PRESTON, IDAHO

Site Specific Development Analysis

P R E F A C E

Preston is a small, rural community located in southeastern Idaho, population 3,750. The geothermal resources in the area include two hot springs and several warm water wells. These resources are within 3 to 4 miles (4.8 to 6.4 km) of this Franklin County community.

Preston was selected for a site specific development analysis for the following reasons: it is located in an area favorable for the development of low-temperature ($<90^{o}C$) geothermal resources; and, the City of Preston requested assistance from the Idaho Office of Energy.

1.0 Introduction

A site specific development analysis is a qualitative and quantitative analysis of technical, economic, environmental, and institutional factors which influence the scale and timing of geothermal development. The analysis is based on current information available in the literature and reflects interest in geothermal development at Preston, Idaho. This study summarizes known information, estimates economic risk, and outlines institutional parameters which are site specific to the Franklin County area. The Preston Site Specific Development Analysis involves locating a production well field near the town of Preston and delivering that resource to both commercial and residential buildings for space heating purposes.

A review of current socio-economic data was conducted to determine the nature of the regional economy and the potentials for growth. Technical papers on space heating and the application of geothermal heat were reviewed to determine heat load, thermodynamics, and energy requirements of a district heating system. Resource data for the Franklin County area was provided by the Idaho Department of Water Resources, the U.S. Geological Survey, and the Idaho Bureau of Mines and Geology. Detailed resource geochemical information was compiled from reports issued by the Idaho Department of Water Resources.

Electricity, fuel oil, and natural gas are the principal energy forms available for space heating in Preston. The current cost of new electrical service is $16.17/MBTU. The average cost of fuel oil is $11.45/MBTU and the average cost of bottled gas is $10.45/MBTU. (All costs are weighted averages corrected for fuel efficiency. (See Table 4.6.2.) This study will estimate the range of development cost for geothermal energy and compare the cost of deliverable geothermal water for space heating with the current conventional energy forms available at Preston, Idaho.

2.0 Site Description

2.1 Location

Preston, Idaho in Franklin County is approximately 68 miles (108.8 km) southeast of Pocatello and 8 miles (12.8 km) from the Utah border. Bear River flows northeast of this Cache Valley community and U.S. Highway 91 passes north-south through the center of town. Figure 2.1.1 shows the location of Preston, Idaho.

The Preston geothermal area is located northwest of town. This area is believed to have significant thermal manifestations which are conducive to development.

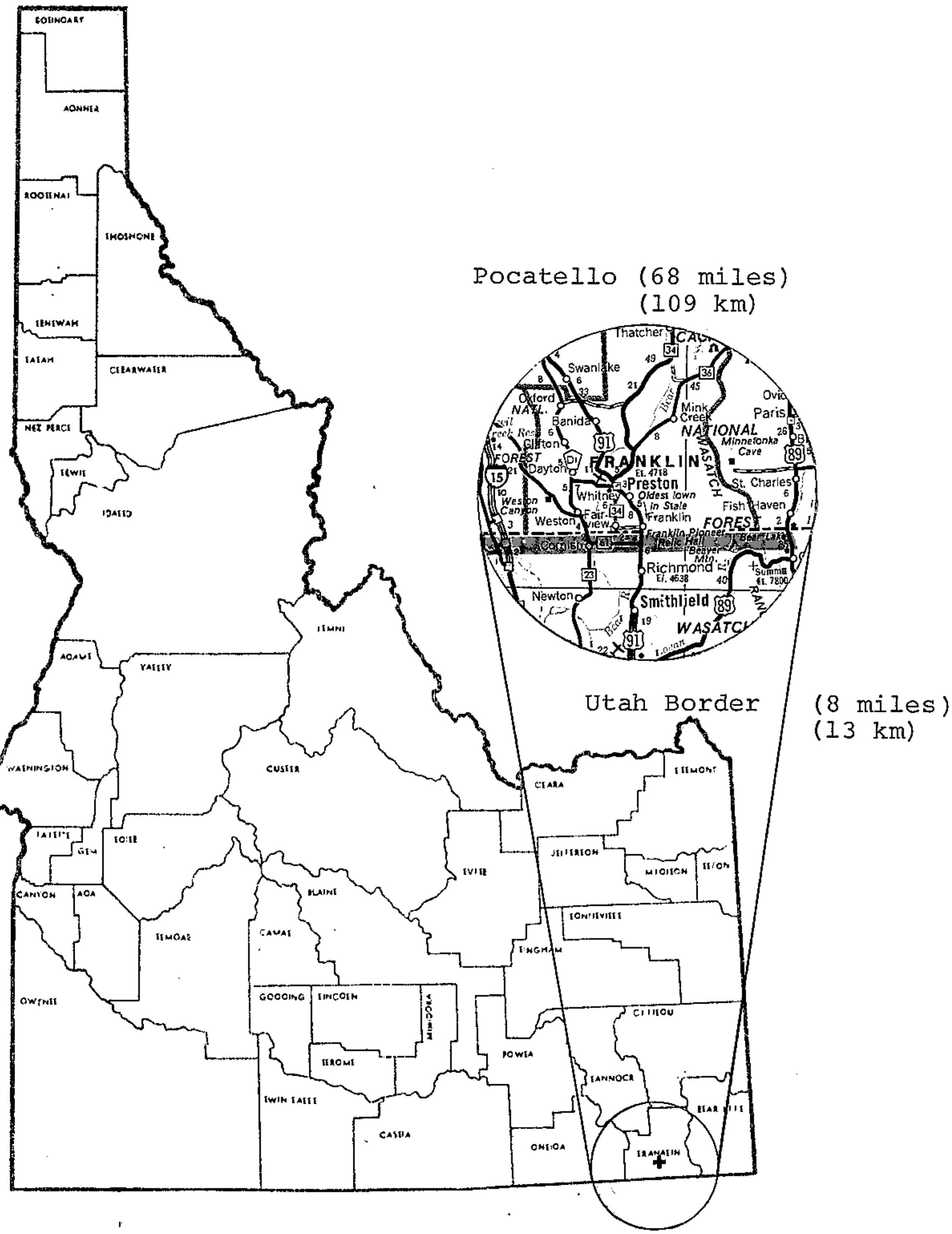


Figure 2.1.1.: Location of Preston, Idaho

TABLE 2.2

POPULATION FORECAST FOR FRANKLIN COUNTY

	1980	1985		1900		1995		2000	
Franklin	8,850	9,270	+ 5	9,700	+ 5	9,910	+ 2	10,240	+ 3
	8,725	9,875	+ 13	10,775	+ 9	11,250	+ 4	11,450	+ 2

% Change From 1980 Actual to 1990 and 2000

		Projected:
1980 - 1990[b] = +20%	1980 - 2000[b] = +45%	1990[b] - 2000 = 20%
1980 - 1990[c] + +20%	1980 - 2000[c] + +35%	1990[c] - 2000 = 12%

[a] U.S. Census Report, November 4, 1980

[b] Idaho Statistical Abstract, University of Idaho, 1980 - Based on data from Idaho Dept. of Water Resources and Boise State University Population and Employment Forecast - State of Idaho, July 1978.

[c] Population, Employment and Households Projected to 2000, U.S. Dept. of Energy, Bonneville Power Administration, February, 1980.

2.2 Demographics

The estimates of the future population of Franklin County and Preston are made on the basis of past trends. Many changes in circumstances especially in economic conditions, can change these trends. Local city and county population changes can vary from the trends of a larger area, such as the state. However, the usual experience is for the small area to follow a pattern set by the larger region.

Population change in the Preston area is related to federal and state estimates. Three estimates, high, medium, and low were made for the population of Idaho until 2000. All of these are based on preliminary and published estimates made by the Census Bureau and the Idaho Department of Water Resources. Population projections for Preston and Franklin County are based on the medium series of estimates of state growth.

Unless a significant oil or gas deposit is found in Franklin County, the growth is expected to reach 9270 by 1985. Past growth indicates an increase in Franklin County population of 17.1% between 1970 and 1978. Table 2.2 shows the population forecast for major communities in Franklin County.

2.3 Regional Economy

The economic activities of Franklin County were analyzed to provide a working knowledge of the present and past economic base, as well as to estimate the type of future activities which could occur. The economy dipped during the early 1970's but appears to be increasing now.

The major businesses in the Preston area include agriculture, state and local government and trade. Table 2.3 lists the major economic elements for Franklin County.

2.4 Employment

The Franklin County labor force increased 1.1% between 1970 and 1975. The percentage of females (16+) in the labor force increased, while total unemployment first rose, then declined to 5.7% in 1978. Typically, unemployment rates reflect the cyclical nature of agriculture. Therefore, unemployment rates are higher during the winter months than the summer. Table 2.4 shows an employment forecast for Franklin County.

