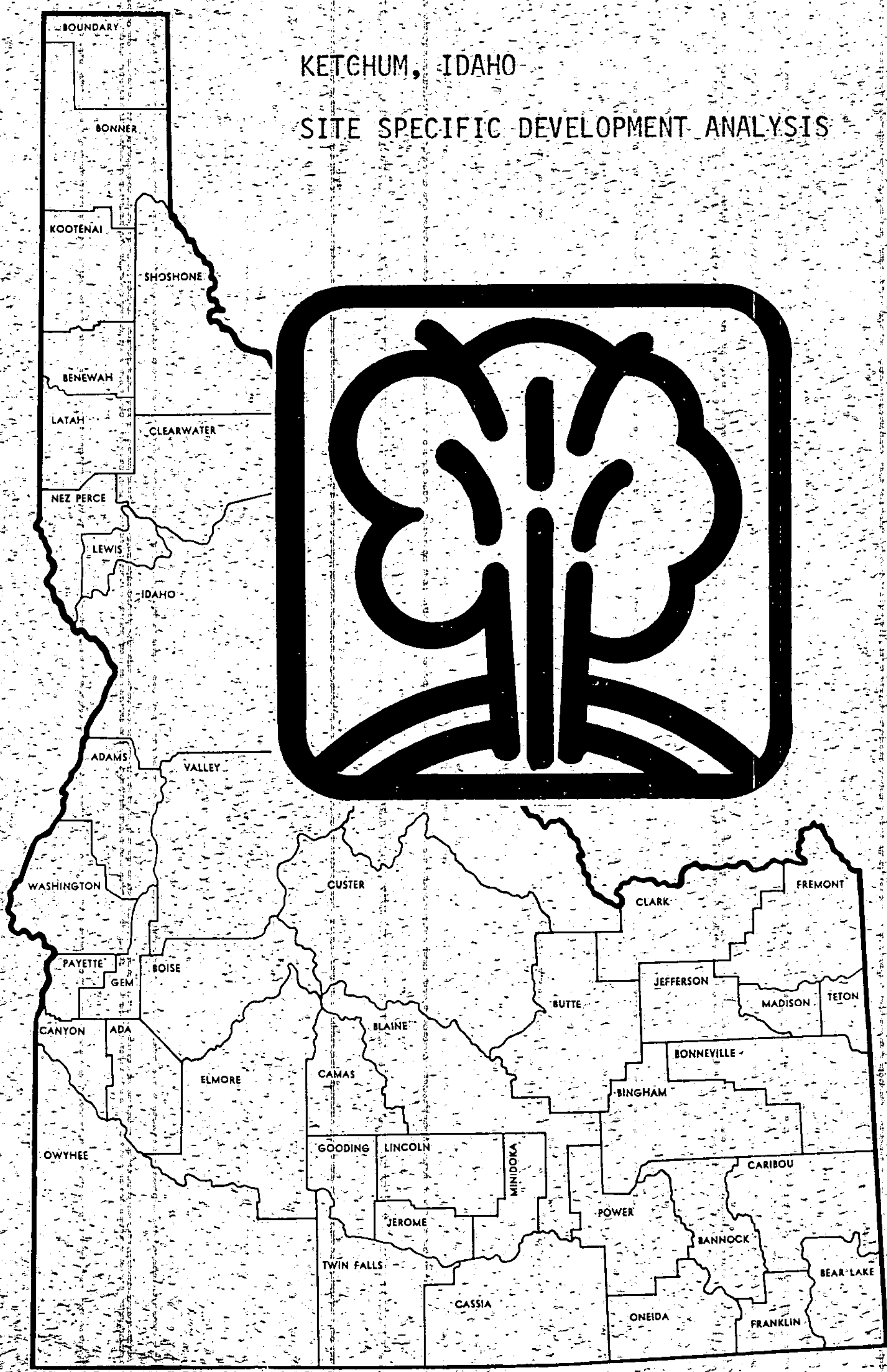
MASTER

Idaho Geothermal Report

KETCHUM, IDAHO

SITE SPECIFIC DEVELOPMENT ANALYSIS



IDAHO OFFICE OF ENERGY

John V. Evans, Governor

Prepared for the United States Department of Energy, Division of Geothermal Energy

DISCLAIMER

KETCHUM, IDAHO

SITE SPECIFIC DEVELOPMENT ANALYSIS

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PREFACE

Ketchum, Idaho is located in Southcentral Idaho, along the Big Wood River in Blaine County. Over 40 homes and businesses are heated by geothermal water derived from Guyer Hot Springs, located 4 km (2.5 mi.) west of the Ketchum town center on Warm Springs Creek.

