory requirements to be met prior to constructing a district heating system in Mammoth; an identification of heating loads (other than space and water heating) which could increase district heating system capacity factor and improve system economics; preparation of a schedule and cost estimate for engineering and design of the full scale district heating system.

Magma Energy, Inc. has begun work on Milestone four. Magma has applied for all necessary permits to drill a 9,000-foot exploratory geothermal well on their Casa Diablo property. Drilling and testing of this well should provide Magma with much needed data regarding the size and temperature of the Casa Diablo geothermal resource as discussed in the RESERVOIR ANALYSIS Section of this report.

The State of California Energy Resources Conservation and Development Commission (ERCDC) is currently funding an 18-month pilot program, Milestone five. This program will demonstrate the geothermal district heating concept in a store and storage shed using existing wells at the Casa Diablo site. The program is also being supported by SCE, which is providing electric energy and a monitary contribution to the project, and by Magma, which is providing the geothermal wells and energy for the project. The pilot plant testing provides a transition from feasibility and other study work to construction and operation of a large scale district heating system. Successful demonstration of the geothermal heating concept in this pilot plant will provide sufficient hardware-related information to allow construction of the first phase district heating system, Milestone six.

It is envisioned that Phase I would be jointly funded by ERDA, under its Field Experiments program, and an investor owned or nonprofit corporation. The Phase I system will provide district heating for businesses and homes in Area 1 of the Village. The system will be tested for one year or more.

Assuming the results of Phase I operation are positive and system economics appear favorable, the Phase I system will be expanded into Village Areas 2 and 3, and will reach a projected capacity of 52 MWt by 1988.

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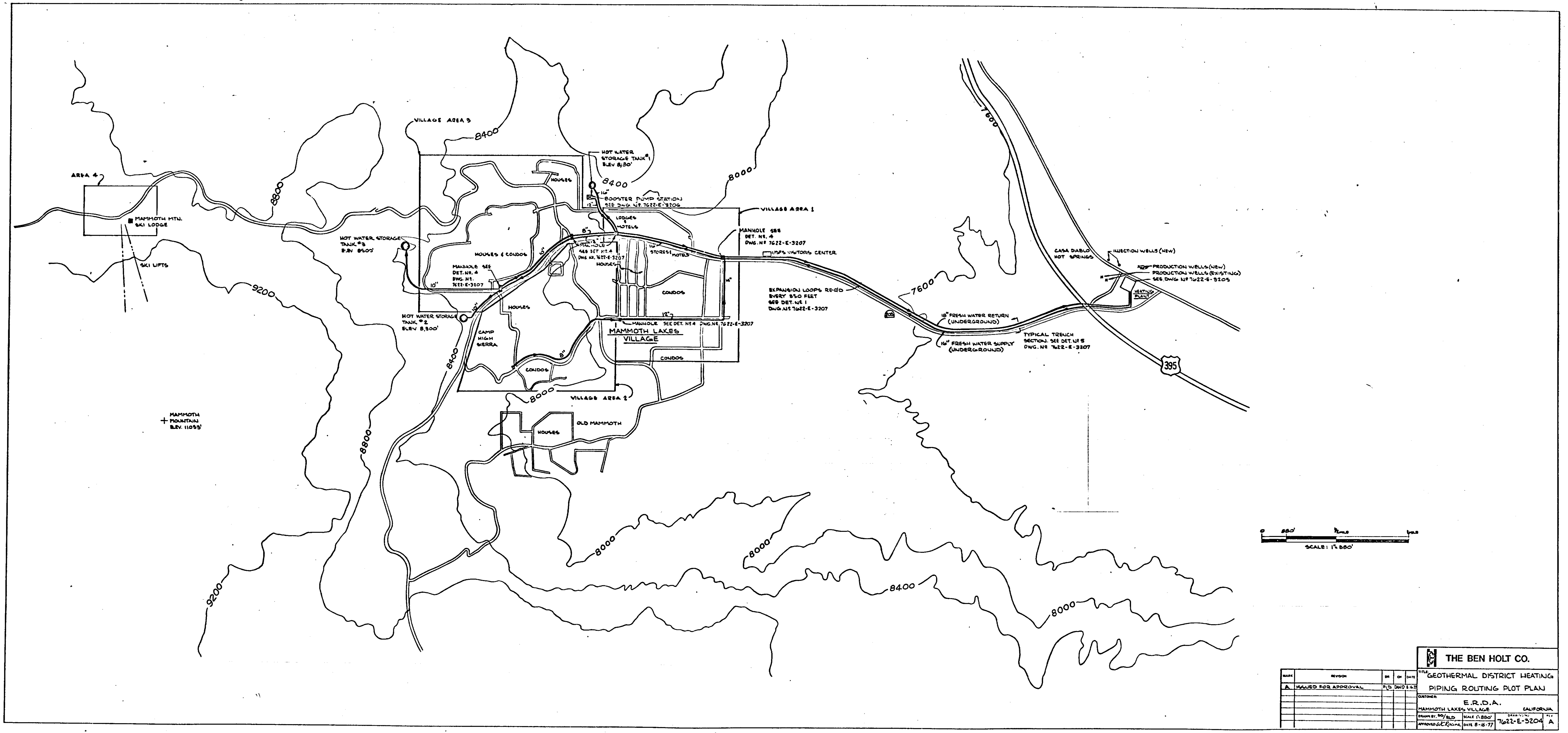
E-1A, E-1B & E-1C
BRINE/FRESH WATER HEAT EXCHANGERS
DUTY: 1.05 x 10^8 BTU/HR. EACH
DESIGN: SHELLSIDE TUBESIDE
PRESS: 500 PSIG 350 PSIG
TEMP: 340°F 340°F
T-2A THRU T-2D
FRESH WATER PRESSURIZATION TANKS
CAPACITY: 16,000 GAL. EACH
DESIGN PRESS: 550 PSIA
DESIGN TEMP: 300°F
T-3
NITROGEN RECEIVER
CAPACITY: 2000 CU. FT.
DESIGN PRESS: 550 PSIA
DESIGIN TEMP: 300°F
T-1
FRESH WATER STORAGE TANK
CAPACITY: 750,000 GAL.
TELEM.
E-1A
E-1B
E-1C
T-2A
T-2B
T-2C
T-2D
T-3
T-1
FRESH WATER SUPPLY
P-3A
P-3B
P-3C
P-3D
EXIST. WELL
NEW WELLS
K-1
P-1A
P-1B
P-1C
P-2A
P-2B
P-5A
P-5B
P-5C
P-4A & B
BRINE PRODUCTION PUMPS
EXISTING WELLS
DESIGN CAPACITY: 500 GPM
DESIGN DISCH. P: 350 PSI
P-3A, B, C & D
BRINE PRODUCTION PUMPS
NEW WELLS
DESIGN CAPACITY: 1000 GPM
DESIGN DISCH. P: 350 PSI
REINJECTION WELLS
N2 TANKS
N2 RECIPROCAL COMPRESSOR
P-1A THRU P-1C
FRESH HOT WATER CIRCULATION PUMPS
DESIGN CAPACITY: 1900 GPM EACH @ 300°F
DESIGN ΔP: 350 PSI
P-2A & P-2B
FRESH WATER MAKE-UP PUMPS
DESIGN CAPACITY: 20 GPM EACH
DESIGN ΔP: 500 PSI
P-5A THRU P-5C
FRESH HOT WATER BOOSTER PUMPS
DESIGN CAPACITY: 1250 GPM EACH @ 300°F
DESIGN ΔP: 320 PSI
NOTES:
1. FOR LEGEND SEE DWG. 7622-E-3203
2. PROVIDE VALVED VENTS AT ALL HIGH POINTS IN PIPING
THE BEN HOLT CO.
TITLE GEOTHERMAL DISTRICT HEATING
HIGH TEMPERATURE SYSTEM
BASE CASE P&ID
CUSTOMER E.R.D.A.
MAMMOTH LAKES VILLAGE CALIFORNIA
MARK REVISION DR. CH DATE
A ISSUED FOR APPROVAL JHP
DRAWN BY JOE POPE
SCALE
DATE 6-1-77
DRAWING NO 7622-E-3201
REV A

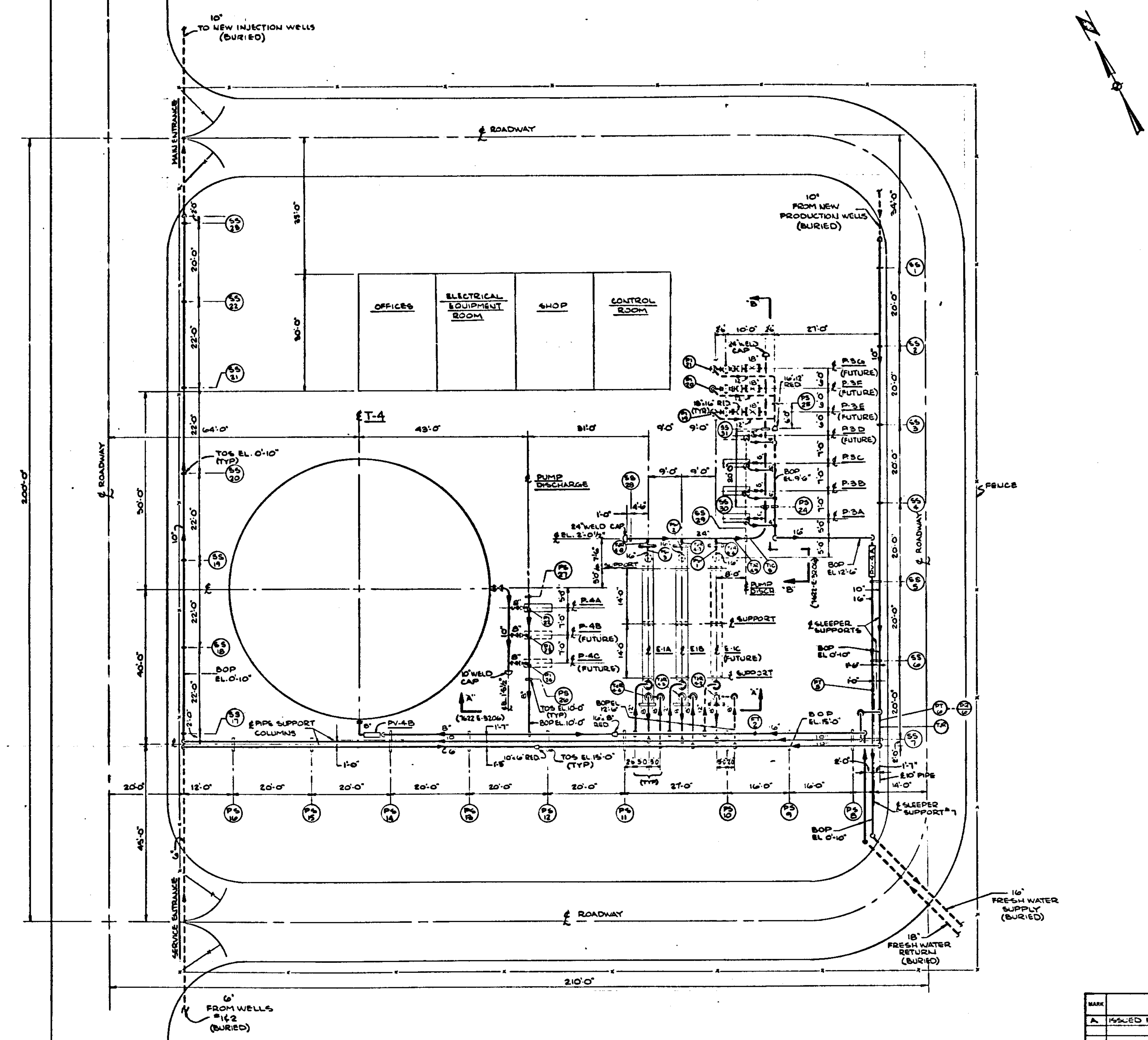
E-1A, E-1B & E-1C
BRINE/FRESH WATER HEAT EXCHANGERS
DUTY: 1.0 x 10^8 BTU/HR.
DESIGN: SHELL SIDE TUBE SIDE
PRESS: 300 PSIG 350 PSIG
TEMP: 340°F 340°F
T-4
RETURN WATER STORAGE TANK
CAPACITY: 1,080,000 GAL.
T-1
HOT WATER STORAGE TANK
CAPACITY: 360,000 GAL.
T-2
HOT WATER STORAGE TANK
CAPACITY: 360,000 GAL.
T-3
HOT WATER STORAGE TANK
CAPACITY: 360,000 GAL.
NOTE
FOR LEGEND SEE DWG 7622-E-3208
P-4A & B
BRINE PRODUCTION PUMPS
(EXISTING WELLS)
DESIGN CAPACITY: 500 GPM
DESIGN DISCH. P: 350 PSI
P-3A, B, & C
BRINE PRODUCTION PUMPS
(NEW WELLS)
DESIGN CAPACITY: 1000 GPM
DESIGN DISCH. P: 350 PSI
REINJECTION WELLS
P-1A THRU P-1C
FRESH HOT WATER CIRCULATION PUMPS
DESIGN CAPACITY: 3000 GPM EACH @ 200°F
DESIGN ΔP: 350 PSI
P-2A & B
FRESH WATER MAKE-UP PUMPS
DESIGN CAPACITY: 30 GPM EACH
DESIGN ΔP: 300 PSI
P-5A THRU P-5C
HOT WATER BOOSTER PUMPS
DESIGN CAPACITY: 2000 GPM EACH @ 200°F
DESIGN ΔP: 250 PSI
FRESH WATER SUPPLY
TELEM.
THE BEN HOLT CO.
TITLE GEOTHERMAL DISTRICT HEATING LOW TEMPERATURE SYSTEM BASE CASE P&ID
CUSTOMER E.R.D.A.
MAMMOTH LAKES VILLAGE CALIFORNIA
DRAWN BY JOE POPE
DATE 5-15-77
DRAW NO. 7622-E-3202
REV. A
MARK REVISION
A ISSUED FOR APPROVAL