TABLE 2.3

Economy - Franklin County

Percent of Average monthly unemployment - 1978:

Jan.	8.6%	Feb.	8.2%	Mar.	7.1%	Apr.	6.7%	May	6.2%	Jun.	7.0%
Jul.	5.1%	Aug.	4.5%	Sep.	3.1%	Oct.	3.4%	Nov.	4.9%	Dec.	5.2%

Percent of labor force unemployed: 1970 6.3% 1972 7.5% 1975 9.0% 1978 5.7%

Month and percentage of highest unemployemtn: 1975 Feb. - 12.9% 1978 Jan. - 8.6%

Month and percentage of lowest unemployment: 1975 Aug. - 4.7% 1978 Sep. - 3.1%

Percent of females (16+) in labor force: 1960 (14+) 21.7% 1970 30.1%

Employment (B.E. A. data)

Total employment	2,687	2,817	2,941	3,052
Farm proprietors	896	881	761	757
Non-farm proprietors	299	437	353	378
Wage and salary employment:				
Federal civilian	46	47	41	38
Military	2	3	56	56
State & local	326	347	447	463
Manufacturing	184	191	201	199
Mining	(D)	(D)	12	(D)
Construction	50	36	51	51
Trans., Comm. & Pub. Util.	98	(D)	105	110
Trade	418	408	283	302
Finance Insurance & Real Estate	37	30	55	73
Services	116	107	(D)	175
Other	(D)	(D)	24	27
Farm	183	197	208	218

(D) Not shown to avoid disclosure of confidential information

Average Idaho tax return (county) - 1978: $306

Average Idaho tax return (state) - 1978: $476

Market value of all property - 1979: $115,763,184

Total property tax collected - 1979: $ 1,650,134

Sales tax: 1974* $347,740 1975* $354,456 1977* $498,645
1979* $600,357

*Fiscal Year

Property tax as percent of market value: County - 1979 1.425% State - 1979 1.392%

Highest tax code area and the tax as a % of market value - 1979: Area (01-1)- 2.038

Per capita income:	1970	$2,673	1978	$5,553
% of national average:	1970	67.4%	1978	70.8%
% of state average:	1970	81.2%	1978	78.5%

Median family income - 1969: $6,456 Median family income* - 1976: $9,125

*HUD estimate

Transfer payments (thousands of dollars - county):

1970 $2,465 1974 $4,258 1975 $5,175 1978 $6,947

Number of business establishments - 1978: 138

TABLE 2.4

Employment Forecast

	1972	1975	1980	1985	1990	1995	2000
Agriculture	1045	1146	1063	977	897	836	780
Mining	3	3	3	3	4	4	4
Construction	56	64	82	90	99	111	124
Manufacturing	246	294	330	362	395	434	476
Trans., Comm. & Utils.	123	140	157	168	180	193	207
Whsle & Retail Trade	595	640	712	740	769	795	822
Finance, Ins. Real Estate	49	62	78	89	100	112	125
Services & Misc.	303	367	448	500	558	622	694
States Local Govt.	339	349	372	409	448	480	515
Federal Govt.	47	43	43	44	44	44	45
	2806	3108	3288	3381	3492	3631	3791

Forcast Summary

	1970	1975	1980	1985	1990	1995	2000
Total Population	7370	8010	8850	9270	9700	9910	10240
Total Employment	2800	3100	3280	3380	3490	3630	3790
Labor Force	3020	3190	3370	3430	3540	3670	3830

From: Population and Employment Forecast - State of Idaho, Series 2, 1975-2000, Department of Water Resources and Boise State University.

TABLE 2.5

Climatological Data for Preston, Idaho

Elevation	4815'
Years of Record	30
Mean Daily Temperature (^{O}F)	
January Minimum	11.2^{O}
January Maximum	32.5^{O}
July Minimum	50.5^{O}
July Maximum	90.2^{O}
Highest Temperature of Record	105^{O}
Lowest Temperature of Record	-36^{O}
Average Annual Days	
Maximum of 90^{O} or more	36
Minimum of 32^{O} or less	175
Average Precipitation, Inches	
Annual Precipitation	15.5
Annual Snowfall	56.0
January Precipitation	1.5
July Precipitation	.65
Average Annual Number	
Days with Precipitation	
.10 inches or more	62
.50 inches or more	12
Degree Days*	7075

*Heating Degree Days base 65^{O}F.

From: Idaho Climatological Summary Data by Counties. National Weather Service Climatology in cooperation with the Idaho Department of Commerce and Development, Boise, Idaho. October 1971.

2.5 Climate

The climate of Franklin County is characterized by warm summers and moderately cold winters. The growing season is about 118 days long and the annual mean temperature is 45.8°F. Table 2.5 lists the climatological data for Preston.

3.0 Resource Evaluation

3.1 Regional Geology

Preston, Idaho is located within the Basin and Range geomorphic province. The geothermal potential is high in this fault-dominated province because the faults act as natural conduits for water to be heated at depth and the thick sedimentary sequences that are characteristic of the province act as a thermal blanket for this heat source. Preston is also located within the Overthrust Belt which is a series of Proterozoic and Paleozoic rocks that include oil, gas and coal deposits. Because of this, much of the area around Preston has been leased for oil and gas exploration.

During the Quaternary, southeastern Idaho was inundated by the Lake Thatcher flood as well as the Great Bonneville Flood (Bright, 1963). The remnants of these floods are reflected in the present day landscape of the area.

Between the two distinct flooding episodes, the Gem Volcanics were intruded (Bright, 1963). A pillow flow from the Gem Volcanics is exposed on Little Mountain (Figure 3.1.1). Also exposed on Little Mountain is the Tertiary Salt Lake Formation, which is a sequence of tuffs, tuffaceous sandstones and conglomerates.

Figure 3.1.1 also shows two suspected faults on either side of Little Mountain. From EROS false color infrared Landsat EDISE imagery, it is hypothesized that a major NW-NE lineament is located approximately where Bear River flows through its channel. These structural features probably control the hydrothermal manifestations in the area.

3.2 Hydrology

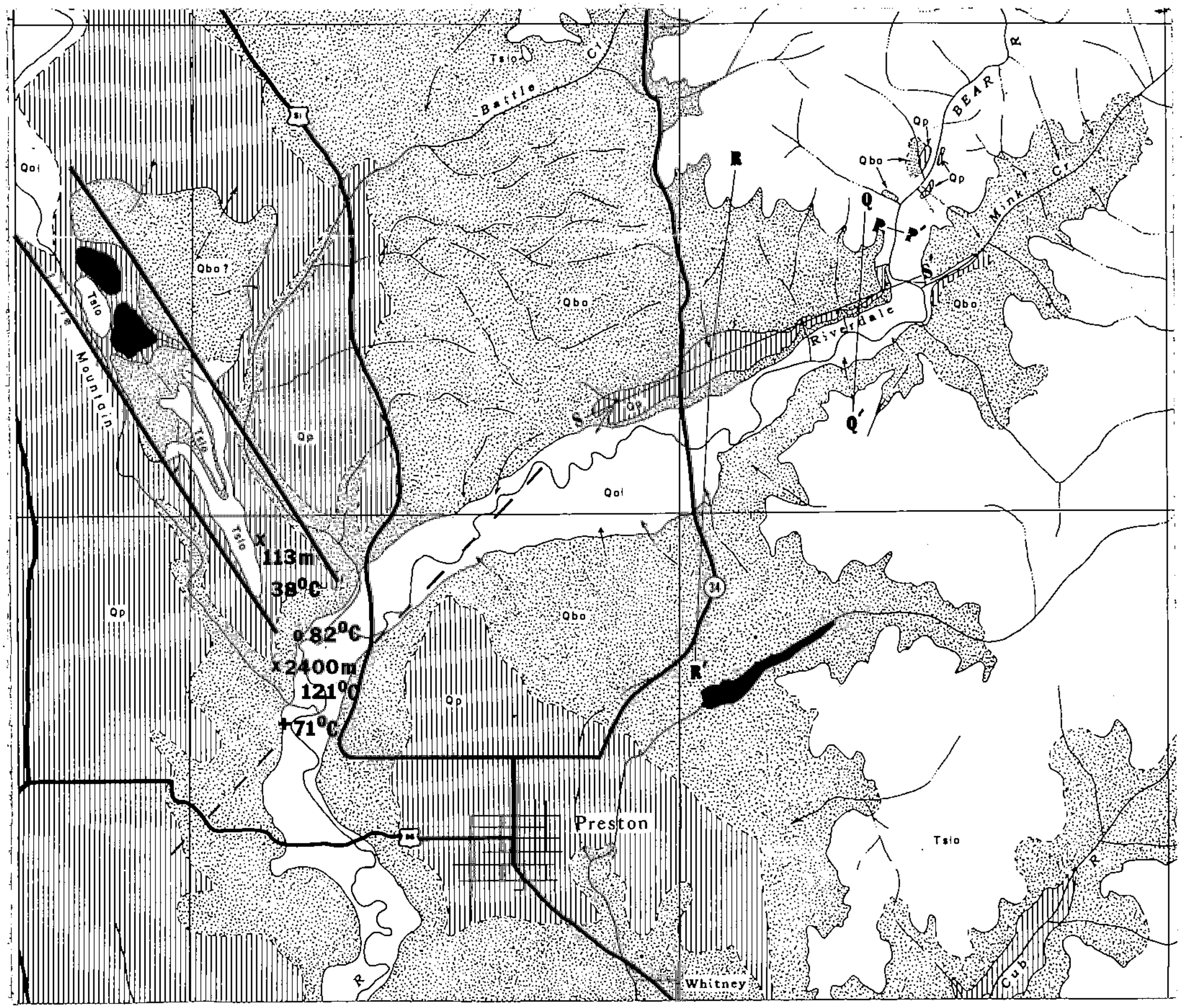
Most of the wells that have been drilled for domestic and irrigation purposes are below 300' (90 m) and are drilled into a sedimentary aquifer. A complete listing of available driller's logs are found in Appendix A.

The Cache Valley is drained by numerous streams that are tributaries to the Bear River. Precipitation (recharge) is by snow and rainfall.