Ketchum, population 2,161, was selected for a site development analysis because: buildings in the town have been heated by geothermal water since 1903; the Department of Water Resources has completed a survey of existing thermal waters; and the City of Ketchum 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 Ketchum, Idaho. This study summarizes known information, estimates economic risk, and outlines institutional parameters which are site specific to the Blaine County area. The Ketchum Site Specific Development Analysis involves locating a production well field near the town of Ketchum 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 Blaine 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.

The resource temperatures are expected to range from a minimum of 71°C (160°F) to a maximum of 125°C (257°F) for drilling depths of less than 914 meters (3,000 feet). Temperatures in this range have proven applications for space heating. Temperatures predicted by geochemical thermometers seem to indicate that thermal waters in the area ascend along fault zones from an aquifer or reservoir source with temperatures from 85°C (185°F) to 125°C (257°F). These higher temperature resources may be circulating to depths approaching 900 meters to 3,048 meters (3,000 to 10,000 feet).

Electricity, fuel oil, and natural gas are the principal energy forms available for space heating in Ketchum. The current cost of new electrical service is $7.00/MBTU. The average cost of fuel oil is $11.10/MBTU and the average cost of gas is $6.50/MBTU. 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 Ketchum, Idaho.

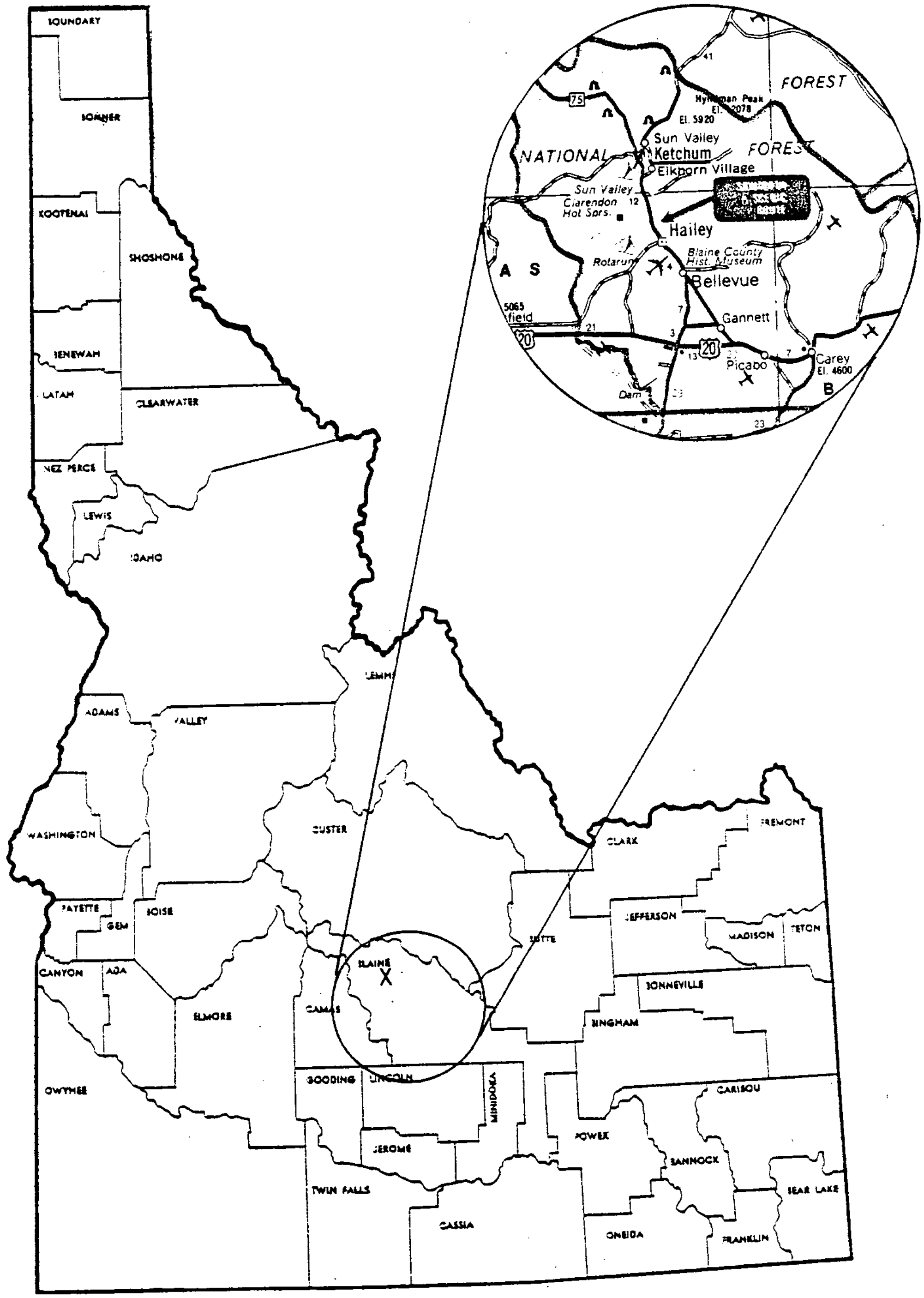
2.0 Site Description

2.1 Location

Ketchum, Idaho, in Blaine County, is approximately 124 km (77 mi.) north of Twin Falls and 250 km (145 mi.) east of Boise. The town of Ketchum is located at the confluence of Warm Springs Creek and Trail Creek with the Big Wood River. U.S. Highway 75

FIGURE 2.1.1

LOCATION OF KETCHUM, IDAHO



runs north-south through town. Figure 2.1.1 shows the location of the community of Ketchum.