E-1A, B & C
BRINE/FRESH WATER HEAT EXCHANGERS
DUTY: 85x10^6 BTU/HR. EACH
DESIGN: SHELL SIDE / TUBE SIDE
PRESS: 350 PSIG / 350 PSIG
TEMP: 340°F / 340°F
T-2
HOT WATER STORAGE TANK
CAPACITY: 325,000 GALS.
T-1
HOT WATER STORAGE TANK
CAPACITY: 430,000 GALS.
T-4
MAIN WATER STORAGE TANK
CAPACITY: 1,080,000 GALS.
T-3
HOT WATER STORAGE TANK
CAPACITY: 325,000 GALS.
HEATING LOADS (TYPICAL)
VENT
E-1A
E-1B
E-1C
P-5A THRU P-5F
HOT WATER BOOSTER PUMPS
P-5A
250 GPM
ΔP=140 PSI
P-5B THRU P-5D
600 GPM
ΔP=250 PSI
P-5E & P-5F
1800 GPM
ΔP=250 PSI
MAMMOTH LAKES VILLAGE
CASA DIABLO GEOTHERMAL AREA
MAKE-UP WATER SUPPLY
P-1A
P-1B
P-2A
P-2B
P-2C
P-3A
P-3B
P-3C
P-3D
P-3E
P-3F
P-3G
P-4A
P-4B
P-4C
P-1A & B
BRINE PRODUCTION PUMPS
(EXISTING WELLS)
(NEW PUMPS)
DESIGN CAPACITY: 425GPM
DESIGN DISCH. P: 350 PSI
P-2A, B & C
BRINE PRODUCTION PUMPS
(NEW WELLS)
DESIGN CAPACITY: 850GPM
DESIGN DISCH P: 350 PSI
REINJECTION WELLS
P-3A THRU P-3G
HOT WATER CIRCULATION PUMPS
P-3A
350 GPM
ΔP=120PSI
P-3B THRU P-3D
900 GPM
ΔP=155 PSI
P-3E THRU P-3G
3000 GPM
ΔP=430 PSI
P-4A, B & C
STORAGE TRANSFER PUMPS
DESIGN CAPACITY: 500 GPM EACH
DESIGN ΔP: 300 PSI
LEGEND
FO — FLOW RESTRICTION ORIFICE
FQI — FLOW TOTALIZER
FR — FLOWRATE RECORDER
FT — FLOWRATE TRANSMITTER
LAH — LEVEL ALARM HIGH
LI — LEVEL INDICATOR
LIT — LEVEL INDICATOR/TRANSMITTER
PI — PRESSURE INDICATOR GAUGE
PIC — PRESSURE INDICATOR/CONTROLLER
PR — PRESSURE RECORDER
PT — PRESSURE TRANSMITTER
PV — PRESSURE CONTROL VALVE
TAL — TEMPERATURE ALARM (LOW)
TI — TEMPERATURE INDICATOR
TIC — TEMPERATURE INDICATOR/CONTROLLER
TJR — MULTIPOINT TEMPERATURE RECORDER
TV — TEMPERATURE CONTROL VALVE
HIC — MANUAL LOADING STATION
HS — MOTOR CONTROL STATION
HV — MANUAL LOADED VALVE
UA — UNIT ALARM.
ZAH — POSITION ALARM (HIGH)
ZSH — POSITION SWITCH (HIGH)
LOCALLY MOUNTED INSTRUMENT
BOARD MOUNTED INSTRUMENT
XJ — TELEMETRY LINK
VALVES
ELECTRIC MOTOR OPERATED CONTROL VALVE
PRESSURE SAFETY RELIEF VALVE
GATE VALVE
GLOBE VALVE
CHECK VALVE
THE BEN HOLT CO.
TITLE GEOTHERMAL DISTRICT HEATING LOW TEMPERATURE SYSTEM P & ID
CUSTOMER E.R.D.A.
MAMMOTH LAKES VILLAGE CALIFORNIA
MARK / REVISION / DR / CH / DATE
A ISSUED FOR APPROVAL UHP 8-1-77
DRAWN BY JOE POPE
DATE 8-1-77
DRAWING NO. 7622-E-3203
REV. A



AREA 4
MAMMOTH MTN. SKI LODGE
SKI LIFTS
MAMMOTH MOUNTAIN ELEV. 11053'
VILLAGE AREA 3
8400
8800
9200
HOT WATER STORAGE TANK #3 ELEV 8505'
HOUSES
HOUSES & CONDOS
MANHOLE SEE DET. NO. 4 DWG. NO. 7622-E-3207
10"
HOT WATER STORAGE TANK #2 ELEV 8,300'
HOUSES
CAMP HIGH SIERRA
CONDOS
8"
8000
VILLAGE AREA 2
HOT WATER STORAGE TANK #1 ELEV 8,130'
16"
BOOSTER PUMP STATION SEE DWG. NO. 7622-E-3206
12"
LODGES & MOTELS
MANHOLE SEE DET. NO. 4 DWG. NO. 7622-E-3207
HOUSES
STORES & MOTELS
CONDOS
14"
MANHOLE SEE DET. NO. 4 DWG. NO. 7622-E-3207
MAMMOTH LAKES VILLAGE
CONDOS
VILLAGE AREA 1
MANHOLE SEE DET. NO. 4 DWG. NO. 7622-E-3207
USFS VISITORS CENTER
EXPANSION LOOPS REQ'D EVERY 350 FEET SEE DET. NO. 1 DWG. NO. 7622-E-3207
OLD MAMMOTH
HOUSES
7600
203
18" FRESH WATER RETURN (UNDERGROUND)
16" FRESH WATER SUPPLY (UNDERGROUND)
TYPICAL TRENCH SECTION. SEE DET. NO. 5 DWG. NO. 7622-E-3207
CASA DIABLO HOT SPRINGS
INJECTION WELLS (NEW)
PRODUCTION WELLS (NEW)
PRODUCTION WELLS (EXISTING)
SEE DWG NO. 7622-E-3205
HEATING PLANT
395
SCALE: 1"=880'
THE BEN HOLT CO.
TITLE: GEOTHERMAL DISTRICT HEATING PIPING ROUTING PLOT PLAN
CUSTOMER: E.R.D.A.
MAMMOTH LAKES VILLAGE CALIFORNIA
DRAWN BY. BD/RLD
SCALE 1"=880'
DRAWING NO. 7622-E-3204
REV A
APPROVED WCRacine
DATE 8-16-77
MARK REVISION DR CH DATE
A ISSUED FOR APPROVAL RLD DWD 8-16-77

REFERENCE DRAWING	
DRAWING NO.	TITLE
7622-E-3204	PIPING ROUTING PLOT PLAN



MARK	REVISION	DR.	CH	DATE
A	ISSUED FOR APPROVAL	RD	DAND	5-18-77

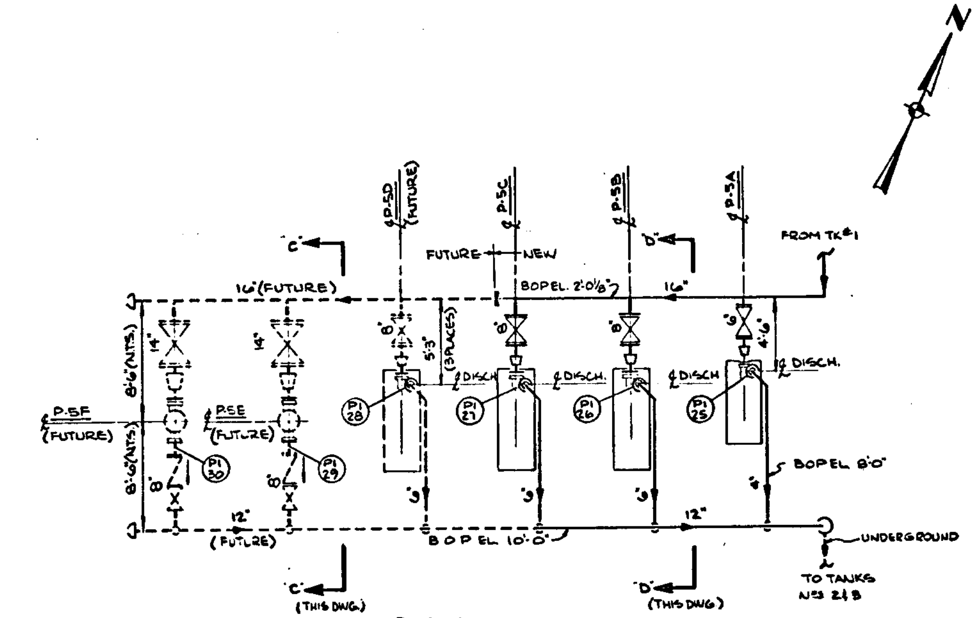
THE BEN HOLT CO.