3.3 Hot Springs and Wells

There are two hot springs near Preston, Battle Creek Hot Springs and Squaw Creek Hot Springs, Figure 3.1.1. Battle Creek

FIGURE 3.1.1



Explanation:

Quaternary

Qal	Alluvium	Lake Bonn Gp
Qp	Provo Fm.	
Qbo	Bonneville Fm.	
Qgvpi	Pillow flow-Gem Volcanics	

Tertiary

Tslo Salt Lake Group & older

✚ Squaw Creek Hot Springs
o Battle Creek Hot Springs
--- Cache Valley Lineament

Modified from: Bright, R.C., 1963, Pleistocene Lakes Thatcher and Bonneville, Southeastern Idaho: PhD Thesis, U. o[f] Minn., 150 p.

TABLE 3.4.1
FRANKLIN COUNTY
GEOCHEMISTRY OF SELECTED HOT SPRINGS AND WELLS AROUND
PRESTON, IDAHO
From: Mitchell, J.C. and others, 1979.

	Eldin Bingham	Battle Creek HS	Battle Creek HS
	15S 39E 7DBC1	15S 39E 8BC1S	15S 39E 8BC2S
Discharge l/min	38	189	8176
T^oC	63	82	43
Depth	0	0	0
SiO_2	68	109	107
Ca	320	174	166
Mg	36	19	15
Na	4600	3161	3071
K	770	552	535
HCO_3	930	696	697
CO_3	0.0	0.0	0.0
SO_4	48.0	35.0	29.0
PO_4	0.12	0.01	0.01
Cl	7800	5241.0	5048.0
F	3.9	6.0	6.0
NO_3	0.0	.11	0.42
B	0.0	7.6	7.3
NH_3	4.4	3.5	3.4
Spec. Cond.	27999	16619	15439
pH (field)	6.7	6.7	6.5
TDS	14103	9639	9320
Carbonate	946	512	476
Non-Carbonate	184	0	0
Alkilinity as $CaCO_3$	762	570	571
% Na	83.8	84.9	85.2
SAR	65.0	60.8	61.2
Cation-Anion Balance	0.469	0.613	0.786

TABLE 3.4.1 (Continued)

	Battle Cr. H.S. 15S 39E 8BDC3S	Battle Cr. H.S. 15S 39E 8BCD4S	Squaw H.S. Well 15S 39E 17BCD1
Discharge l/min	0	19	435
$T^{o}C$	81	84	84
Depth	0	0	2
SiO_2	109	97	124
Ca	162	215	279
Mg	19.0	24	24
Na	3053	4184	4368
K	533	686	782
HCO_3	757	610	791
CO_3	0.0	0.0	0.0
SO_4	37.0	33	35
PO_4	0.01	0.01	0.02
Cl	5034	6967	7398
F	6.0	6.4	4.3
NO_3	0.28	0.06	0.12
B	7.2	10	8.1
NH_3	3.6	5.3	4.3
Spec. Cond.	15949	18479	20459
pH (field)	6.5	6.8	6.5
TDS	9325	12512	13403
Carbonate	482	635	795
Non-Carbonate	0	135	147
Alkilinity as $CaCO_3$	620	500	648
% Na	85.1	85.7	84.1
SAR	60.5	72.2	67.4
Cation-Anion Balance	.318	1.255	0.836

TABLE 3.4.1 (Continued)

	Squaw H.S. 15S 39E 17BDC1S	Squaw H.S. 15S 39E 17BDC2S
Discharge l/min	140	450
T^oC	69	73
Depth	0	0
SiO_2	126	126
Ca	271	241
Mg	23	26
Na	4184	3844
K	708	533
HCO_3	816	866
CO_3	0.0	0.0
SO_4	27.0	23.0
PO_4	0.03	0.02
Cl	6877	6396
F	4.3	4.8
NO_3	0.16	0.06
B	7.3	9.7
NH_3	4.2	4.6
Spec. Cond.	20519	16859
pH(field)	6.5	6.6
TDS	12621	11619
Carbonate	771	708
Non-Carbonate	102	0
Alkilinity as $CaCO_3$	669	710
% Na	84.4	85.7
SAR	65.6	62.8
Cation-Anion Balance	1.833	0.046

Hot Springs is comprised of one large pool and numerous vents and seeps that are actively depositing travertine. The springs were used for hog carcass scalding and for recreational purposes.

Squaw Creek Hot Springs consists of one well and many seeps. CO_2 is emitted in places giving the appearance of boiling water. Both calcareous and siliceous deposits are forming around the vents and wellhead. At one time the springs were used for recreation until the health authorities closed it down. Presently a hog barn is being heated by a small amount of water that is diverted from the well.

A warm water well that was drilled by Little Mountain, Figure 3.1.1, encountered 32°C (100°F) at 112.5m(375'). Because the individual was drilling for cold water, the well was abandoned by filling the well with driller's mud.

Also shown in Figure 3.1.1 are test wells drilled by Sunoco. The deepest of these wells was 2400m(8000'). At approximately 1500m(5000'), 121°C(250°F) water was encountered. The 121°C (250°F) aquifer was below several meters of Brigham Quartzite which was very difficult to drill through. Drilling continued to 2400m(8000') in hopes of finding 204°C(400°F) water. Unfortunately, the hotter water was not discovered. The well was isothermal to the total depth. Because the hotter water was not found, all of the test holes were abandoned with cement.

There have been other wells drilled in the area by oil companies. However, the results are unavailable at this time.

3.4 Geochemistry

The geochemistry of the Eldin Bingham well, Battle Creek Hot Springs and Squaw Creek Hot Springs are found in Table 3.4.1. It is important to note that the total dissolved solids (TDS) are high in these waters. This could pose a corrosion problem in respect to the pipes and pumps needed for a district space heating system or for any other utilization of the resource.

3.5 Site Selection

The most likely place to drill for hot water would be in the vicinity of the Sunoco wells and hot springs, Figure 3.1.1. Not only are the hot springs an indication of hot water at depth but the two NW trending faults that intersect with the Cache Valley linement are structural indicators of the possible presence of hot water. Faulting and the relationship to hot water in the Basin and Range province were discussed in a previous section.

4.0 Site Specific Application

Following is a preliminary outline of a geothermal district heating system for the City of Preston, Idaho, which makes use of the geothermal resource in the area known as Squaw Springs northwest of the city.

The system outlined in this report has six production wells, a transmission system to distribute geothermal water around the city, and a set of return pipes which will carry used geothermal water to a set of four disposal wells. While pipes for supply and disposal are carried throughout the city, the individual hookups to homes and commercial establishments are not included as part of the overall cost estimate. Costs of individual hookups and retrofit of existing heating systems will be similar to that of new conventional systems, so ultimately some thought must be given to ways to help individuals defray or spread these costs over time.

A fund of one and one-half million dollars might be set up as part of the eventual financing package to provide loans of about $1000 to the approximately 1500 customers of the heating system for retrofit. Some sort of incentive like a loan fund with attractive terms may be needed to encourage a rapid rate of conversions from conventional fuel sources to the new geothermal system.

This system was designed only to provide preliminary cost data on which to base projections of economic feasibility. Favorable evidence on the economic feasibility of a geothermal district heating system for Preston needs to be followed up with more detailed engineering work on the design of an actual system.

A summary capital cost breakdown for the system is found in Table 4.0.

4.1 Considerations for Direct Use of Geothermal Energy

The first step in a feasibility analysis of this kind is to identify potential applications of the resource. After technical possibility has been established one must compare supply and demand for heat as they appear in the particular applications. (See Table 4.1.) On the supply side one must identify the probable resource temperature, temperature drop, and flow rate to determine how much heat will likely be available, both over a year and on a peak hourly basis. On the demand side one needs to examine the details of the space heating system to determine the yearly and peak heat loads. If the projected supply of BTU's available form the geothermal resource is sufficient to cover probable heat demands one can then move on to examination of the actual cost and potential profitability of using geothermal heat instead of more conventional fuel sources.

TABLE 4.0

CAPITAL COST BREAKDOWN

I.	Transmission System (see 4.5.1)	
	Pipeline to town	$ 920,000
	Town perimeter	500,000
	Laterals	375,000
		$1,795,000
II.	Production System (see 4.5.2)	
	Six wells	99,000
	Pumps	108,000
		207,000
III.	Disposal System (see 4.5.3)	
	Pipeline	40,000
	Four wells	94,200
	Pumps	72,000
		206,200
IV.	Retrofit Loan Fund	1,500,000
	TOTAL	$3,708,200 *

*Amortized oever 30 years at 10% requires yearly debt service of $390,373.

*Deep wells make amortization $729,488 by adding $3,375,624 as the cost of production system (II.) for a total of $6,876,824.

TABLE 4.1

HEATING SUPPLY vs. HEAT DEMAND

	Peak (BTU/hr)	Annual (BTU/yr)
Heat Supply (Six wells at 650 gpm and 180°F)	7.4×10^7	6.5×10^{11}
Heat Demand	7.4×10^7	2.0×10^{11}

4.2 Potential Resource Application

Use of geothermal heat instead of a conventional fuel source would generate savings. For purposes of this paper, savings represent the dollar amounts of conventional fuels needed to meet the space heating demand in Preston. The number of BTU's required to meet projected space heating demand is multiplied by the price per usable BTU (price after correction for conversion efficiency) for conventional fuels to get the dollars' worth of conventional fuels required. Since these dollars' worth of conventional fuels are not spent after conversion to geothermal they represent the gross savings from geothermal. To arrive at the net savings (used in Table 4.6.3) the added costs due to geothermal must be subtracted from the gross saving.