The Ketchum geothermal area is located in Warm Springs Creek valley. Warm Springs Creek follows a north-northeast trending canyon and is probably fault controlled. The hot springs are located 4 kilometers (2.5 mi.) west of town next to the creek. Figure 2.1.2 is a site map of the Guyer Hot Springs.

2.2 Demographics

The estimates of the future population of Blaine County and Ketchum 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 smaller area to follow a pattern set by the larger region.

Population change in the Ketchum area is related to federal and state estimates. Three estimates, high, medium, and low, were made for the population of Idaho until 1990. 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 Ketchum and Blaine County are based on the medium series of estimates of state growth.

Growth in Blaine County is predicted to concentrate along the Big Wood River between Hailey and Sun Valley. Ketchum, originally known as Leadville, has an estimated 1980 population of 2,161. The population forecast for major communities in the Ketchum area is shown in Table 2.2. The apparent decrease in the Ketchum population can be attributed to seasonal differences in measurement dates. The 1975 estimate was based upon a survey taken in February 1977 while the 1980 Census took place in April of this year.

The town functions largely as a resort and, to a lesser degree, as a trading center for the outlying areas. Recent population changes in the Ketchum-Sun Valley area are due to rapid growth in the local tourist industry.

Guyer Hot Springs are located in a residential area a short distance from the Warm Springs chairlift on Bald Mountain. There are several residences near the hot springs and much new development exists between the hot springs and the center of Ketchum.

The City of Ketchum, like other cities in the Wood River Valley, has experienced a significant increase in housing starts over the last ten years. Since 1970 approximately 1,380 new apartments, condominiums, and homes have been constructed in Ketchum. The unincorporated areas surrounding Ketchum and Sun Valley have also shown a steady increase in new housing units over the last ten years. The growth is in large part due to an increasing number of vacation homes being constructed in the Upper Wood River basin.