TITLE: GEOTHERMAL DISTRICT HEATING PIPING PLAN AT HEATING PLANT

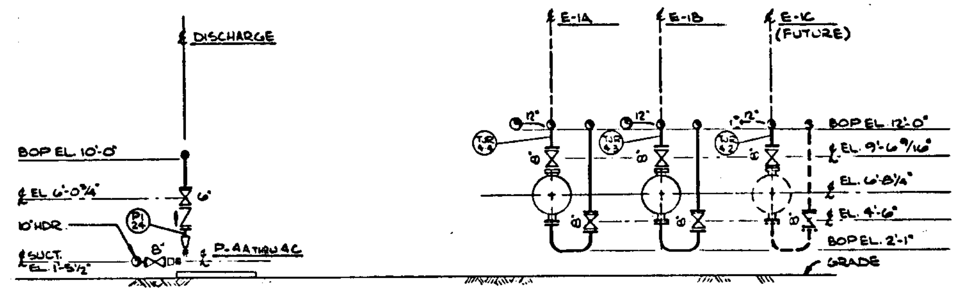
CUSTOMER: ERDA
MAMMOTH LAKES VILLAGE CALIFORNIA

DRAWN BY: DORN	SCALE 1"=10'-0"	DRAWING NO 7622-E-3205	REV. A
APPROVED WKRacine	DATE 8-19-77		

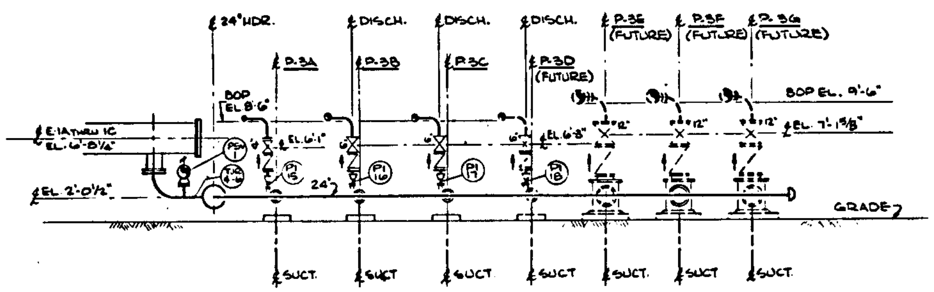
REFERENCE DRAWING	
DRAWING NO.	TITLE
7622-E-3204	PIPING ROUTING PLOT PLAN
7622E-3205	PIPING PLOT PLAN - PLANT



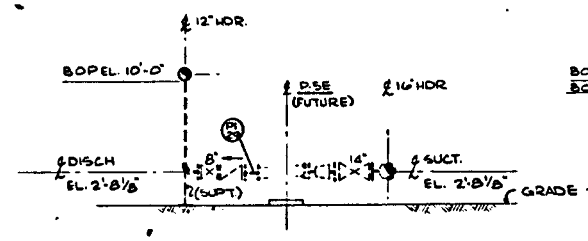
PLAN
BOOSTER PUMP STATION
SCALE: ¼"=1'-0"



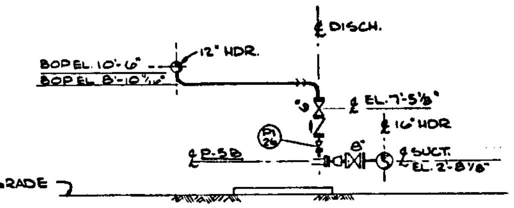
SECTION "A-A"
(REF. DWG. 7622-E-3205)
SCALE: 3/16"=1'-0"



SECTION "B-B"
(REF. DWG. 7622-E-3205)
SCALE: 3/16"= 1'-0"



SECTION "C-C"
(REF. THIS DWG.)
SCALE: 3/16"=1'-0"

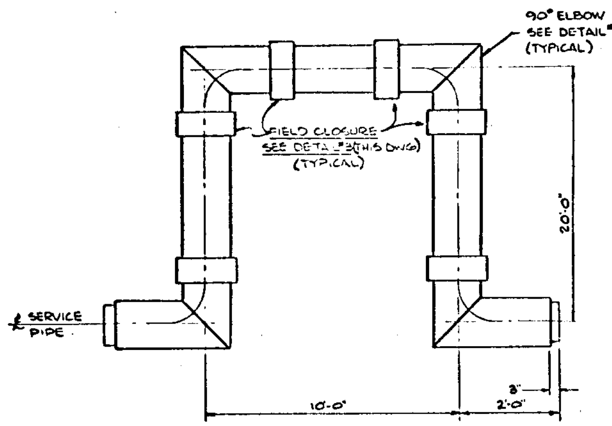


SECTION "D-D"
(REF. THIS DWG.)
SCALE: 3/16"=1'-0"

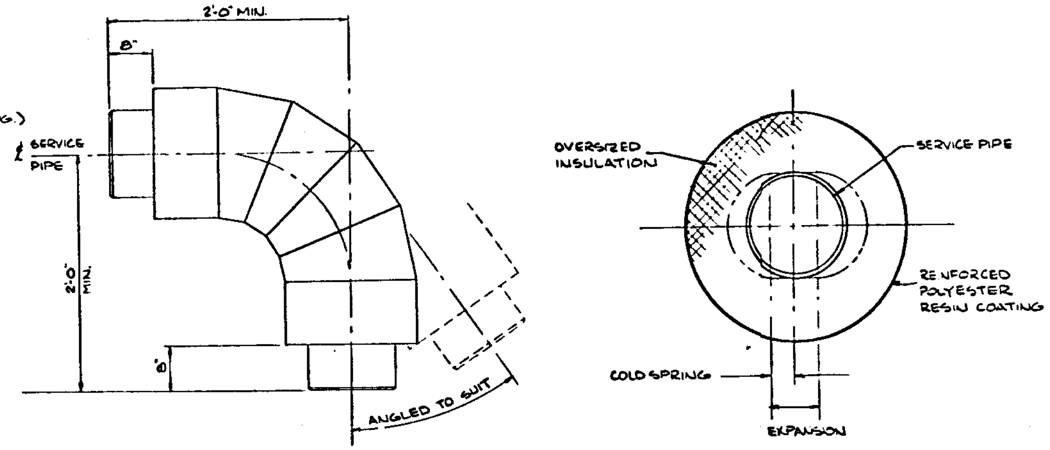
MARK	REVISION	DR.	CH	DATE
A	ISSUED FOR APPROVAL	RLD	DND	3-18-77

THE BEN HOLT CO.			
TITLE: GEOTHERMAL DISTRICT HEATING PIPING PLAN & SECTIONS			
CUSTOMER: ERDA MAMMOTH LAKES VILLAGE CALIFORNIA			
DRAWN BY DORN	SCALE NOTED	DRAWING NO. 7622-E-3206	REV. A
APPROVED [illegible]	DATE 6-10-77		

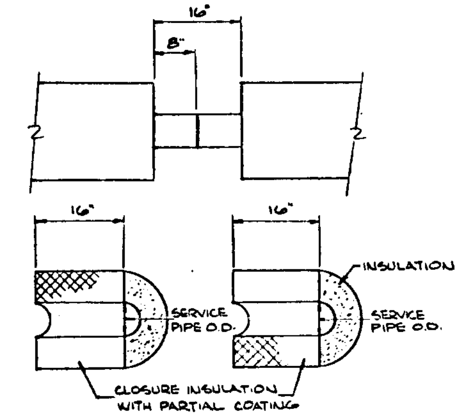
REFERENCE DRAWING	
DRAWING NO.	TITLE
7622-E-3201	PIPING ROUTING PLAN



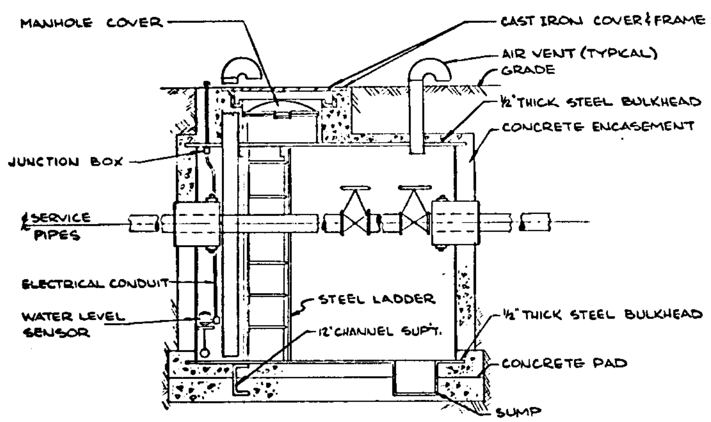
DETAIL #1
TYPICAL EXPANSION LOOP (PLAN)