4.3 Heat Available

Economical temperature drop across a heat exchanger is estimated by the equation:

$$\Delta t = (.6 \times \text{temperature}) - 70^{\circ}F$$

with a $83^{\circ}C$ ($180^{\circ}F$) resource this gives a temperature drop (Δt) of $22^{\circ}C$ ($38^{\circ}F$). The quantity of heat available from a single 650 gpm well is given by the equation:

$$Q = 500\ (\Delta t)\ \dot{W},$$

Q = quantity in BTU/hr
t = temperature drop
$\dot{W}$ = flow in gpm

$$Q = 500\ (38^{\circ}F)\ 650\ \text{gpm}$$
$$= 1.24 \times 10^{7}\ \text{BTU/m}$$

Multiplying this peak heat supply by 8760 hours per year gives the total yearly amount of heat available, 1.08×10^{11} per year.

4.4 Heat Load Estimated for Preston

Heat load estimates were derived using the methodology developed by the Oregon Institute of Technology for their assessment of geothermal potential within the BPA marketing area. This methodology requires input of degree days, population, and design temperatures. Actual heating loads depend on these input variables in combination with assumed saturation rates for various types of space or water heating.

This methodology generates separate estimates for residential and commercial sectors for both space and water heating from both electricity and fossil fuels. Heat load estimates generated in this fashion give a weight of about 75% to residential use and 25% to commercial use. This sectoral breakdown is roughly consistent with that in other small Idaho cities where more complete enumeration of heat loads was possible.

The total heating demand for Preston, for both space and water heating is about 2.0×10^{11} BTU's per year using the OIT methodology. Estimates of this magnitude are comparable to numbers generated using EG&G's Rules of Thumb for geothermal space heating. These estimates are also close to numbers generated by New Mexico Energy Institute's Direct-Use Model. For all the above reasons these heat load estimates seem reasonable.

Water records show 1196 residential hookups and 197 commercial hookups in Preston - 93 of these are combined business and residential use. Alternatively, dividing population of 3750 by average household size of 2.4 gives about 1500 households. Using this approximate number of households and Rules of Thumb which estimate residential use based on design temperature and average insulation one gets a design (peak) heat load of slightly less than 8×10^7 BTU's per hour, also consistent with numbers derived using the OIT methodology. The relation between design heat load on an hourly basis and annual heat load is specified by the annual utilzation figure of 31%. This figure represents the degree of excess capacity characteristics of space heating which utilize only a small fraction of total available heat from a geothermal well system. Any off peak (summer) uses of geothermal water would add to revenues generated by the system. By allowing fuller utilization of available capacity they would help spread the costs over more uses, thus improving the overall economics of the system.

4.5 Proposed Facilities

4.5.1 Transmission System

The transmission system is made up of three distinct parts. A large main line will run from the production well site to town, capable of carrying the entire 246 l/s (3900 gpm) needed for peak heating load. This pipe will be 7010 m (2300 feet) long and 35.6 cm (14 in.) in diameter and cost will be $131 per meter ($40 per foot).

At the edge of town the pipeline will split to form a rectangular perimeter. This line capable of carrying 126 l/s (2000 gpm), will be 6096 m (20,000 feet) in length and 25.4 cm (10 in.) in diameter, at a cost of $82 per meter ($25 per foot).

Finally there will be laterals in the main town, five in all, for a total distance of 7620 m (25,000 feet). This pipe will be 10 cm (4 in.) in diameter, capable of carrying up to 25 l/s (400gpm) and costing $49 per meter ($15 per foot). The complete transmission pipe network is outlined in Figure 4.5.1.

All pipe cost estimates and capacities are for Amerson Bondstrand pipe and pre-insulated FRP pipe in a PVC jacket with polyurethane foam insulation.

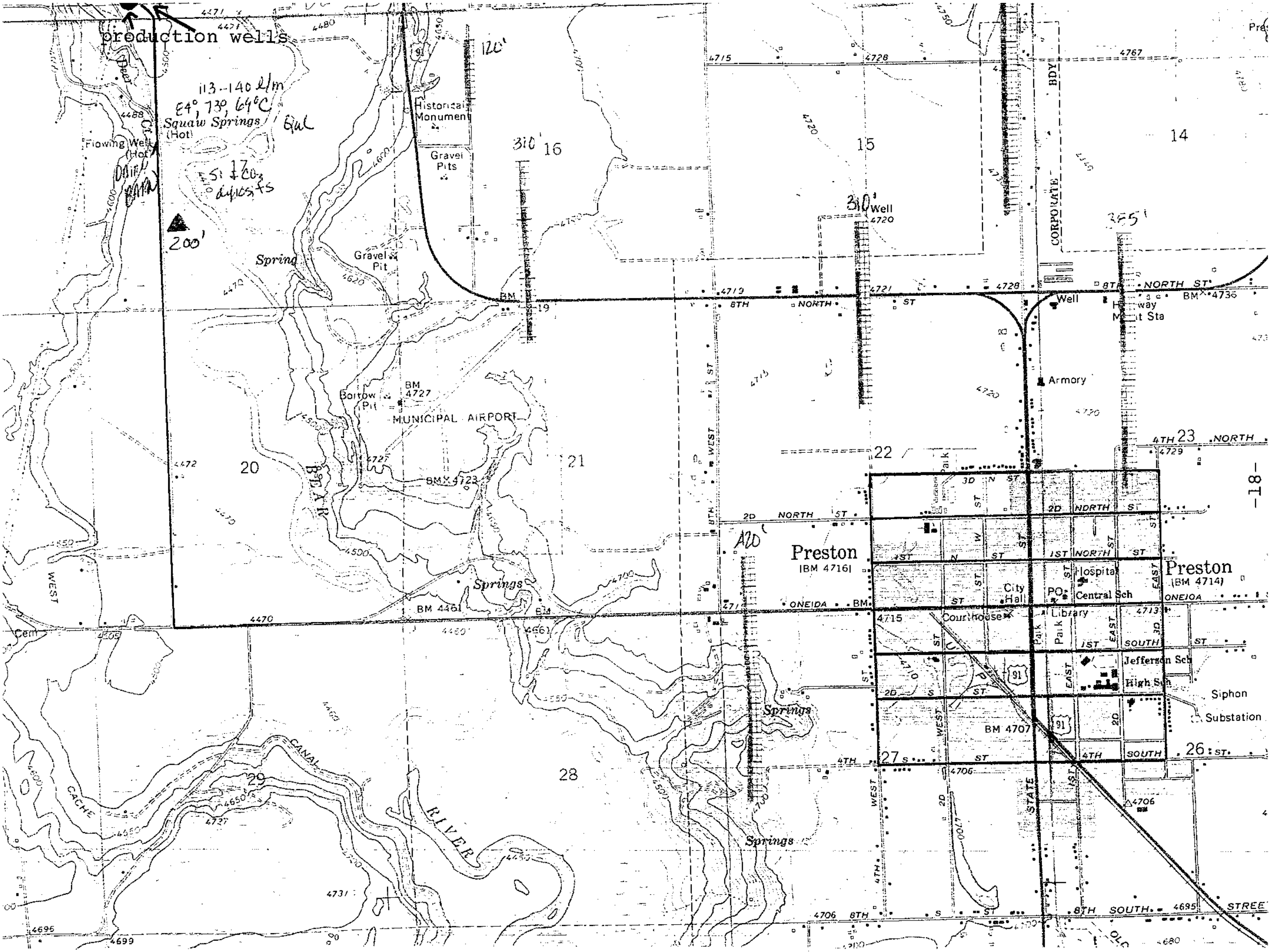

production wells
113-140 l/m
E4°, 73°, 64°C
Squaw Springs (Hot)
Flowing Well (Hot)
17
CO2 deposits
200'
Spring
Gravel Pit
Historical Monument
Gravel Pits
120'
310' 16
15
310' Well 4720
14
CORPORATE BDY
385'
8TH NORTH ST
Well
Armory
Borrow Pit
BM 4727
MUNICIPAL AIRPORT
BEAR
20
21
22
23
BMX 4723
Springs
BM 4461
ONEIDA
Preston (BM 4716)
Preston (BM 4714)
420'
City Hall
PO
Central Sch
Hospital
Library
Courthouse
Park
Jefferson Sch
High Sch
Siphon
Substation
BM 4707
STATE
28
29
27
26
CANAL
CACHE
RIVER
Springs
8TH SOUTH
Cem
WEST

FIGURE: 4.5.1

4.5.2 Supply System

Six 41 l/s (650 gpm) wells would be drilled near the site of the present Squaw Springs. The wells are assumed to be 91 m (300 ft) deep, with a temperature of 83°C (180°F).

Each well is to be drilled 35.6 cm (14 in.) to 30.5 m (100 ft.) with 25.4 cm (10 in.) casing, then 3.5 cm (12 in.) to the 91 m (300 ft.) level with 20 cm (8 in.) production casing back to the surface.

Drilling costs are estimated to be \$3.20/cm/m (\$2.50/in/ft) for the entire depth of drilling. Casing costs are estimated to be \$1.37/cm/m (\$1.05/in/ft) for the entire depth of the well. A 25% contingency figure was added to bring the total cost of the well to an estimated \$16,500, or \$180 per meter (\$55 per foot) for a drilled and cased well.