FIGURE 2:1.2

GUYER HOT SPRINGS AND VICINITY

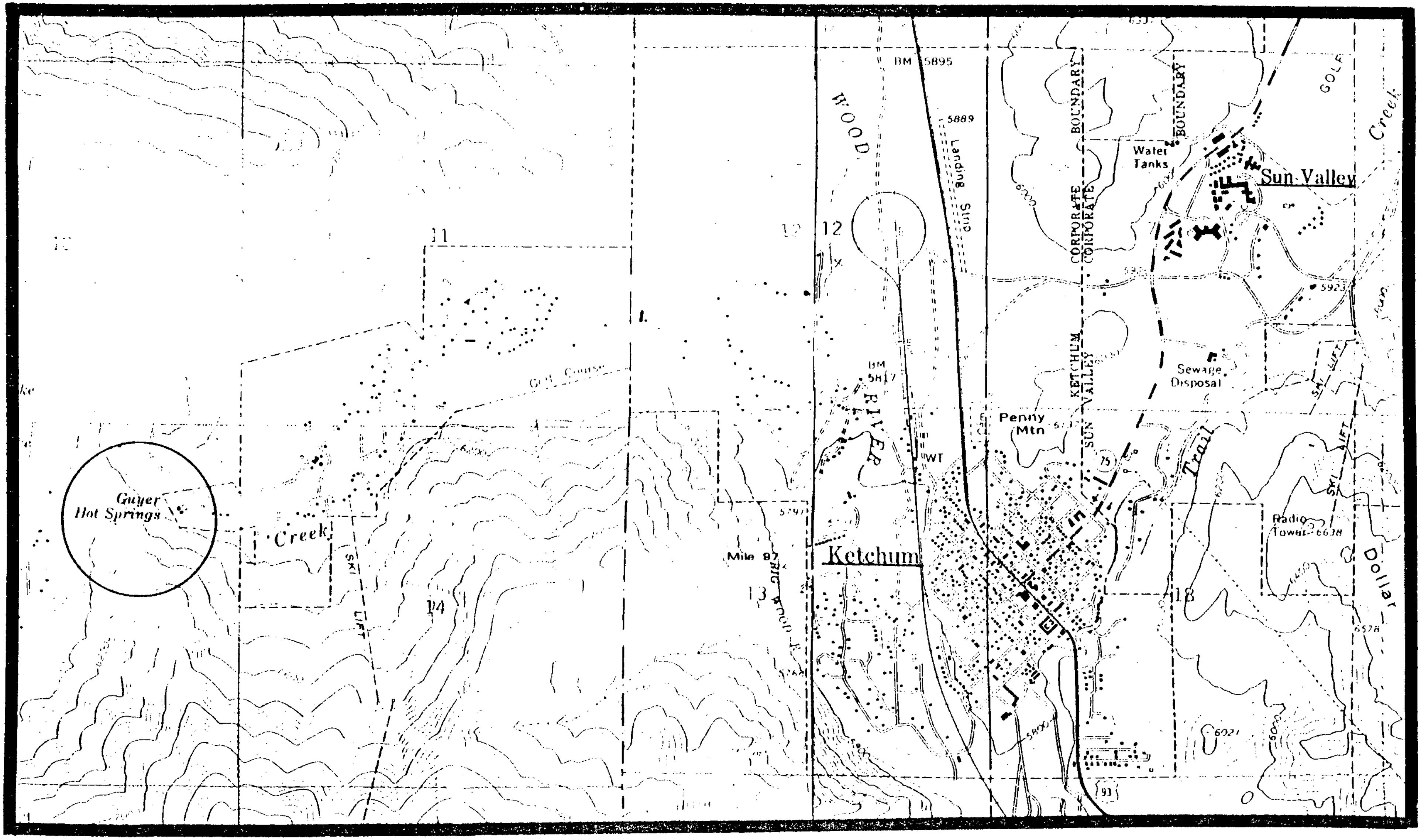


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TABLE 2.2

POPULATION FORECAST

	1970	1975	1980	1985	1990	1995	2000
BLAINE COUNTY	5740	7750	9638	12100	14090	16500	19370
Bellevue	537	639	1034	1435	1991	2763	3834
Hailey	1425	1979	2104	2992	4247	6030	8562
Ketchum	1454	2698	2161	2635	3212	3916	4774
Sun Valley	180	239	520	884	1502	2553	4340

Sources: U. S. Dept. of Commerce, 1970 Census Figures

County Profiles of Idaho, Idaho Division of Budget, Policy Planning and Coordination, 3rd ed., 1978 estimate

U. S. Dept. of Commerce, 1980 Preliminary Updated Census Figures

Population and Employment Forecast - State of Idaho, Series 2 - Projections, 1975-2000, Idaho Department of Water Resources

IOE Forecast Based on 1970-1980 Growth Rate

Blaine County is a rural county which will continue to grow and that growth will be urban and concentrated in the Upper Wood River Basin. Growth in the Ketchum area will depend upon continued growth in the tourist industry and the location of a year-round industry in the area.