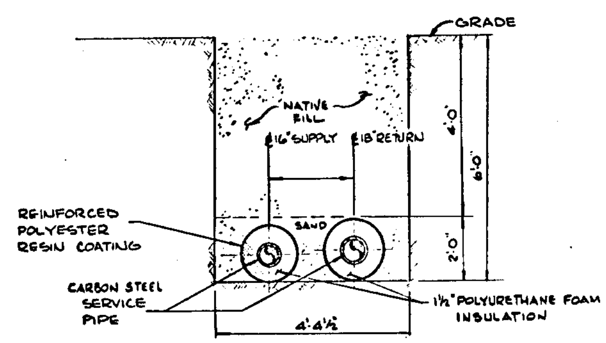
DETAIL # 2



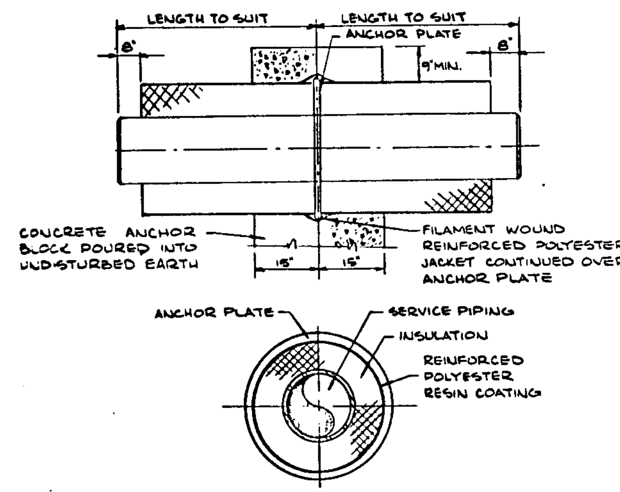
DETAIL # 3
TYPICAL FIELD CLOSURE



DETAIL # 4
TYPICAL MANHOLE



DETAIL # 5
PIPE TRENCH TYPICAL



DETAIL # 6
TYPICAL PIPING SYSTEM ANCHOR

MARK	REVISION	DR.	CH.	DATE
A	ISSUED FOR APPROVAL	RLD	DAND	8-15-77

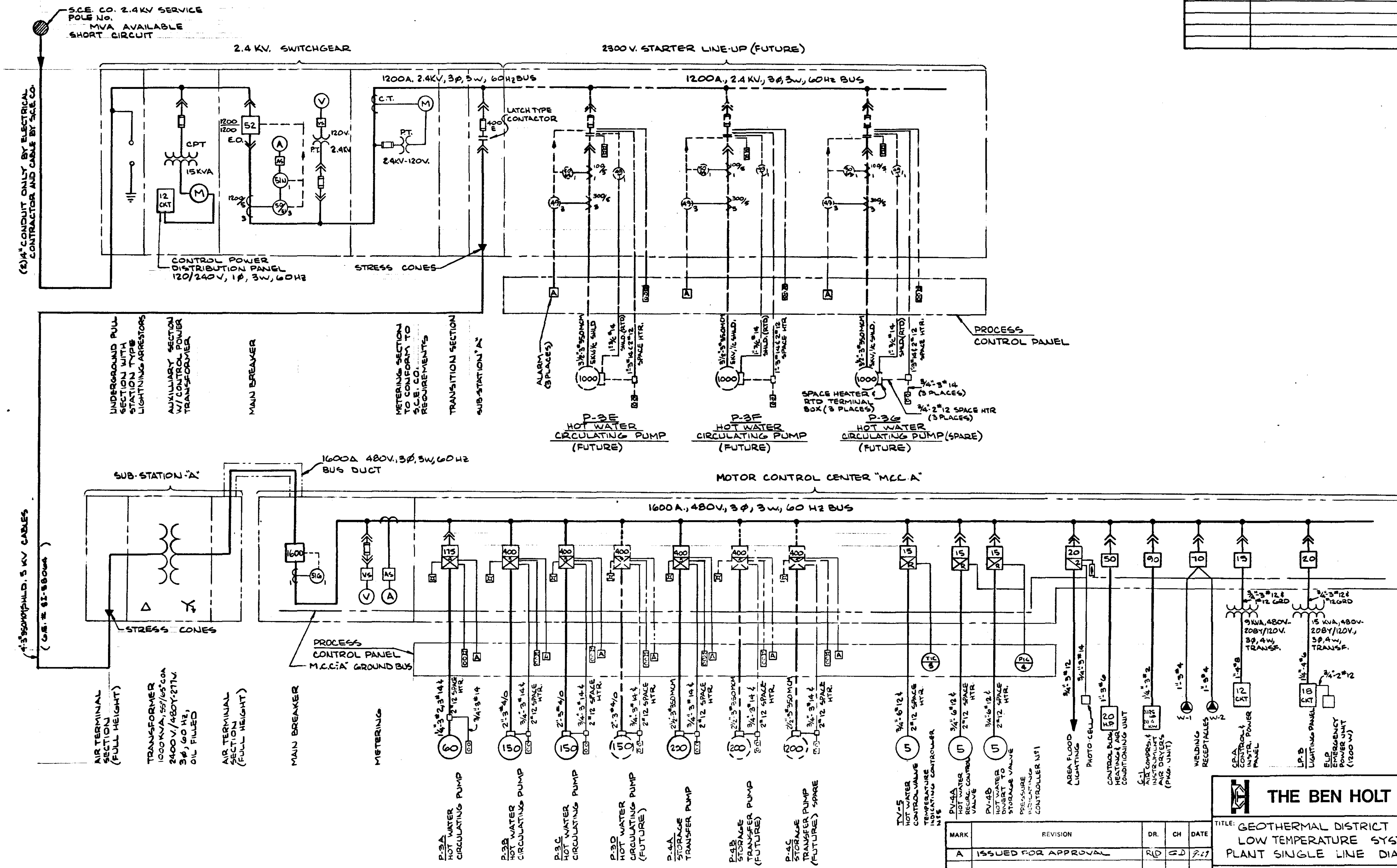
THE BEN HOLT CO.

TITLE: GEOTHERMAL DISTRICT HEATING
UNDERGROUND PIPING DETAILS

CUSTOMER: E.R.D.A.
MAMMOTH LAKES VILLAGE CALIFORNIA

DRAWN BY DORN	SCALE –	DRAWING NO. 7622-E-3207	REV. A
APPROVED	DATE 8-18-77		

REFERENCE DRAWING	
DRAWING NO.	TITLE
7622-D-3602	AREA "I" SINGLE LINE DIAGRAM
7622-D-3603	DISTRICTS " " "



MARK	REVISION	DR.	CH	DATE
A	ISSUED FOR APPROVAL	RD	GD	9-27

THE BEN HOLT CO.

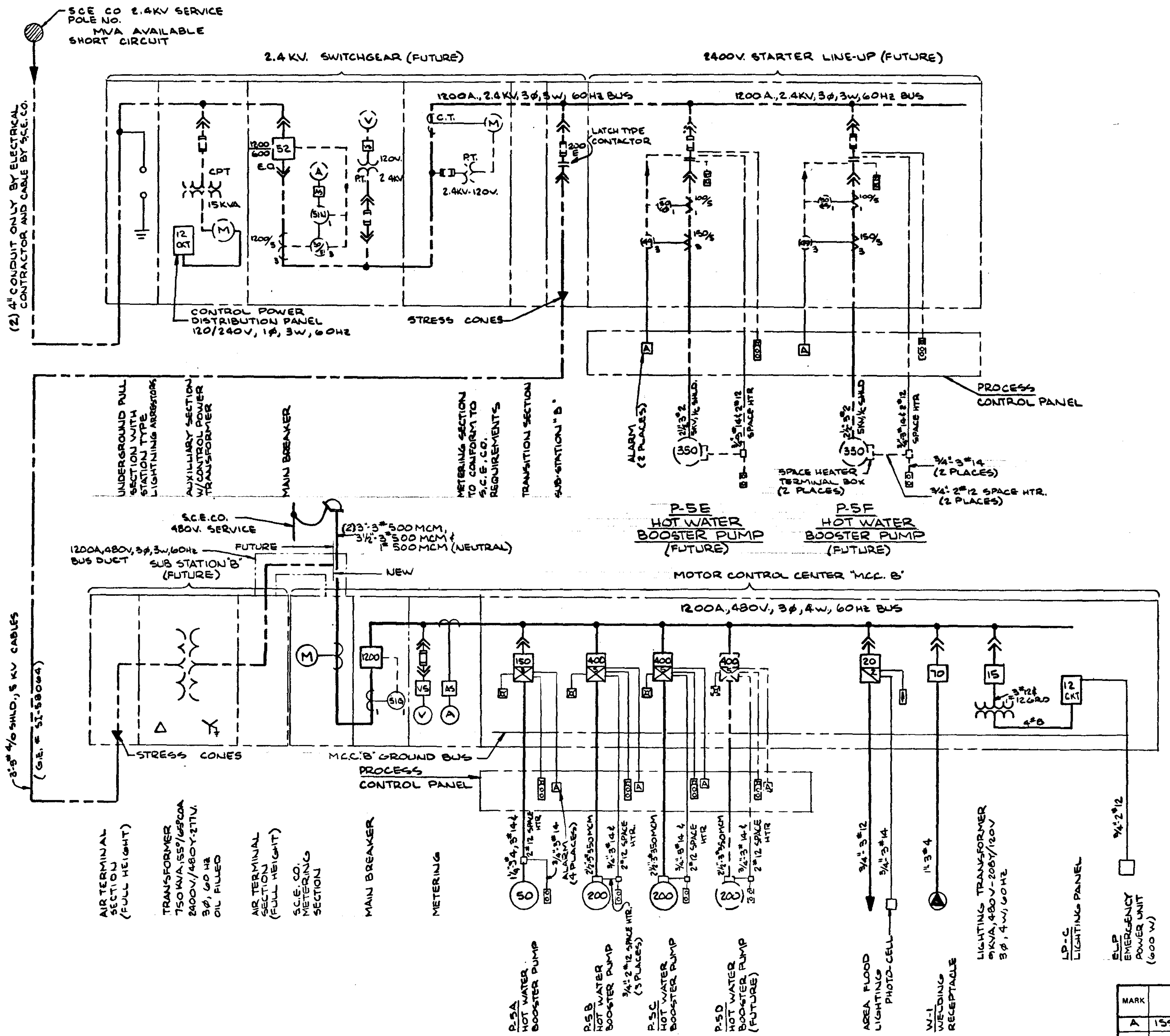
TITLE: GEOTHERMAL DISTRICT HEATING LOW TEMPERATURE SYSTEM PLANT SINGLE LINE DIAGRAM

CUSTOMER: E.R.D.A.

MAMMOTH LAKES VILLAGE CALIFORNIA

DRAWN BY: R DORN	SCALE: NONE	DRAWING NO. 7622-D-3601	REV. A
APPROVED: WCRacine	DATE: 6-23-77		

REFERENCE DRAWING	
DRAWING NO.	TITLE
7622-D-3601	PLANT SINGLE LINE DIAGRAM
7622-D-3603	DISTRICTS " " "



MARK	REVISION	DR.	CH	DATE
A	ISSUED FOR APPROVAL	RLD	GD	9-27

THE BEN HOLT CO.

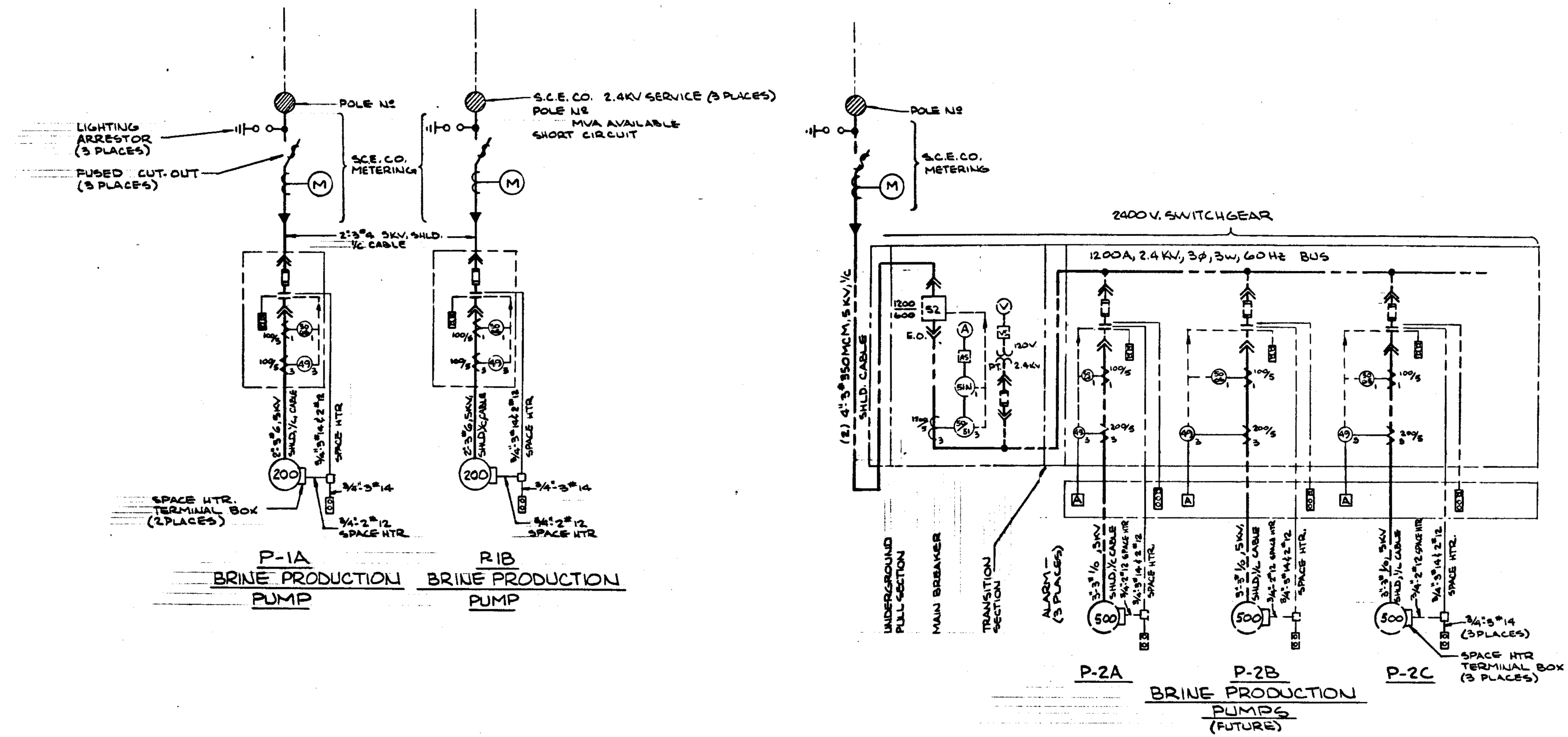
TITLE: GEOTHERMAL DISTRICT HEATING LOW TEMPERATURE SYSTEM AREA #1 SINGLE LINE DIAGRAM