Downhole vertical turbine pumps of 25 horsepower are to be used to supply water from the wells to the distribution system. Each of these pumps with its associated valves and fittings is estimated to cost \$18,000. Each pump would consume an average of 50,728 KWH per year. At an average cost of 2.5¢ per KWH and a 31% load factor this means about \$1275 per pump per year for electricity.

An alternative to utilizing the apparent shallow low temperature resource would be to drill deeper in hopes of encountering a hotter temperature. Preliminary geology and data from oil and gas wells in the area suggest a possibility of 121°C (250°F) water at about 1524 m (5000 feet).

Deep well costs are estimated using an IOE generated equation as the predictor. This equation, cost = 7604 + 103 (depth), predicts a cost of \$522,604 for a 1524 m (5000 ft.) well.

Pumps for this deeper well would be more expensive than for the shallow well, running about \$40,000 each for the pump and accessories. Assuming the static water level in the well stays constant the annual pumping cost would essentially be the same as for the shallower well.

4.5.3 Disposal System

Four disposal wells would be drilled to handle disposal of the spent geothermal fluid. Each well would be drilled 46 cm (18 in.) to a depth of 15 m (50 ft.) and cased with 40.6 cm (16 in.) casing. Drilling of a 35.6 cm (14 in.) hole would continue to 152 m (500 ft.) with this reach left uncased. Using the same drilling and casing costs plus the 25% contingency figure results in an estimated cost of \$23,550 per disposal well. The disposal system would be identical regardless of the depths of the production wells used.

Pumping costs are assumed to be the same as for production pumps, \$1275 per year. Exact location of the injection wells is not specified in this report. However, disposal will require a 35.6 cm (14 in.) main

TABLE 4.6.1

20 YEAR PROJECTION OF GEOTHERMAL COSTS

Years	(1) Amortization	(2) Electric Power	(3) Operations	(4) Total Geothermal Cost	(5) Cost per 10^6 BTU
1981	$390,373	16,639	12,750	419,762	2.10
1982	390,373	17,804	13,834	422,011	2.11
1983	390,373	19,050	15,010	424,433	2.12
1984	390,373	20,383	16,285	427,041	2.14
1985	390,373	21,810	17,670	429,853	2.15
1986	390,373	23,337	19,172	432,882	2.16
1987	390,373	24,971	20,801	436,145	2.18
1988	390,373	26,719	22,569	439,661	2.20
1989	390,373	28,589	24,488	443,450	2.22
1990	390,373	30,590	26,569	447,532	2.24
1991	390,373	32,731	28,828	451,932	2.26
1992	390,373	35,023	31,278	456,674	2.28
1993	390,373	37,474	33,936	461,783	2.31
1994	390,373	40,097	36,821	467,291	2.34
1995	390,373	42,904	39,951	473,228	2.37
1996	390,373	45,908	43,347	479,628	2.40
1997	390,373	49,121	47,031	486,525	2.43
1998	390,373	52,560	51,029	493,962	2.47
1999	390,373	56,239	55,366	501,978	2.51
2000	390,373	60,175	60,072	510,620	2.55
2001	390,373	64,388	65,179	519,940	2.60

(1) Capital cost of $3,708,200 amortized over 30 years at 10%.
(2) Electricity for pumps, escalated 8.5% per year.
(3) Estimated at ½% of pipe cost plus 2% of pump and well cost, escalated 7% per year.
(4) Sum of columns (1), (2), and (3).
(5) Column (4) divided by 2.0×10^5 BTU's to convert to 10^6 BTU's.

ADDENDUM:

Deep wells make the amortization $729,488 ($6,876,824 over 30 years at 10%). This figure raises total geothermal cost to $758,877 in 1981 and $859,055 in 2001. The cooresponding costs per 10^6 BTU are $3.79 in 1981 and $4.30 in 2001.

TABLE 4.6.2

COMPARISON OF FUEL COST PER 10^6 BTU's

Years	(1) Bottled Gas	(2) Electricity	(3) Fuel Oil	(4) Geothermal
1982	$10.45	$16.17	$11.75	2.10
1983	11.34	17.54	12.69	2.11
1984	12.30	19.04	13.71	2.12
1985	13.35	20.65	14.80	2.14
1986	14.48	22.41	15.99	2.15
1987	15.71	24.31	17.26	2.16
1988	17.05	26.38	18.65	2.18
1989	18.50	28.62	20.14	2.20
1990	20.07	31.08	21.75	2.22
1991	21.78	33.70	23.49	2.24
1992	23.63	36.56	25.37	2.26
1993	25.64	39.67	27.40	2.28
1994	27.81	43.04	29.59	2.31
1995	30.18	46.70	31.96	2.34
1996	32.74	50.67	34.51	2.37
1997	35.53	54.97	37.27	2.39
1998	38.55	59.65	40.25	2.43
1999	41.82	64.72	43.48	2.47
2000	45.38	70.22	46.95	2.51
2001	49.24	76.19	50.71	2.60

(1) Price of 69.9¢ per gallon divided by .8 to adjust for conversion efficiency, multiplied by 11.96 to convert to 10^6 BTU's, escalated 8.5%

(2) Weighted average residential rate (from Utah Power & Light) of 5.5176¢ per KWH multiplied by 293 to get to 10^6 BTU's, escalated 8.5%.

(3) Price of $1.14 per gallon divided by .7 to adjust for conversion efficiency, multiplied by 7.2 to convert to 10^6 BTU's, escalated 8%.

(4) See column (5) of Table 4.6.1.

TABLE 4.6.3

20 YEAR OPERATING COST SAVINGS (SHALLOW WELLS)

Year	(1) Gas	(2) Electric Power	(3) Operations & Maintenance	(4) Geothermal Savings	(5) Present Value At 10%
1982	2,090,000	12,750	16,639	2,060,611	1,873,282
1983	2,267,650	13,834	17,804	2,236,012	1,847,943
1984	2,460,400	15,010	19,050	2,426,340	1,822,945
1985	2,669,534	16,285	20,383	2,632,866	1,798,282
1986	2,896,445	17,670	21,810	2,856,965	1,773,950
1987	3,142,642	19,172	23,337	3,100,133	1,749,944
1988	3,409,767	20,801	24,971	3,363,995	1,726,261
1989	3,699,597	22,569	26,719	3,650,309	1,702,896
1990	4,014,063	24,488	28,589	3,960,986	1,679,844
1991	4,355,258	26,569	30,590	4,298,099	1,657,103
1992	4,725,455	28,828	32,731	4,663,896	1,634,667
1993	5,127,119	31,278	35,023	5,060,818	1,612,532
1994	5,562,924	33,936	37,474	5,491,514	1,590,696
1995	6,035,773	36,821	40,097	5,958,855	1,569,152
1996	6,548,813	39,951	42,904	6,465,958	1,547,898
1997	7,105,463	43,347	45,908	7,016,208	1,526,931
1998	7,709,427	47,031	49,121	7,613,275	1,506,245
1999	8,364,728	51,029	52,560	8,261,139	1,485,838
2000	9,075,730	55,366	56,239	8,964,125	1,465,706
2001	9,847,167	60,072	60,175	9,726,920	1,445,844
2002	10,684,176	65,179	64,388	10,554,609	1,426,250
			Total	$110,363,633	$34,444,209

(1) Annual heat load estimate (2.0 x 10^{11} BTU/yr) divided by 10^6 BTU, times $10.45, escalated 8.5%.
(2) Electricity for pumps, escalated 8.5% per year.
(3) Estimated at 1/2% of pipe cost plus 3% of well and pump cost, escalated 7% per year.
(4) Column (1) minus columns (2) and (3).
(5) Column (4) discounted at 10% to present value.

TABLE 4.6.4

20 YEAR OPERATING COST SAVINGS (DEEP WELLS)

Years	(1) Gas	(2) Electric Power	(3) Operations & Maintenance	(4) Geothermal Savings	(5) Present Value at 10%
1982	$2,090,000	12,750	80,011	1,997,239	1,815,671
1983	2,267,650	13,834	85,612	2,168,204	1,791,904
1984	2,460,400	15,010	91,605	2,353,785	1,768,433
1985	2,669,534	16,285	98,017	2,555,232	1,745,257
1986	2,896,445	17,670	104,878	2,773,897	1,722,371
1987	3,142,642	19,172	112,220	3,011,250	1,699,772
1988	3,409,767	20,801	120,075	3,268,891	1,677,457
1989	3,699,597	22,569	128,480	3,548,548	1,655,423
1990	4,014,063	24,488	137,474	3,852,101	1,633,666
1991	4,355,258	26,569	147,097	4,181,592	1,612,184
1992	4,725,455	28,828	157,394	4,539,233	1,590,973
1993	5,127,119	31,278	168,411	4,927,430	1,570,031
1994	5,562,924	33,936	180,200	5,348,788	1,549,353
1995	6,035,773	36,821	192,814	5,806,138	1,528,937
1996	6,548,813	39,951	206,311	6,302,551	1,508,780
1997	7,105,463	43,347	220,753	6,841,363	1,488,879
1998	7,709,427	47,031	236,206	7,426,190	1,469,232
1999	8,364,728	51,029	252,740	8,060,959	1,449,834
2000	9,075,730	55,366	270,432	8,749,932	1,430,683
2001	9,847,167	60,072	289,362	9,497,733	1,411,777
2002	10,684,176	65,179	309,617	10,309,380	1,393,112
			TOTALS	$ 107,520,436	$ 33,513,729

(1) Annual heat load estimate (2.0 X 10^{11} BTU/yr) divided by BTUs times $10.45, escalated 8.5% per year
(2) Electricity for pumps escalated 8.5% per year
(3) Estimated at 1/2% of pipe cost plus 2% of well and pump cost, escalated 7% per year
(4) Column (1) minus columns (2) and (3)
(5) Column (4) discounted at 10% to present value

and 15.2 cm (6 in.) connections to each of the four separate disposal wells. These pipes can be uninsulated and so will be cheaper than pipes used for the production system. This type of pipe costs roughly \$1.37/cm/m (\$1.00/in./ft.).