2.3 Regional Economy

Blaine County economic activities 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. Blaine County has had a growing economy in terms of total number of persons employed and personal income. Employment is seasonal and dependent upon the winter ski season. The economy of the Ketchum area depends primarily on tourism and construction. The community has no major industries other than recreation and construction. Table 2.3 lists the major economic elements for Blaine County.

2.4 Employment

The Blaine County labor force increased approximately 30% between 1970 and 1975. This trend is expected to continue, although presently not at that rate. Continued expansion of tourism and resulting employment opportunities should reinforce immigration into the Ketchum area. Ketchum is expected to grow at a lesser rate than the county population growth rate of 5.3 percent per year. Table 2.4 lists an employment forecast summary for Blaine County.

2.5 Climate

The climate of Blaine County varies with elevation. The lower Big Wood River Valley and the Snake River Plain areas have a semi-arid climate with warm summers and moderate winters. The mountainous areas are cool in summer and cold in winter, with heavy sonwfalls.

The average frost-free period for the major agricultural areas is 80 to 110 days. Due to the short growing seasons, crops that are frost tolerant and mature quickly are the most successful. These include grains, hay, pasture and seed potatoes.

Climatological data has been collected for Sun Valley since 1951. The weather station at Sun Valley was discontinued in 1972 and moved to the Ketchum Ranger Station, where records are currently being kept. Table 2.5 summarizes data from Hailey and Sun Valley. Data from Richfield, in Lincoln County, was added to more accurately reflect the climate of the county occurring on the Snake River Plain.

TABLE 2.3

ECONOMY - BLAINE COUNTY

Percent of average monthly unemployment - 1978:

Jan. 7.4%	Feb. 5.9%	Mar. 6.1%	Apr. 11.8%	May 10.8%	Jun. 6.8%
Jul. 5.9%	Aug. 4.4%	Sep. 4.9%	Oct. 6.0%	Nov. 7.3%	Dec. 6.9%

Percent of labor force unemployed: 1970 9.5%; 1972 11.7%; 1975 15.0% 1978 7.0%

Month and percentage of highest unemployment: 1975 May 23.1% 1978 Apr. 11.8%

Month and percentage of lowest unemployment: 1975 Aug. 9.8%; 1978 Aug. 4.4%

Percent of females (16+) in labor force: 1960 (14+) 39.5%; 1970 50.7%

Employment (B.E.A. data)	1967	1970	1977	1978
Total employment	2,484	3,159	5,013	5,888
Farm proprietors	256	259	234	233
Non-farm proprietors	354	468	620	664
Wage and salary employment:				
Federal civilian	88	73	110	108
Military	--	--	55	55
State & local	225	396	632	655
Manufacturing	30	59	346	238
Mining	(D)	(D)	(L)	(L)
Construction	73	194	378	461
Trans., Comm. & Pub. Util.	43	57	(D)	131
Trade	368	490	1,059	1,381
Finance, Inc. & Real Est.	40	53	207	251
Services	(D)	931	1,045	1,467
Other	--	(D)	(D)	59
Farm	162	136	174	182

(D) Not shown to avoid disclosure of confidential information.
(L) Less than 10 workers.

Average Idaho tax return (county) - 1978: $444

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

Market value of all property - 1979: $300,198,656

Total property tax collected - 1979: $4,374,959

Sales tax: 1974* $1,030,358 1975* $1,219,403 1977* $1,292,307
1979* $2,364,521
*Fiscal Year

Property tax as percent of market value: County 1979 1.457%: State 1979 1.392%

Highest tax code area and the tax as a % of market value 1979: Area (01-1) 1.763%

Per capita income:	1970	$3,764;	1978	$7,664
% of national average:	1970	94.9%	1978	97.8%
% of state average:	1970	114.4%	1978	103.3%

Median family income 1969: $8,580 Median family income* 1976: $11,375
*HUD estimate

Transfer payments (thousands of dollars - county):
1970 $2,021 1974 $3,819 1975 $4,971 1978 $6,253