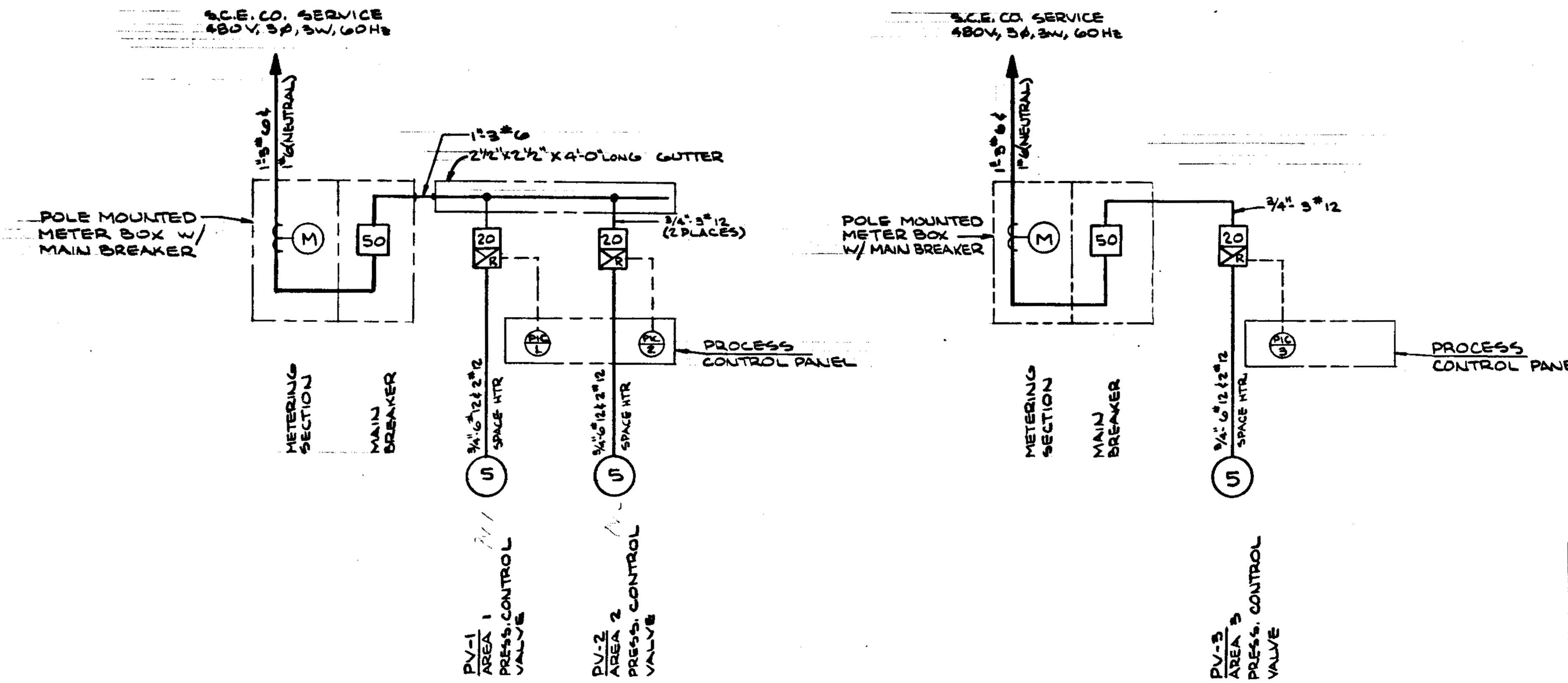
CUSTOMER: E.R.D.A.

MAMMOTH LAKES VILLAGE CALIFORNIA

DRAWN BY: R. DORN	SCALE: NONE	DRAWING NO. 7622-D-3602	REV. A
APPROVED:	DATE 6-30-77		

REFERENCE DRAWING	
DRAWING NO.	TITLE
7622-D-3601	PLANT SINGLE LINE DIAGRAM
7622-D-3602	AREA "I" " " "





MARK	REVISION	DR.	CH	DATE
A	ISSUED FOR APPROVAL	RLD	GD	9-29

THE BEN HOLT CO.

TITLE: GEOTHERMAL DISTRICT HEATING LOW TEMPERATURE SYSTEM, WELLS & DISTRICTS SINGLE LINE DIAGRAMS

CUSTOMER: E.R.D.A.

MAMMOTH LAKES VILLAGE CALIFORNIA

DRAWN BY: R. DORN	SCALE: NONE	DRAWING NO. 7622-D-3603	REV. A
APPROVED WC Racine	DATE: 7-1-77		

THE BEN HOLT CO.

HEAT EXCHANGER SPECIFICATION

CUSTOMER USERDA	JOB NO. 7622
	ITEM NO. E-1A, B, C
PLANT Geothermal District Heating System	REV. NO. 1 DATE 7/5/77
LOCATION Mammoth Lakes, California	QUOTE NO. 7622-Q3
SERVICE Fresh Water/Geothermal Brine	REFERENCE

SIZE 32"D x 432"L TYPE CEN. CONNECTED IN SERIES/PARALLEL 0/3

SURFACE PER SHELL 5,367 NO. OF SHELLS 3 TOTAL SURFACE 16,101

PERFORMANCE

	SHELL SIDE	TUBE SIDE
FLUID CIRCULATED	Fresh Water	Geothermal Brine(1500 ppm TDS)
TOTAL FLUID ENTERING		
VAPOR		
LIQUID each of 3	1.42 (10^6) lb/hr	0.57 (10^6) lb/hr
STEAM		
NON-CONDENSABLES		
FLUID VAPORIZED OR CONDENSED		
STEAM CONDENSED		
GRAVITY—LIQUID @ TEMP.	0.98 @ 140 °F	0.90 @ 340 °F
VISCOSITY—LIQUID @ TEMP.	0.49 c.s.@ 140 °F	0.33 c.s.@ 190 °F
MOLECULAR WEIGHT—VAPORS		
SPECIFIC HEAT—LIQUIDS	1.0 B.T.U./LB.°F	1.0 B.T.U./LB.°F
LATENT HEAT—VAPORS	B.T.U./LB.	B.T.U./LB.
TEMPERATURE IN	140 °F	340 °F
TEMPERATURE OUT	200 °F	190 °F
OPERATING PRESSURE	250 P.S.I.G.	350 P.S.I.G.
NUMBER OF PASSES PER SHELL	1	4
VELOCITY	FT./SEC.	6.7 FT./SEC.
PRESSURE DROP (ALLOW/CALC.)	20 / 13 P.S.I.	100 / 21 P.S.I.
FOULING FACTOR (MIN.)	0	0.002

HEAT EXCHANGED – B.T.U./HR. 85 (10^6) each M.T.D. (CORRECTED) 64.3

TRANSFER RATE – SERVICE 246 CLEAN

CONSTRUCTION

	SHELL SIDE	TUBE SIDE
DESIGN PRESSURE	350 P.S.I.G.	350 P.S.I.G.
TEST PRESSURE	525 P.S.I.G.	525 P.S.I.G.
DESIGN TEMPERATURE	350 °F	350 °F

TUBES SA-214 NO. 770 O.D. 3/4" BWG. 14 LENGTH 36'-0" PITCH 15/16" Tri.

SHELL SA-516 I.D. 32"O.D. THICKNESS

SHELL COVER FLOATING HEAD COVER

CHANNEL SA-516 CHANNEL COVER SA-516

TUBE SHEET – STATIONARY SA-516 FLOATING

BAFFLES – CROSS C.S. TYPE Segmental THICKNESS SPACING

BAFFLE – LONG TYPE THICKNESS

TUBE SUPPORTS C.S. THICKNESS

GASKETS

CONNECTIONS – SHELL-IN 16" OUT 16" SERIES 300 #RF

CHANNEL-IN 12" OUT 12" SERIES 300 #RF

CORROSION ALLOWANCE – SHELL SIDE 0 TUBE SIDE 1/16"

CODE REQUIREMENTS ASME VIII TEMA CLASS C

WEIGHTS – EACH SHELL BUNDLE FULL OF WATER

REMARKS:

THE BEN HOLT CO.
CENTRIFUGAL PUMP SPECIFICATION

CUSTOMER USERDA	JOB NO. 7622
PLANT Geothermal District Heating System NO. REQUIRED 1	ITEM NO. P-3A
LOCATION Mammoth Lakes, California MOTOR DRIVE X	REV. NO. 1 DATE 7/26/77
SERVICE Hot Water Circulation TURBINE DRIVE ____	QUOTE NO. 7622-Q1
	REFERENCE ____

OPERATING CONDITIONS

LIQUID PUMPED Fresh Water @ 215 °F — DISCH. PRESSURE 370 P.S.I.G.
CAPACITY, AT TEMP., NORMAL 350 GPM — DESIGN 350 GPM — SUCT. PRESSURE 250* P.S.I.G.
AT TEMP., SP. GR. 0.96 VISC. 0.3 — VAP. PR. 15.6 P.S.I.A. — DIFF. PRESSURE 120 P.S.I.
DIFF. HEAD 289 FT.
NPSH AVAILABLE 592 FT.(LIQUID) — CORR. MATERIAL ____ EROSIVE MATERIAL ____
____ % OR ____ P.P.M. ____ % OR ____ P.P.M.
NPSH REQUIRED 8 FT.(WATER)
HYDRAULIC H.P. 25 — *Maximum suction pressure = 350 psig @ no flow

PUMP SPECIFICATIONS

MANUFACTURER Goulds Pumps Inc. — NO. OF STAGES 1
SIZE & TYPE 3 x 4 - 11H 3736 — PERFORMANCE CURVE 1789-3
R.P.M. 3550 — EFFICIENCY 63.5 — IMPELLER DIAM. BID 8-3/4 MIN. 8 MAX. 11½
BHP @ DESIGN 38.6 — MAX. BHP. REQD. 58.5 — RECOMMENDED DRIVER HP. 60
CIRCULAR NO. ____ — DIMENSION PRINT X — SECTION DWG. ____

MATERIALS OF CONSTRUCTION

CASING & NOZZLE C.S.
IMPELLER C.I.
CASING RING C.I.
IMPELLER RINGS C.I.
SHAFT SAE 4140
SHAFT SLEEVE 316SS HDFCD
PACKING GLAND C.S.
PACKING J. Crane 101M
SEAL CAGE G. F. Teflon
BASE PLATE Fab. Stl.

CONSTRUCTION FEATURES

CASE SPLIT HORIZONTAL ____ VERTICAL XX
SUPPORT C/L ____ FOOT XX BRACKET ____
IMPELLER OPEN ____ CLOSED XX SEMI-ENC. ____
STUFF. BOX WATER JACKET: ☐ YES ☒ NO
MECH. SEAL ____ INTERNAL ____ EXTERNAL ____
SINGLE ____ DOUBLE ____ BALANCED ____ UNBALANCED ____
BEARINGS WATER JACKETED: ☒ YES ☐ NO
LUBRICATION OIL XX GREASE ____
FLEXIBLE COUPLING: MAKE Fast TYPE Model B
COUPLING GUARD: ☒ YES ☐ NO

DRIVER DATA – MOTOR

MAKE West HP 60
TYPE Ind. R.P.M. 3600
PHASE 3 CYCLE 60 VOLTS 460
FRAME 364TS

DRIVER DATA – TURBINE

MAKE ____ H.P. ____
TYPE ____ R.P.M. ____
WATER RATE @ DESIGN LOAD ____ LBS/HR. BHP.
STEAM INLET ____ P.S.I.G. ____ °F
STEAM EXHAUST ____ P.S.I.G. ____ °F

NET WEIGHT

PUMP, BASE, CPLG. ____ LB.
MOTOR ____ LB.