Assuming a disposal site can be located within a quarter mile of town, means disposal pipeline would cost roughly \$40,000.

4.6 Cost Analysis

A 20-year projection of geothermal costs per 10^6 BTU's is found in Table 4.6.1. For this system total geothermal cost is the sum of amortization (debt service on the capital outlay of \$3,708,200) plus operations and maintenance expense plus electric power to run the pumps. This total cost is allocated over yearly usage of 2.0×10^{11} BTU's to arrive at a figure which allows for easy comparison with conventional fuel costs.

Comparison with conventional fuels is carried out in Table 4.6.2. This table makes the comparison in terms of fuel cost per 10^6 BTU's with correction for fuel conversion efficiency. The projected geothermal cost is \$2.10 per 10^6 BTU's, 20% of the cost of bottled gas and even less compared with the other alternatives.

The projected geothermal system offers BTU's at a very competitive cost, with the margin of competitiveness rising over time as conventional fuel costs rise faster than geothermal costs. The projections of conventional fuel costs are all based on a study by Dames and Moore for the Idaho Public Utilities Commission in 1977. There is now ample evidence that these projections are much too low.

Keep in mind that if a case for geothermal heat can be made with these rates of increase for conventional fuel alternatives, <u>which we know are very conservative</u>, actual increases beyond these low projections only serve to enhance the competitiveness of geothermal heat.

Table 4.6.3 projects yearly operating cost savings from the use of geothermal heat. In this case the amortized capital cost is not used since the object is to see how soon the savings in operating costs will repay the original capital cost. Operations and maintenance plus power for pumping are subtracted from the dollar value of conventional fuel saved to generate a 20-year stream of savings. These savings are then discounted at 10% to convert them to present value. The net present value is the total of these discounted savings over the years. The payback period required for savings to recoup capital cost is 2 years. The internal rate of return, an interest rate which just equates the present value of a savings stream to investment cost, is 64%, a very attractive figure for a potential investor.

Table 4.6.4 projects yearly operating cost savings under the assumption that deep wells are required to develop the resource. The same procedures are followed to generate a 20 year stream of savings. Addition of funds for deep well drilling almost doubles the original capital investment from $3,708,200 to $6,876,824. This doubles the period required for payback, to four years. The internal rate of return is also cut dramatically to 38%. However, even with this enormous increase in capital costs the payback period and rate of return come out favorable to potential investors.

The near doubling of capital cost entailed in a shift from shallow to deep wells provides a fairly good picture of the sensitivity of payback and rates of return to changes in cost. Payback and rates of return change just about proportionally to the change in capital cost. However, the savings from the system are relatively unaffected, leaving geothermal as an attractive investment in both cases.

4.7 Economic Conclusions

Projected costs and savings are dramatic indicating a real potential for district space heating in Preston. Potential heat load and the cold climate provide a relatively high utilization factor for space heating. Primary uncertainty about the resource seems to be more involved with ownership and access rather than with its existence.

Projected costs for using conventional fuels to meet Preston's space heating demand are very high due to unavailability of natural gas via pipeline and to the relatively high (for Idaho) electricity rates. It is the high cost of conventional fuels, rather than the low cost of geothermal heating, which makes a geothermal district heating system appear so attractive.

A more detailed engineering design and cost analysis would almost certainly result in a system which is more costly, both in terms of initial investment and in terms of yearly operations, than that briefly outlined here. However, the margin of competitiveness seems so large that redesign would still leave a system which offered large savings for users and an attractive business proposition for investors.

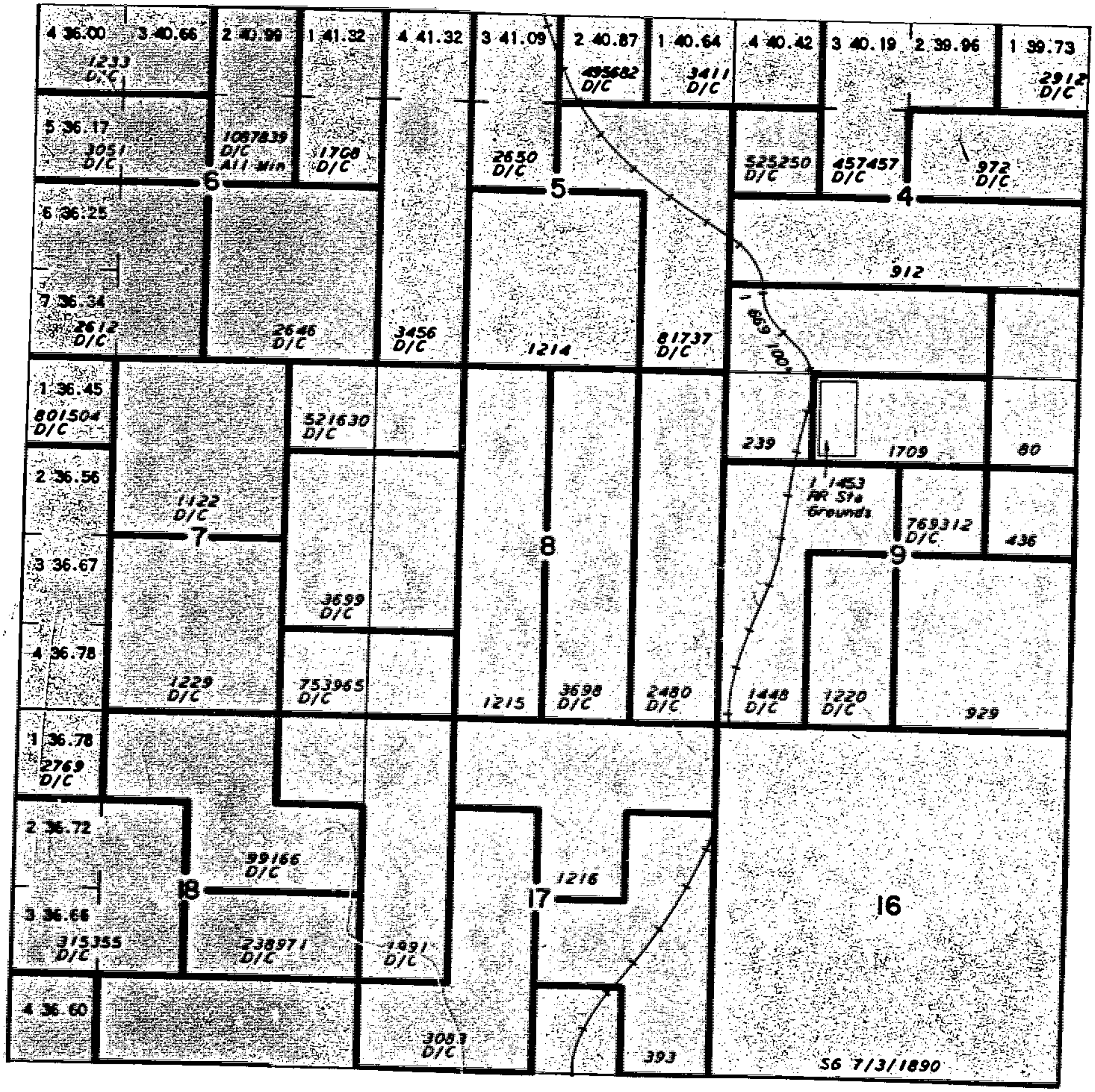


Figure 5.1.1: Master Title Plat of T15SR39E Sections 4, 5, 6, 7, 8, 9, 16, 17 and 18 showing private ownership.

5.0 Development Process

The development of geothermal waters at Preston, Idaho will require close cooperation between the City of Preston, the private land owners, the Idaho Department of Water Resources, and the residents of Preston. The impacts of developing a district heating system must address the potential effects on existing water users and the method of disposal of the thermal water.

5.1 Resource Ownership

The hot springs and exploratory wells are all located on private land. As shown in Figure 5.1.1, private land also surrounds these areas. If the city of Preston or any other possible developer of the resource would want to explore these areas, a lease agreement would have to be worked out with the private land owner.

5.2 State Permitting Requirements for Geothermal Resources

The groundwaters of the State of Idaho are a public resource. The Department of Water Resources has responsibility for administration of the use of these groundwater resources, and to conserve and protect them against waste and contamination.

Section 42-237a and Sections 42-1601 through 42-1605, Idaho Code, require all flowing wells to be capped or equipped in a manner that will allow the flow of water to be completely stopped when not in use. Flowing and non-flowing wells are to be constructed in a manner as to prevent waste and contamination through leaky well casings, pipe fittings, valves or pumps, either above or below the land surface or through improper or inadequate sealing.

Section 42-238, Idaho Code, gives the Department of Water Resources authority to establish and require compliance with minimum water well construction standards. Every water well constructed in Idaho must be in compliance.