Number of business establishments 1978: 410

TABLE 2.4

POPULATION AND EMPLOYMENT FORECAST

BLAINE COUNTY - 1978

EMPLOYMENT SUMMARY	1972	1975	1980	1985	1990	1995	2000
Agriculture	392	403	362	322	285	259	235
Mining	4	6	6	6	6	6	6
Construction	344	246	393	484	585	725	896
Food and Kindred	20	27	32	36	41	48	55
Wood Products	6	16	18	20	23	26	28
Other Manufacturing	98	268	398	481	569	690	838
Trans. Comm. & Utils.	74	106	136	157	181	211	247
Whlsle and Retail Trade	782	1043	1471	1738	2052	2432	2889
Finance, Ins. Real Est.	121	232	328	393	469	562	674
Services and Misc.	1043	1347	1854	2202	2615	3109	3699
State and Local Govt.	494	627	830	974	1140	1339	1677
Federal Government	74	98	98	99	100	100	101
Total	3452	4419	5932	6918	8072	9512	11251

FORECAST SUMMARY	1970	1975	1980	1985	1990	1995	2000
Total Population	5740	7750	10390	12100	14090	16500	19370
Total Employment	3450	4410	5930	6910	8070	9510	11250
Labor Force	3530	4720	6350	7400	8630	10170	12020

Source: Idaho Department of Water Resources and Center for Research, Grants and Contracts, Boise State University

TABLE 2.5

CLIMATOLOGICAL DATA FOR BLAINE COUNTY

Station	Hailey	Sun Valley*	Richfield**
Elevation	5,328'	5,812'	4,306'
Years of Record	59	29	44
Average Daily Temperature (^{o}F)			
January Minimum	6.7	1.9	11.1
January Maximum	30.6	30.8	29.9
July Minimum	49.5	36.9	50.7
July Maximum	86.5	82.1	87.4
Lowest Temperature of Record	-36	-46	-40
Highest Temperature of Record	109	96	105
Average Annual Days			
Maximum of 90^{o} or more	19	6	19
Minimum of 32^{o} or less	191	285	188
Growing Season #	94	95	105
Average Precipitation (inches)			
Annual Precipitation	14.53	17.01	9.64
Annual Snowfall	88.5	118.9	35.4
January Precipitation	2.11	2.22	1.41
July Precipitation	.41	.71	.26
Average Annual Number of Days with Precipitation			
.10 inches or more	40	49	39
.50 inches or more	8	13	6
Degree Days	8070	9986	7306

* Ketchum is 2 kilometers (1.2 miles) southwest of Sun Valley
** Richfield was added from Lincoln County

#The average number of days between mean last 32^{o} temperature in spring and mean first 32^{o} in fall, that is the average freeze free period.

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

2.6 Hydrology

The ultimate source of water within the Ketchum area is precipitation which falls within the drainage area of the basin. Not all precipitation falling on the basin is available for use, however. The water balance equation:

Inflow = Outflow + Storage

must be satisfied. Inflow, in the case of a basin with impermeable boundaries such as the Ketchum area, is derived entirely from precipitation. Outflow usually consists of evapotranspiration losses, and streamflow and groundwater flow out of the basin. Storage changes may consist of surface storage (+ or -) in lakes and ponds or fluctuations of groundwater level and soil moisture content. The ground and surface water systems in the Ketchum area appear to be closely interrelated, based on the geology of the area, and any stress placed on one will have an effect upon the other.

2.6.1 Ground Water

A large source of information is available regarding the groundwater hydrology of the Ketchum area. The Idaho Department of Water Resources (IDWR) studied the Ketchum-Sun Valley area and reported on it in their Water Information Bulletin No. 40. The 1975 report is entitled "Effects of Urbanization on the Water Resources of the Ketchum-Sun Valley area, Blaine County, Idaho".

The principal groundwater feature in Ketchum is the alluvial-filled valley floor, generally characterized by its coarse-grained, highly permeable nature. Geologic cross-sections of the Big Wood River Valley at Hailey, Ketchum, and North Fork indicate coarse alluvial fill bounded by impermeable rock. Figure 2.6.1 is a detailed geologic section based on drillers' reports for wells in the vicinity of Ketchum which show the relationships more clearly. Locations of the cross-sections are shown in Figure 2.6.2.

The small number and distribution of wells in which water-level measurements were taken in the IDWR study precludes any accurate representation of the groundwater flow pattern; however, some generalizations can be made. Groundwater in an alluvial-filled valley with an unconfined, homogenous aquifer would be expected to move in a downstream direction and toward the topographically low portion of the basin. This is the general flow pattern in the Sun Valley-Ketchum study area, except as locally modified by geologic boundaries such as faults, bedrock, and lateral changes in permeability in the alluvial fill of the valley. Large-scale recharge to or discharge from the groundwater system also alters the flow pattern in the vicinity of the recharge or discharge area.