SHIPPING WEIGHT

PUMP, BASE, CPLG. ____ LB.

Special Instructions or Features Pump must meet API 610 specification.

THE BEN HOLT CO.

CENTRIFUGAL PUMP SPECIFICATION

CUSTOMER: USERDA	JOB NO.: 7622
PLANT: Geothermal District Heating System — NO. REQUIRED: 3	ITEM NO.: P-3B, C, D
LOCATION: Mammoth Lakes, California — MOTOR DRIVE: X	REV. NO.: 1 DATE: 7/26/77
SERVICE: Hot Water Circulation — TURBINE DRIVE:	QUOTE NO.: 7622-Q1
	REFERENCE:

OPERATING CONDITIONS

LIQUID PUMPED: Fresh Water @ 215 °F — DISCH. PRESSURE: 375 P.S.I.G.

CAPACITY, AT TEMP., NORMAL: each 900 GPM — DESIGN: 900 GPM — SUCT. PRESSURE: 220* P.S.I.G.

AT TEMP., SP. GR.: 0.96 — VISC.: 0.3 — VAP. PR.: 15.6 P.S.I.A. — DIFF. PRESSURE: 155 P.S.I.

DIFF. HEAD: 373 FT.

NPSH AVAILABLE: 520 FT. (LIQUID) — CORR. MATERIAL: ____ EROSIVE MATERIAL: ____

____ % OR ____ P.P.M. ____ % OR ____ P.P.M.

NPSH REQUIRED: 17 FT. (WATER)

HYDRAULIC H.P.: 81

*Maximum suction pressure = 350 psig @ no flow

PUMP SPECIFICATIONS

MANUFACTURER: Goulds Pumps Inc. — NO. OF STAGES: 1

SIZE & TYPE: 4 x 6-13DV 3736 — PERFORMANCE CURVE: CDS 1827-2

R.P.M.: 3550 — EFFICIENCY: 70% — IMPELLER DIAM. BID: 10 MIN.: 9 MAX.: 13

BHP @ DESIGN: 116 — MAX. BHP. REQD.: 137.6 — RECOMMENDED DRIVER HP.: 150

CIRCULAR NO.: — DIMENSION PRINT: X — SECTION DWG.:

MATERIALS OF CONSTRUCTION

CASING & NOZZLE	C.S.
IMPELLER	C.I.
CASING RING	C.I.
IMPELLER RINGS	C.I.
SHAFT	SAE 4140
SHAFT SLEEVE	316SS HDFCD
PACKING GLAND	C.S.
PACKING	J. Crane 101M or EQ.
SEAL CAGE	G. F. Teflon
BASE PLATE	Fab. Stl.

CONSTRUCTION FEATURES

CASE SPLIT: HORIZONTAL ____ VERTICAL XX

SUPPORT: C/L ____ FOOT XX BRACKET ____

IMPELLER: OPEN ____ CLOSED XX SEMI-ENC. ____

STUFF. BOX WATER JACKET: ☐ YES ☒ NO

MECH. SEAL: ____ INTERNAL ____ EXTERNAL ____

SINGLE ____ DOUBLE ____ BALANCED ____ UNBALANCED ____

BEARINGS WATER JACKETED: ☒ YES ☐ NO

LUBRICATION: OIL XX GREASE ____

FLEXIBLE COUPLING: MAKE Fast TYPE Model B

COUPLING GUARD: ☒ YES ☐ NO

DRIVER DATA – MOTOR

MAKE: West — H.P.: 150

TYPE: Ind. — R.P.M.: 3600

PHASE: 3 — CYCLE: 60 — VOLTS: 460

FRAME: 445TS

DRIVER DATA – TURBINE

MAKE: ____ H.P.: ____

TYPE: ____ R.P.M.: ____

WATER RATE @ DESIGN LOAD: ____ LBS/HR. BHP.

STEAM INLET: ____ P.S.I.G. ____ °F

STEAM EXHAUST: ____ P.S.I.G. ____ °F

NET WEIGHT

PUMP, BASE, CPLG.: ____ LB.

MOTOR: ____ LB.

SHIPPING WEIGHT

PUMP, BASE, CPLG.: ____ LB.

Special Instructions or Features: Pump must meet API 610 specification.

THE BEN HOLT CO.
CENTRIFUGAL PUMP SPECIFICATION

CUSTOMER: USERDA
PLANT: Geothermal District Heating System — NO. REQUIRED: 3
LOCATION: Mammoth Lakes, California — MOTOR DRIVE: X
SERVICE: Hot Water Circulation — TURBINE DRIVE:

JOB NO.: 7622
ITEM NO.: P-3E, F, G
REV. NO.: 1 — DATE: 7/26/77
QUOTE NO.: 7622-Q1
REFERENCE:

OPERATING CONDITIONS

LIQUID PUMPED: Fresh Water @ 200 °F
CAPACITY, AT TEMP., NORMAL: each 3000 GPM — DESIGN: 3000 GPM
AT TEMP., SP. GR.: 0.96 — VISC.: 0.3 — VAP. PR.: 11.5 P.S.I.A.
DISCH. PRESSURE: 550 P.S.I.G.
SUCT. PRESSURE: 120* P.S.I.G.
DIFF. PRESSURE: 430 P.S.I.
DIFF. HEAD: 1035 FT.
NPSH AVAILABLE: 289 FT. (LIQUID)
NPSH REQUIRED: 30 FT. (WATER)
HYDRAULIC H.P.: 753
CORR. MATERIAL: ______ % OR ______ P.P.M. — EROSIVE MATERIAL: ______ % OR ______ P.P.M.

*Maximum suction pressure = 350 psig @ no flow

PUMP SPECIFICATIONS

MANUFACTURER: Goulds Pump Inc. — NO. OF STAGES: 8
SIZE & TYPE: 12 x 18 BHC VIC (Vert. Turb.) — PERFORMANCE CURVE: 7202B
R.P.M.: 1770 — EFFICIENCY: — IMPELLER DIAM. BID: 11-3/4 MIN. 10-3/4 MAX. 12-15/1
BHP @ DESIGN: 886 — MAX. BHP. REQD.: 934 — RECOMMENDED DRIVER HP.: 1000
CIRCULAR NO.: — DIMENSION PRINT: X — SECTION DWG.:

MATERIALS OF CONSTRUCTION

CASING & NOZZLE: C.I.
IMPELLER: C.I.
CASING RING: C.I.
IMPELLER RINGS: C.I.
SHAFT: Alloy Steel
SHAFT SLEEVE: 11-13 Chrome
PACKING GLAND: C.I.
PACKING: J. Crane 101M or EQ.
SEAL CAGE: BRZ
BASE PLATE: ---

CONSTRUCTION FEATURES

CASE SPLIT: HORIZONTAL ______ VERTICAL XX
SUPPORT: C/L ______ FOOT ______ BRACKET ______
IMPELLER OPEN ______ CLOSED XX SEMI-ENC. ______
STUFF. BOX WATER JACKET: ☐ YES ☐ NO
MECH. SEAL ______ INTERNAL ______ EXTERNAL ______
SINGLE ______ DOUBLE ______ BALANCED ______ UNBALANCED ______
BEARINGS WATER JACKETED: ☐ YES ☒ NO
LUBRICATION OIL ______ GREASE: Mtr
FLEXIBLE COUPLING: MAKE ______ TYPE ______
COUPLING GUARD: ☒ YES ☐ NO

DRIVER DATA – MOTOR

MAKE: West — HP: 1000
TYPE: Ind. — R.P.M.: 1800
PHASE: 3 — CYCLE: 60 — VOLTS: 2300
FRAME:

DRIVER DATA – TURBINE

MAKE: ______ H.P.: ______
TYPE: ______ R.P.M.: ______
WATER RATE @ DESIGN LOAD: ______ LBS/HR. BHP.
STEAM INLET: ______ P.S.I.G. ______ °F
STEAM EXHAUST: ______ P.S.I.G. ______ °F

NET WEIGHT

PUMP, BASE, CPLG.: ______ LB.
MOTOR: ______ LB.

SHIPPING WEIGHT

PUMP, BASE, CPLG.: ______ LB.

Special Instructions or Features: Pump must meet API 610 specification.

THE BEN HOLT CO.

CENTRIFUGAL PUMP SPECIFICATION

CUSTOMER: USERDA

PLANT: Geothermal District Heating System — NO. REQUIRED: 3

LOCATION: Mammoth Lakes, California — MOTOR DRIVE: X

SERVICE: Storage Transfer — TURBINE DRIVE:

JOB NO.: 7622

ITEM NO.: P-4A, B, C

REV. NO.: 1 — DATE: 8/31/77

QUOTE NO.: 7622-Q1

REFERENCE:

OPERATING CONDITIONS

LIQUID PUMPED: Fresh Water @ 150 °F

CAPACITY, AT TEMP., NORMAL: each 500 GPM — DESIGN: 500 GPM

AT TEMP., SP. GR.: 0.98 — VISC.: 0.4 — VAP. PR.: 3.7 P.S.I.A.

DISCH. PRESSURE: 301 P.S.I.G.

SUCT. PRESSURE: 1 P.S.I.G.

DIFF. PRESSURE: 300 P.S.I.

DIFF. HEAD: 707 FT.

NPSH AVAILABLE: 21 FT. (LIQUID)

NPSH REQUIRED: 10 FT. (WATER)

CORR. MATERIAL: ____ EROSIVE MATERIAL: ____

____ % OR ____ P.P.M. ____ % OR ____ P.P.M.

HYDRAULIC H.P.: 88

*Maximum suction pressure = 25 psig

PUMP SPECIFICATIONS

MANUFACTURER: Goulds Pumps, Inc.

SIZE & TYPE: 3 x 6 - 13DV 3736

R.P.M.: 3560 — EFFICIENCY: 60%

BHP @ DESIGN: 146 — MAX. BHP. REQD.: 199

CIRCULAR NO.: — DIMENSION PRINT: X

NO. OF STAGES: 1

PERFORMANCE CURVE: CDS 1821

IMPELLER DIAM. BID: 12 — MIN.: 9 — MAX.: 13

RECOMMENDED DRIVER HP.: 200

SECTION DWG.:

MATERIALS OF CONSTRUCTION

CASING & NOZZLE: C.S.

IMPELLER: C.I.

CASING RING: C.I.

IMPELLER RINGS: C.I.

SHAFT: SAE 4140

SHAFT SLEEVE: 316 SS HDFCD

PACKING GLAND: C.S.

PACKING: J. Crane 101M

SEAL CAGE: G. F. Teflon

BASE PLATE: Fab. Stl.