Title 42, Chapter 39, Idaho Code, gives the Department authority to establish and require compliance with standards for construction and abandonment of waste disposal and injection wells.

Pursuant to the provisions of Section 42-238, Idaho Code, Title 42, Chapter 29, Idaho Code, and the provisions of Title 67, Chapter 52, Idaho Code, the Idaho Water Resource Board has established minimum standards for construction of water wells, and minimum standards for construction or abandonment of waste disposal and injection wells.

All wells deeper than 5.4m(18 feet) must be drilled by a well driller licensed to operate in Idaho. Well drillers must conform to the rules and regulations of the Idaho Department of Water Resources when constucting water wells and waste disposal and injection wells.

All water wells shall be constructed in a manner that will guard against waste and contamination of the groundwater resources of the State of Idaho.

All wells constructed for public supply of domestic water must meet all of the requirements set forth by the Idaho Department of Health and Welfare. The well driller and the property owner are charged with the responsibility of taking whatever steps might be necessary in any unique situation to guard against waste and contamination of the groundwater resources. It will be necessary in some cases to construct wells with significant additional controls beyond the minimum standards to accomplish these goals. Casing shall be installed in every well, and for water wells shall extend at least 12 inches above the land surface surrounding the water well, and to a minimum of 18 feet below land surface.

An approved permit from the Department of Water Resources is generally required before work can begin on geothermal wells. The two exemptions to this requirement relate to exploratory wells and to low temperature geothermal wells. If an exploratory well is less than six inches in diameter and less than 1,000 feet deep and is to be used only for collecting geotechnical data, the owner must simply file a notice of intent to drill with the director of the department. Also, as explained in Section 42-4003(e), Idaho Code, wells from which low temperature water is used for such purposes as space heating or fish propagation are exempt from the permit requirement if the owner has obtained an approved water right.

The following permits and bonds are required under the Geothermal Resources Act:

(a) Form 4003-1, Application for Permit to Drill for Geothermal Resources;
(b) Form 4003-2, Application for Permit to Alter a Geothermal Well;
(c) Form 4003-3, Application for Permit to Convert a Well to a Geothermal Injection Well;
(d) Form 4005, Geothermal Resources Surety Bond;
(e) Form 4007, Notice of Intent to Abandon Well;
(f) Form 4009, Report of Abandonment of a Well.

5.3 Public Funding Factors

There are several public assistance mechanisms available to the City of Preston. Under Idaho Code 50-323, the City can seek to fund all or part of a district heating system with a revenue bond. Such a bond would require a two-thirds majority approval by the voters and the selling of the bond on the bond market. The bond would be repaid by revenues generated from user fees or from tax money. Property tax limitations limit the potential property tax revenues of the city.

The Economic Development Administration has public works grants and loans for which Preston could apply. These grants, or loans, require approval and support of the City as well as the Regional Economic Development Agency. The objective of this program is to promote the growth and expansion of private-sector industry through public works and development facilities grants, with the aim of alleviating unemployment in a community.

Direct grants are awarded for up to 50 percent of total project costs. Applicant must provide balance through bond issues, borrowing from commercial lending institutions, general revenues, or other federal funds. Supplementary grants may be available if the applicant cannot match the required share of funds and qualifies on the basis of high unemployment or low incomes. The additional funding along with the initial direct grant can bring the federal contribution up to 80 percent of the total project. Direct loans may be available when financial assistance cannot otherwise be obtained to complete the project.

Eligible activities include projects which attempt to overcome economic problems of EDA-designated areas. These include public facility development such as water facilities serving commercial users. Projects which are shown to compete with an existing privately owned public utility are ineligible.

The Farm Home Administration has a Community Facility Loan program. The objective of this program is to construct, extend, or otherwise improve community facilities providing essential services to rural residents. These are insured loans which have up to 40-year terms and 5 percent interest rates. Typical eligible activities are programs for construction, enlargement, or improvement of community facilities providing essential services to rural areas, such as fire protection, health care, industrial development; capital improvements; and acquisition of land, leases, and right-of-way needed to undertake such facility improvements.

Borrowers must be unable to generate funds from other sources at reasonable rates and terms and must have authority to borrow and repay loans and operate and maintain the facility being financed. Pre-applications may be submitted at any time. Notification will be given within 45 days of an application's acceptance.

The HUD Office of Community Planning and Development offers a program on "Innovative Grants for Community Energy Conservation".

This program is intended to encourage the development of comprehensive strategies that will achieve significant energy savings at the local level. The program solicits innovative approaches which integrate alternative energy supply with neighborhood revitalization and other community and economic development programs. A prerequisite for entry into the program is a statement that the applicant government has begun the task of comprehensive energy planning and program development.

Activities funded under the Innovative Grants Program must address one or more of the following:

1. Assist low and moderate income persons to conserve energy without reducing their standard of living. Under this objective at least 50 percent of the beneficiaries must be low and moderate income persons.

2. Encourage the provision of energy conservation services and energy supplies through the expansion and/or establishment of small and/or minority businesses.

HUD has not limited this program to any single approach or technology. Applicants may propose to accomplish energy savings through loans or grants for such physical measures as building retrofit and renewable energy equipment installations. Applicants are urged to consider projects which assist large segments of the public over more limited approaches.

If an applicant chooses to apply for funds to support a particular equipment technology, it must meet the following criteria:

1. Be technologically proven and demonstrated;
2. Lead to substantial energy savings;
3. Promise to pay back or recapture initial investment costs over the long run;
4. Provide for repair and maintenance after installation.

In all cases, the applicant must present a detailed projection of energy savings to be achieved through proposed approaches, including estimates on how and when the project can be expected to "payback" on the initial investment in terms of energy dollars saved. In addition, applicants should attempt to describe the expected impact of the energy savings on the local economy over time.

Most DOE funding programs have died or appear to be moving in that direction. The current administration appears intent on reducing federal funding for geothermal direct uses. The official federal position is that this kind of geothermal development is already economically and technically sound and thus the private sector can handle it alone.

One mechanism that seems sure to be more fully utilized in the future for funding geothermal projects is that of the limited partnership.

The City of Boise retained a financier to pull together some private individuals as limited partners in a drilling venture. The limited partnership allows private capital to assume the initial risk of drilling for a usable geothermal resource. Limited partners get a nice tax shelter, with depletion allowances and a choice in how to treat intangible drilling costs. Once the resource is proven, then ordinary bonding procedures can be utilized to construct a distribution system and put the geothermal to use in a district space heating system.

6.0 Conclusions and Recommendations

Space heating the town of Preston, as outlined in this report, appears to have good promise of being economically viable. Rates of return and payback periods are attractive enough to justify such investment, even with conservative assumptions regarding rates of increase for conventional fuel sources. The high capital costs of a space heating system are more than amply returned in future benefits.

To secure the benefits of a geothermal district space heating system Preston should hire/appoint a consultant or a steering group to take over the direction of such a project. First priority for this group should be to sit down with private landowners in the Squaw Springs area to work out arrangements for leasing the resource site. After some agreement has been worked out to secure a resource the group should begin a concerted search for funds to undertake the project. At the same time a community outreach program should be undertaken to explain to all community members how geothermal district heating could be used and how it would save money. A small scale demonstration project may be a fitting way to show the community how geothermal energy can work.

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WELL LOCATION	DEPTH	TEMPERATURE	WATER	MATERIAL
Franklin County NW¼ NW¼ Sec. 16 T15S R39E	120'			0-2' Soil, gravel & sand
				2-4' Sand & gravel
			Yes	4-18' Sand, gravel and water
			No	18-20' Sand and clay
			"	20-120' Clay
Franklin County NW¼ NW¼ Sec. 16 T15S R39E	120'			0-2' Soil, gravel, sand
				2-4' Sand and gravel
			Yes	4-18' Sand, water and water
				18-20' Sand and clay
				20-120' Clay
Franklin County SW¼ SW¼ Sec. 31 T15 R39E			No	0-20' Clay and sand
			"	20-31' Clay and sand
			Yes	31-41' Sand
Franklin County SW¼ SW¼ Sec. 22 T15S R39E	422'			0-2' Soil
				2-28' Sandy clay
			Yes	28-35' Sandy clay and water
				35-300' Clay, blue to grey
				300-360' A little harder but still gray clay
				360-370' Sticky grey clay
			Yes	370-375' Rock and sand
			"	375-420' Sand and a few small gravel
Franklin County NE¼ SW¼ Sec. 16 T15S R39S	310'		No	0-2' Soil
			Yes	2-18' Sand, gravel, clay, water
			"	18-21' Sand
			No	21-22' Hard yellow clay
			Yes	22'45' Sand, very fine
			No	45-80' Sandy blue clay
			"	80-160'Soft blue shale
			Yes	160-180' Fine sand
			No	180-200' Soft gray shale
			"	200-220' Sandy clay
			"	220-240' Hard grey shale
			Yes	240-270' Fine sand
			"	270-280' Gray shale
			No	280-305' Shale
			Yes	305-310' Gravel, sand coarse
Franklin County SW¼ SW¼ Sec. 31 T15S R39E	40'		No	0-20' Clay and sand
			"	20-31' Clay and sand
			Yes	31-41' Sand

WELL LOCATION	DEPTH	TEMPERATURE	WATER	MATERIAL
Franklin County	340'		No	0-1' Soil
NW¼ NW¼ Sec. 13,			"	1-5' Hard Pan
T15S, R39E			"	5-20' Yellow Clay
			"	20-45' Yellow Gumbo
			"	45-75' Blue light clay
			"	75-85' Harder, using pulldown chain
			"	85-120' Trace of Sand
			"	120-135' Clay & trace sand
			"	135-200' Clay
			"	200-220' Sand strips, sort of brown hard clay and some sand
			"	220-240' Water going white
			"	240-260' Pull down
			"	260-280' Soft sandstone
			"	280-300' soft sandstone
			"	300-320' Sort of sandstone
			"	320-340' Brown hard clay
Franklin County	384'5"		No	0-3' Soil
SE¼ SW¼ Sec. 14,			Yes	3-5' Yellow clay and sand
T15S R39E			"	5-10' Gray clay and sand
			"	10-40' Buff colored silt and sand
				40-180' Grey clay
				180-200' Sort of hard blue clay
				200-220' Harder blue clay
				220-240' Same drilling rough
				240-260' Same but a little softer
				260-280' Same
			Yes	280-300' Buff colored clay
			"	300-340' Same but rough spots
			"	340-360' Getting harder
			"	360-370' Hard rough
			"	370-385' Rock and gravel
Franklin County	310'		No	0-2' Soil
NE¼ SW¼ Sec. 15			Yes	2-18' Sand Gravel Clay Water at 5'
T14S R39E			"	18-21' Sand
			No	21-22' Hard Yellow Clay
			Yes	22-45' Sand, Very Fine
			No	45-80' Sandy Blue Clay
			"	80-160' Soft Blue Shale
			Yes	160-180' Fine Sand
			No	180-200' Soft Gray Shale
			"	200-220' Sandy Clay
			"	220-240' Hard Gray Shale
			Yes	240-270' Fine Sand
			"	270-280' Gray Shale
			No	280-305' Shale
			Yes	305-310' Gravel, Sand Coarse

WELL LOCATION	DEPTH	TEMPERATURE	WATER	MATERIAL
Franklin County T16S R39E Sec. 1 NW¼ NW¼	250'9"			2-250'9" Casing set in hole and gravel packed to top
				0-1' Soil
				1-20' Yellow clay
			Yes	20-60' Blue clay
			"	60-80' Blue, white clay, a trace of coarse sand
			"	80-98' Same, losing water
			"	98-120' Same, some red clay
			"	120-130' White (chalky)
			"	130-160' Blue sand, lost one feet drilling
			"	160-170' Alternating, strips of shale and blue clay. Shale about 6" per strip Clay about 3' apart
			"	170-185' Same
			"	185-200' A little has shale
			"	200-210' About the same
			"	210-215' Shale, some sand
			"	215-250' Gravel
Franklin County T16S R39E Sec. 7 NE¼ SW¼	140'	50^{o}	No	0-18' Sandy red clay
			"	18-37' Sandy gray clay
			Trace	37-39' Very fune sand
			No	39-123' Gray clay
			Yes	123-126' Fine sand
			"	126-130' Coarse sand
			No	130-139' Gray clay
			"	139-140' Fine sand
Franklin County SW¼ NW¼ Sec. 7 T16S R39E	354'	58^{o}		0-2' Soil clay streaks
				2-23' Sand
				23-275' Blue clay
				275-276' Gravel
				276-283' Blue clay
				283-320' Clay
				320-322' Gravel
				322-324' Gravel clay
				324-354' Clay
Franklin County T16S R39E Sec. 9 SW¼ SW¼	205'			0-5' Clay
				5-19' Gravel
				19-30' Clay
				30-40' Sandy clay
				40-125' Blue Shale
				125-130' Brown Shale (Hard)
				130-138' " " Soft
				138-168' Blue Shale
				168-170' Sand-very little gravel
				170-180' Green Shale
				180-183' Shale & Sand
				183-205' Sand

WELL LOCATION	DEPTH	TEMPERATURE	WATER	MATERIAL
Franklin County SE¼ SE¼ Sec. 12 T16S R39E	272'			0-2' Soil
				2-35' Clay (yellow)
				35-206' Clay (blue)
				206-209' Sand
				209-227' Blue clay
				227-231' Gravel
				231-239' Gravel (clay)
				239-242' Clay
				242-248' Gravel
				248-250' Clay
				250-251' Gravel
				251-260' Clay
				260-266' Gravel
				266-272' Clay
Franklin County T16S R39E Sec. 18 SE¼ SW¼	462'			0-2' Soil
				2-16' Gravely clay
				16-26' Sand
				26-40' Clay, blue
				40-80' " yellow
				80-143' " blue
				143-148' Gravely clay
				148-150' Clay, blue
				150-156' Gravely clay
				156-204' Clay, blue
			Yes	204-212' Gravely clay
				212-238' Clay, blue
			Yes	238-242' Gravel
				242-252' Clay, blue
			Yes	252-265' Gravel
				265-271' Clay, blue
			Yes	271-273' Gravel
				273-291' Clay, blue
			Yes	291-293' Gravel
			"	293-297' Gravel
				297-325' Clay, blue
			Yes	325-327' Gravel
				327-362' Clay, blue
			Yes	362-364' Gravel
			"	364-366' Gravelly clay
				366-386' Clay, blue
			Yes	386-392' Gravel
				392-394' Clay, blue
			Yes	394-397' Gravel
				397-416' Clay, blue
			Yes	416-417' Gravel
				417-426' Clay, blue
			Yes	426-435' Gravel
				435-462' Clay, blue

WELL LOCATION	DEPTH	TEMPERATURE	WATER	MATERIAL
Franklin County	518'			0-2' Soil
NW¼ SE¼ Sec. 18				2-6' Sandy clay
T16S R39E				6-9' Sand
				9-40' Yellow clay
				40-160' Blue clay
				160-169' Gravelly clay
				169-197' Blue clay
				197-200' Gravel
				200-202' Blue clay
				202-203' Gravel
				203-229' Blue clay
			Yes	229-232' Gravel
				232-234' Blue clay
			Yes	234-237' Gravel
				237-268' Blue clay
			Yes	268-272' Gravel
				272-273' Blue clay
			Yes	273-275' Gravel
				275-291' Blue clay
			Yes	291-296' Gravel
				296-307' Blue Clay
			Yes	307-308' Gravel
				308-330' Blue clay
			Yes	330-333' Gravel
				333-341' Blue clay
			Yes	341-351' Gravel
				351-366' Blue clay
			Yes	366-367' Gravel
				367-396' Blue clay
			Yes	396-399' Gravel
				399-428' Blue clay
			Yes	428-433' Gravel
				433-465' Blue clay
			Yes	465-468' Gravel
				468-481' Blue clay
			Yes	481-486' Gravel
				486-488' Blue clay
			Yes	488-496' Gravel
				496-513' Blue clay
			Yes	513-515' Gravel
				515-518' Blue clay
Franklin County	142'		No	0-7' Soil & clay
SW¼ SW¼ Sec. 4			"	7-15' Gravel
T15S R39E			"	15-20' Hard packed white or gray sand
			Yes	20-24' Very light sand & white sand water-sand moves with water
			Yes	24-30' Blue clay, small amount of gravel, blue sand
			No	30-58' Blue clay & little gravel
			Yes	58-60' Pea gravel, sand, water (this sand out of place)
			Yes	60-80' Sand, water flowing
			No	80-100' Blue clay
			Yes	100-105' Blue clay and sand

WELL LOCATION	DEPTH	TEMPERATURE	WATER	MATERIAL
Franklin County SW¼ SW¼ Sec. 4 T15S R39E (Cont'd.)			Yes	105-130' Small gravel, blue clay, sand, large flow of water
			Yes	130-135' Large gravel, blue clay, water flowing
			Yes	135-140' Almost solid gravel
			Yes	140-142' Blue gray clay, seems to be breaking from pressure below
Franklin County SE¼ NE¼ Sec. 6, T15S, R39E	375'	100°		1-25' Sandy soil
				25' Fine sand
				25-40' Fine sand
				40-50' Fine sand
				50-60' Fine sand
				60-80' Fine sand
				80-100' Fine sand
				100-120' Coarse sand
				120-140' Coarse sand & few small gravel
				140-155' Hard shale stringers
				155-200' Med. sand, very few small gravel
				200-210' Coarse sand & small gravel
				210-225' Blue clay, rock at 220-225'
				225-240' Blue clay, broken rock
				240-270' Blue clay & broken rock, turning
				270-300' Yellow clay & small rock
				300-320' Yellow clay & small gravel
				320-340' Same water @ 90%
				340-375' Same water @ 96% Back filled up to top Hot water can't use
Franklin County SE¼ NE¼ Sec. 6 T15S R39E	62'			0-30' Sandy soil
			Yes	30-45' Sand & Water
			Yes	45-50' Sand, blue clay & water
			Yes	50-62' Sandy blue clay, shale & water
Franklin County SW¼ NW¼ Sec. 10 T15S R39E	270'		No	0-60' Clay
			Yes	60-268' Gray clay
			Yes	268-270' Green gravel
Franklin County SE¼ SE¼ Sec. 10 T15S R39E	390'			0-15' Clay
			Yes	15-16' Sandy clay & little water
				16-55' Yellow clay
			Yes	55-75' Real fine silty sand & water
				75-80' Yellow clay
				80-380' Yellow clay
			Yes	380-385' Sand & water
				385-390' Sand & water, gravel, water Some blue clay