CONSTRUCTION FEATURES

CASE SPLIT: HORIZONTAL ____ VERTICAL: XX

SUPPORT: C/L ____ FOOT: XX BRACKET ____

IMPELLER: OPEN ____ CLOSED: XX SEMI-ENC. ____

STUFF. BOX WATER JACKET: [ ] YES [X] NO

MECH. SEAL: ____ INTERNAL ____ EXTERNAL ____

SINGLE ____ DOUBLE ____ BALANCED ____ UNBALANCED ____

BEARINGS WATER JACKETED: [X] YES [ ] NO

LUBRICATION: OIL XX — GREASE ____

FLEXIBLE COUPLING: MAKE: Fast — TYPE: Model B

COUPLING GUARD: [X] YES [ ] NO

DRIVER DATA – MOTOR

MAKE: West — HP: 200

TYPE: Ind. — R.P.M.: 3600

PHASE: 3 — CYCLE: 60 — VOLTS: 460

FRAME: 447TS

DRIVER DATA – TURBINE

MAKE: ____ H.P.: ____

TYPE: ____ R.P.M.: ____

WATER RATE @ DESIGN LOAD: ____ LBS/HR. BHP.

STEAM INLET: ____ P.S.I.G. ____ °F

STEAM EXHAUST: ____ P.S.I.G. ____ °F

NET WEIGHT

PUMP, BASE, CPLG.: ____ LB.

MOTOR: ____ LB.

SHIPPING WEIGHT

PUMP, BASE, CPLG.: ____ LB.

Special Instructions or Features: Pump must meet API 610 specification.

THE BEN HOLT CO.

CENTRIFUGAL PUMP SPECIFICATION

CUSTOMER: USERDA

PLANT: Geothermal District Heating System — NO. REQUIRED: 1

LOCATION: Mammoth Lakes, California — MOTOR DRIVE: X

SERVICE: Hot Water Booster — TURBINE DRIVE:

JOB NO.: 7622

ITEM NO.: P-5A

REV. NO.: 1 — DATE: 7/26/77

QUOTE NO.: 7622-Q1

REFERENCE:

OPERATING CONDITIONS

LIQUID PUMPED: Fresh Water @ 215 °F

CAPACITY, AT TEMP., NORMAL: 250 GPM — DESIGN: 250 GPM

AT TEMP., SP. GR.: 0.96 — VISC.: 0.3 — VAP. PR.: 15.6 P.S.I.A.

DISCH. PRESSURE: 170 P.S.I.G.

SUCT. PRESSURE: 30 P.S.I.G.

DIFF. PRESSURE: 140 P.S.I.

DIFF. HEAD: 337 FT.

NPSH AVAILABLE: 69 FT. (LIQUID)

NPSH REQUIRED: 6.5 FT. (WATER)

HYDRAULIC H.P.: 20

CORR. MATERIAL: ___ EROSIVE MATERIAL: ___

___ % OR ___ P.P.M. ___ % OR ___ P.P.M.

PUMP SPECIFICATIONS

MANUFACTURER: Goulds Pumps, Inc.

SIZE & TYPE: 2 x 4 - 11 3736

R.P.M.: 3550 — EFFICIENCY: 53%

BHP @ DESIGN: 38.5 — MAX. BHP. REQD.: 49.6

CIRCULAR NO.: — DIMENSION PRINT: X

NO. OF STAGES: 1

PERFORMANCE CURVE: 1799

IMPELLER DIAM. BID: 9-1/2 — MIN.: 7-1/2 — MAX.: 11-1/4

RECOMMENDED DRIVER HP.: 50

SECTION DWG.:

MATERIALS OF CONSTRUCTION

CASING & NOZZLE: C.S.

IMPELLER: C.I.

CASING RING: C.I.

IMPELLER RINGS:

SHAFT: SAE 4140

SHAFT SLEEVE: 316 SS HDFCD

PACKING GLAND: C.S.

PACKING: J. Crane 101M or Eq.

SEAL CAGE: G. F. Teflon

BASE PLATE: Fab. Stl.

CONSTRUCTION FEATURES

CASE SPLIT: HORIZONTAL ___ VERTICAL X

SUPPORT: C/L ___ FOOT X BRACKET ___

IMPELLER: OPEN ___ CLOSED X SEMI-ENC. ___

STUFF. BOX WATER JACKET: ☐ YES ☒ NO

MECH. SEAL: ___ INTERNAL ___ EXTERNAL ___

SINGLE ___ DOUBLE ___ BALANCED ___ UNBALANCED ___

BEARINGS WATER JACKETED: ☒ YES ☐ NO

LUBRICATION: OIL X GREASE ___

FLEXIBLE COUPLING: MAKE Fast — TYPE Model B

COUPLING GUARD: ☒ YES ☐ NO

DRIVER DATA – MOTOR

MAKE: West — HP: 50

TYPE: Ind. — R.P.M.: 3600

PHASE: 3 — CYCLE: 60 — VOLTS: 460

FRAME: 326TS

DRIVER DATA – TURBINE

MAKE: — H.P.:

TYPE: — R.P.M.:

WATER RATE @ DESIGN LOAD: ___ LBS/HR. BHP.

STEAM INLET: ___ P.S.I.G. ___ °F

STEAM EXHAUST: ___ P.S.I.G. ___ °F

NET WEIGHT

PUMP, BASE, CPLG.: ___ LB.

MOTOR: ___ LB.

SHIPPING WEIGHT

PUMP, BASE, CPLG.: ___ LB.

Special Instructions or Features:

Pump must meet API 610 specification.

THE BEN HOLT CO.

CENTRIFUGAL PUMP SPECIFICATION

CUSTOMER: USERDA
PLANT: Geothermal District Heating System — NO. REQUIRED: 3
LOCATION: Mammoth Lakes, California — MOTOR DRIVE: X
SERVICE: Hot Water Booster — TURBINE DRIVE: ___

JOB NO.: 7622
ITEM NO.: P-5B, C, D
REV. NO.: 1 — DATE: 7/26/77
QUOTE NO.: 7622-Q1
REFERENCE: ___

OPERATING CONDITIONS

LIQUID PUMPED: Fresh Water @ 200 °F
CAPACITY, AT TEMP., NORMAL: each 600 GPM — DESIGN: 600 GPM
AT TEMP., SP. GR.: 0.96 — VISC.: 0.3 — VAP. PR.: 11.5 P.S.I.A.
DISCH. PRESSURE: 280 P.S.I.G.
SUCT. PRESSURE: 30 P.S.I.G.
DIFF. PRESSURE: 250 P.S.I.
DIFF. HEAD: 602 FT.
NPSH AVAILABLE: 69 FT. (LIQUID)
NPSH REQUIRED: 10 FT. (WATER)
CORR. MATERIAL: ___ % OR ___ P.P.M. — EROSIVE MATERIAL: ___ % OR ___ P.P.M.
HYDRAULIC H.P.: 88

PUMP SPECIFICATIONS

MANUFACTURER: Goulds Pumps Inc. — NO. OF STAGES: 1
SIZE & TYPE: 3x6-13 DV 3736 — PERFORMANCE CURVE: 1821-3
R.P.M.: 3560 — EFFICIENCY: 60% — IMPELLER DIAM. BID: 12-1/8 MIN.: 9 MAX.: 13
BHP @ DESIGN: 146 — MAX. BHP. REQD.: 194 — RECOMMENDED DRIVER HP.: 200
CIRCULAR NO.: ___ — DIMENSION PRINT: X — SECTION DWG.: ___

MATERIALS OF CONSTRUCTION

CASING & NOZZLE: C.I.
IMPELLER: ___
CASING RING: ___
IMPELLER RINGS: ___
SHAFT: Alloy Steel
SHAFT SLEEVE: ___
PACKING GLAND: ___
PACKING: ___
SEAL CAGE: ___
BASE PLATE: ___

CONSTRUCTION FEATURES

CASE SPLIT HORIZONTAL: ___ VERTICAL: XX
SUPPORT C/L: ___ FOOT: XX BRACKET: ___
IMPELLER OPEN: ___ CLOSED: XX SEMI-ENG: ___
STUFF. BOX WATER JACKET: ☐ YES ☒ NO
MECH. SEAL: ___ INTERNAL: ___ EXTERNAL: ___
SINGLE: ___ DOUBLE: ___ BALANCED: ___ UNBALANCED: ___
BEARINGS WATER JACKETED: ☒ YES ☐ NO
LUBRICATION OIL: XX GREASE: ___
FLEXIBLE COUPLING: MAKE: Fast TYPE: Model B
COUPLING GUARD: ☐ YES ☐ NO

DRIVER DATA – MOTOR

MAKE: West. — HP: 200
TYPE: Ind. — R.P.M.: 3600
PHASE: 3 — CYCLE: 60 — VOLTS: 460
FRAME: 447TS

DRIVER DATA – TURBINE

MAKE: ___ H.P.: ___
TYPE: ___ R.P.M.: ___
WATER RATE @ DESIGN LOAD: ___ LBS/HR. BHP.
STEAM INLET: ___ P.S.I.G. ___ °F
STEAM EXHAUST: ___ P.S.I.G. ___ °F

NET WEIGHT

PUMP, BASE, CPLG.: ___ LB.
MOTOR: ___ LB.

SHIPPING WEIGHT

PUMP, BASE, CPLG.: ___ LB.

Special Instructions or Features: Pump must meet API 610 specification.

THE BEN HOLT CO.

CENTRIFUGAL PUMP SPECIFICATION

CUSTOMER: USERDA

PLANT: Geothermal District Heating System — NO. REQUIRED: 2

LOCATION: Mammoth Lakes, California — MOTOR DRIVE: X

SERVICE: Hot Water Booster — TURBINE DRIVE:

JOB NO.: 7622

ITEM NO.: P-5E, F

REV. NO.: 1 — DATE: 7/26/77

QUOTE NO.: 7622-01

REFERENCE:

OPERATING CONDITIONS

LIQUID PUMPED: Fresh Water @ 200 °F

CAPACITY, AT TEMP., NORMAL: 1800 GPM — DESIGN: 1800 GPM

AT TEMP., SP. GR.: 0.96 — VISC.: 0.3 — VAP. PR.: 11.5 P.S.I.A.

DISCH. PRESSURE: 280 P.S.I.G.

SUCT. PRESSURE: 30 P.S.I.G.

DIFF. PRESSURE: 250 P.S.I.

DIFF. HEAD: 602 FT.

NPSH AVAILABLE: 69 FT. (LIQUID)

NPSH REQUIRED: 22 FT. (WATER)

CORR. MATERIAL: ______ % OR ______ P.P.M.

EROSIVE MATERIAL: ______ % OR ______ P.P.M.

HYDRAULIC H.P.: 263

PUMP SPECIFICATIONS

MANUFACTURER: Goulds Pumps Inc. — NO. OF STAGES: 7

SIZE & TYPE: 8x14 JHO VIC (Vert. Turb.) — PERFORMANCE CURVE: 1145

R.P.M.: 1770 — EFFICIENCY: 83% — IMPELLER DIAM. BID: 10-7/8 MIN.: 8.5 MAX: 10-5/8

BHP @ DESIGN: 316.5 — MAX. BHP. REQD.: 321 — RECOMMENDED DRIVER HP.: 350

CIRCULAR NO.: — DIMENSION PRINT: X — SECTION DWG.:

MATERIALS OF CONSTRUCTION

CASING & NOZZLE: C.I.

IMPELLER: C.I.

CASING RING: C.I.

IMPELLER RINGS: C.I.

SHAFT: Alloy Steel

SHAFT SLEEVE: 11-13 Chrome

PACKING GLAND: C.I.

PACKING: J. Crane 101M or Eq.

SEAL CAGE: BKE

BASE PLATE: --

CONSTRUCTION FEATURES

CASE SPLIT: HORIZONTAL ______ VERTICAL: XX

SUPPORT: C/L ______ FOOT ______ BRACKET ______

IMPELLER: OPEN XX — CLOSED ______ — SEMI-ENC. ______

STUFF. BOX WATER JACKET: [ ] YES [X] NO

MECH. SEAL ______ INTERNAL ______ EXTERNAL ______

SINGLE ______ DOUBLE ______ BALANCED ______ UNBALANCED ______

BEARINGS WATER JACKETED: [ ] YES [X] NO

LUBRICATION OIL ______ GREASE: Mtr.

FLEXIBLE COUPLING: MAKE ______ TYPE ______

COUPLING GUARD: [X] YES [ ] NO

DRIVER DATA – MOTOR

MAKE: West. — HP: 350

TYPE: Ind — R.P.M.: 1800

PHASE: 3 — CYCLE: 60 — VOLTS: 2300

FRAME:

DRIVER DATA – TURBINE

MAKE: ______ H.P.: ______

TYPE: ______ R.P.M.: ______

WATER RATE @ DESIGN LOAD: ______ LBS/HR. BHP.

STEAM INLET: ______ P.S.I.G. ______ °F

STEAM EXHAUST: ______ P.S.I.G. ______ °F

NET WEIGHT

PUMP, BASE, CPLG.: ______ LB.

MOTOR: ______ LB.

SHIPPING WEIGHT

PUMP, BASE, CPLG.: ______ LB.

Special Instructions or Features: Pump must meet API 610 specification.

1. ELECTRICAL CHARACTERISTICS

The electrical characteristics of induction motors shall be as follows:

1.1 Below 1/2 HP: 120 Volt, single phase, 60 HZ.

1.2 1/2 HP to 200 HP: 460 Volt, three phase, 60 HZ.

1.3 250 HP and above: 2300 Volt, three phase, 60 HZ.
(See Spec. 3600-4)

1.4 Motors below 1/2 HP involved in process functions shall be 460 Volts.

2. ENCLOSURES

All 460 V motors shall be totally enclosed (TEFC) with vents and drain plugs.

3. INSULATION

Motors shall have a minimum of Class B insulation, and shall not exceed an 80°C rise above an ambient operating temperature of 80°F when operated continuously at full load.

4. TORQUE AND STARTING CURRENT

All motors not subject to special starting torque requirements such as loaded compressors, crushers, etc., shall be NEMA Design B.

5. SPECIAL MOTORS

Motors exceeding NEMA frame sizes or for applications exceeding normal starting torque requirements shall be covered by individual Specifications.

6. STANDARDS

Electrical motors covered by this Specification shall be designed, manufactured, and tested according to requirements of the IEEE, NEMA, and ANSI.

7. CONDUIT BOX

The motor conduit box on all motors shall be cast iron diagonally split with threaded hole for conduit.

8. BEARINGS

8.1 All motors shall have grease-lubricated ball bearings.

8.2 Bearings shall have a fitting and drain for addition of grease lubricant while running.

8.3 Ball bearings shall be vacuum-degassed steel, motor quality. Bearing design and grease used shall have a three-year life without regreasing at maximum bearing temperature resulting from maximum bearing load and service factor horsepower with 80°F ambient temperature.

8.4 Vertical motors shall have thrust bearings suitable for the thrust load imposed by the driven equipment. Bearings shall be rated for a five-year average life.

8.5 Motors shall be equipped with suitable seals to prevent moisture from entering through the shaft opening.

9. CONSTRUCTION

Motor construction shall be with cast iron feet, end bells and fan housing, industry standard for "Chemical Type", "Severe Duty".

10. SPACE HEATERS

10.1 Space heaters shall be manufacturer's standard size and shall operate at 120 Volts.

10.2 Space heaters shall be completely wired, with leads brought to the power lead terminal box.

11. APPLICATION

11.1 Unless otherwise stated, motors shall be suitable for operation outdoors at an elevation of 7,300' above sea level, ambient operating temperature of 80°F in a geothermal plant located at Mammoth Lakes Village, California.

EXCEPTION: Pumps P-5A through P-5F are at an elevation of 8,100' above sea level.

11.2 Standard guarantees shall apply.

12. EFFICIENCY

Jobsite operating efficiencies shall be stated in proposal.

13. DRAWINGS AND DATA AFTER ORDER

Motor Outline Drawings

All Motor Outline Drawings shall include location of the junction boxes, AC dimensions, type of enclosure, weight of motor and electrical data (horsepower, RPM, voltage, phases, frequency and efficiency at full, 3/4 and 1/2 load).

Motor Drawings shall also show the following.

Space heater watts, voltage, phases and connection box.

1. ELECTRICAL CHARACTERISTICS

Motors covered by this Specification shall be 250 HP and above, 2300 Volt, 3 phase, 60 Hertz induction type. (See Specification 3600-2 for smaller, 460 Volt motors.)

2. ENCLOSURES

2.1 All motors shall be WP-II as defined by NEMA MG-1-1.25H and shall be furnished with corrosion-resistant screens or louvers.

2.2 Motor fans shall preferably be suitable for rotation in either direction. They shall be of non-sparking, corrosion-resistant material, accurately balanced before assembly on shaft.

2.3 All horizontal motors shall be equipped with jackscrews for vertical adjustment during alignment.

2.4 All motors shall be equipped with a grounding bolt on the motor frame and sized for No. 2/0 AWG bare copper wire.

3. INSULATION

3.1 Motors shall have a full Class B sealed insulation, and shall not exceed an 80°C rise by resistance above an ambient operating temperature of 80°F when operated continuously at full load.

3.2 Sealed insulation shall withstand under water high potential tests in accordance with IEEE Standards.

4. TORQUE AND STARTING CURRENT

4.1 Unless specific load WK^2 values are given, motor torque characteristics shall conform to NEMA MG-1-20.41.

4.2 Motor starting current shall not exceed 650% of full load current when started at rated voltage. Motor shall be braced for full voltage starting.

5. APPLICATION

5.1 Unless otherwise stated, motors shall be suitable for operation outdoors at an elevation of 7,300' above sea level, ambient operating temperature of 80°F, and in a geothermal plant located at Mammoth Lakes Village, California.

EXCEPTION: Pumps P-5A through P-5F are at an elevation of 8,100' above sea level.

5.2 Load description, method of connection to drive, rotation, and any departure from stated ambient conditions shall be part of the inquiry.

5.3 Standard guarantees shall apply.

6. STANDARDS

Electric motors covered by this Specification shall be designed, manufactured, and tested according to the requirements of the IEEE, NEMA, and ANSI. All motors shall be suitable for installations conforming to the latest edition of The National Electrical Code.

7. CONDUIT BOX

7.1 Motors shall have weatherproof gasketed cast or heavy fabricated steel terminal boxes with threaded conduit entrances and sealed leads between motor housing and terminal box.

7.2 Adequate provisions shall be made for terminating cable, including suitable lugs, and space for stress cones for the cable specified by the purchaser.

8. BEARINGS AND LUBE OIL SYSTEM

8.1 Bearings shall be of the sleeve or thrust type as required and approved for the application. Bearings furnished shall have had five years of proven service.

8.2 Oil lubrication bearings shall have reservoirs of generous capacity effectively covered so no dust or other foreign materials can enter the bearing. Oil slingers and catchers shall be designed to prevent the escape of oil from the bearing and creepage along the shaft. Reservoirs shall be provided with drains, tapped fill openings, and separate level gauge glasses. A permanent indication of proper oil level shall be provided. Plastic oiler bottles, if used shall be inhibited against sunlight attack.

8.3 Sleeve-bearing motors will be coupled to driven equipment with limited-end-float couplings and shall have end play in accordance with NEMA Specification MG-I-6.11. Rotor end-play limits shall be indicated on motor outline drawing and shall be stamped on the motor nameplate or separate metal tags permanently fastened to the motor, or marked on the motor shaft.

8.4 The design of thrust bearings for vertical motors shall be submitted for Purchaser's approval. Vertical motors shall have thrust bearings suitable for the thrust load imposed by the driven equipment. Bearings shall be rated for a five-year average life.

8.5 Motors shall be equipped with suitable seals to prevent moisture from entering through the shaft opening.

8.6 Forced feed lubrication systems shall be provided on motors only when it is the motor Seller's recommendation and standard practice. When a forced feed lubrication system is furnished, complete information and details shall be furnished with the quotation. Oil pressure lubrication systems for bearings shall conform with the following minimum requirements.

8.6.1 The main lube oil pump may be driven from the motor shaft. Auxiliary lube oil pump and electric motor shall be interlocked to assure adequate oil pressure to the motor bearings for startup, coast-down or emergency.

8.6.2 Lube oil systems shall be arranged with dual oil filters, switchover valves and oil pressure gauges to indicate pressure differential across the filter.

8.6.3 Oil filters shall be replaceable while motor is in service.

8.6.4 Adequate cooling of the oil shall be provided by a oil cooler, or sufficient radiating service on the oil reservoir.

8.6.5 A sight flow indicator shall be provided in the oil return line to reservoir from each bearing.

8.6.6 All piping shall be seamless steel tubing with Swagelock fittings.

8.6.7 A dial-type thermometer shall be provided in each bearing outlet line.

8.6.8 A pressure switch shall be installed in the lube oil pump discharge for alarm and control functions. Contacts shall be separate for each function.

8.6.9 Motors with forced lubrication system shall be provided with one temperature switch on each sleeve bearing. Switch shall have one set of normally open and one set of normally closed contacts (rated 10 Amperes at 120 V.A.C.) that operate on high bearing temperature. Switch shall have a NEMA IV enclosure.

8.6.10 The motor lubrication system may be combined with that of the driven equipment system with Purchaser's approval.

9. RESISTANCE TEMPERATURE DETECTORS

9.1 Motors 1000 HP and larger shall have 6 (2 per phase) 120 ohm copper resistance temperature detectors in the stator winding with the leads brought out to a terminal block in a junction box separate from the main power leads box.

9.2 Motors 600 HP and larger shall have bearing temperature devices, resistance type for temperature monitoring only.

Note: A common junction box may be used for space heater leads and/or RTD leads.

10. MOTOR DIFFERENTIAL PROTECTION

Motors 1500 HP and above shall have 3 50/5 ratio window type current transformers, supplied and mounted in the motor junction box by the motor seller, for differential protection of the motor windings only. Motor leads T1 and T4 shall pass through one C.T., leads T2 and T5 through the second C.T. and T3 and T6 through the third C.T. T4, T5 and T6 are then connected together for the "Wye". Each C.T. secondary terminal shall be brought to terminal strips located in the main power leads junction box. The differential relays will be provided by the Purchaser.

11. LIGHTNING AND SURGE PROTECTION

Motors 1500 HP and larger shall be furnished with lightning arrestors and surge capacitors mounted in the main power leads junction box.

12. SPACE HEATERS

12.1 All motors shall have space heaters and shall operate at 230 Volts unless specified otherwise in writing.

12.2 Space heaters shall be completely wired, with leads brought to a terminal box separate from the power lead terminal box.

13. EFFICIENCY

Job site operating efficiencies shall be stated in proposal.

14. DRAWINGS AND DATA AFTER ORDER

Motor Outline Drawings

All motor outline drawings shall include location of the junction boxes, AC dimensions, type of enclosure, weight of motor and electrical data (horsepower, rpm, voltage, phases, frenquency and efficiency at full, 3/4 and 1/2 load).

Motor drawings shall also show the following when these items are specified.

14.1 Location and rating of all current transformers.

14.2 Space heater watts, voltage, phases and connection box.

14.3 Connection box and wiring for RTD's or other embedded temperature detectors.

15. TESTS

Standard commerical tests shall be done and copies of test shall be furnished.