Figure 2.6.1

Detailed geologic cross-section of Big Wood River Valley at Ketchum.

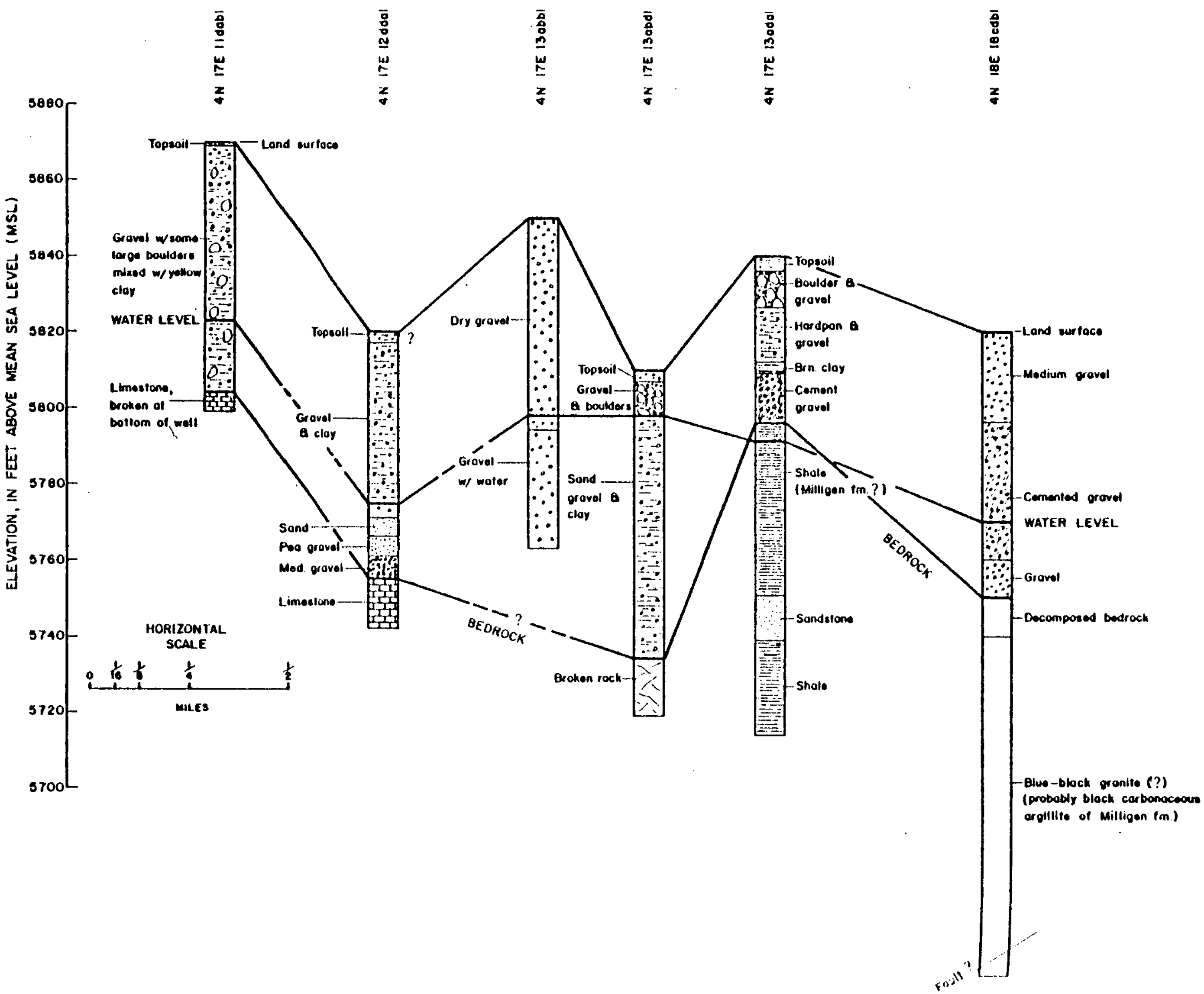
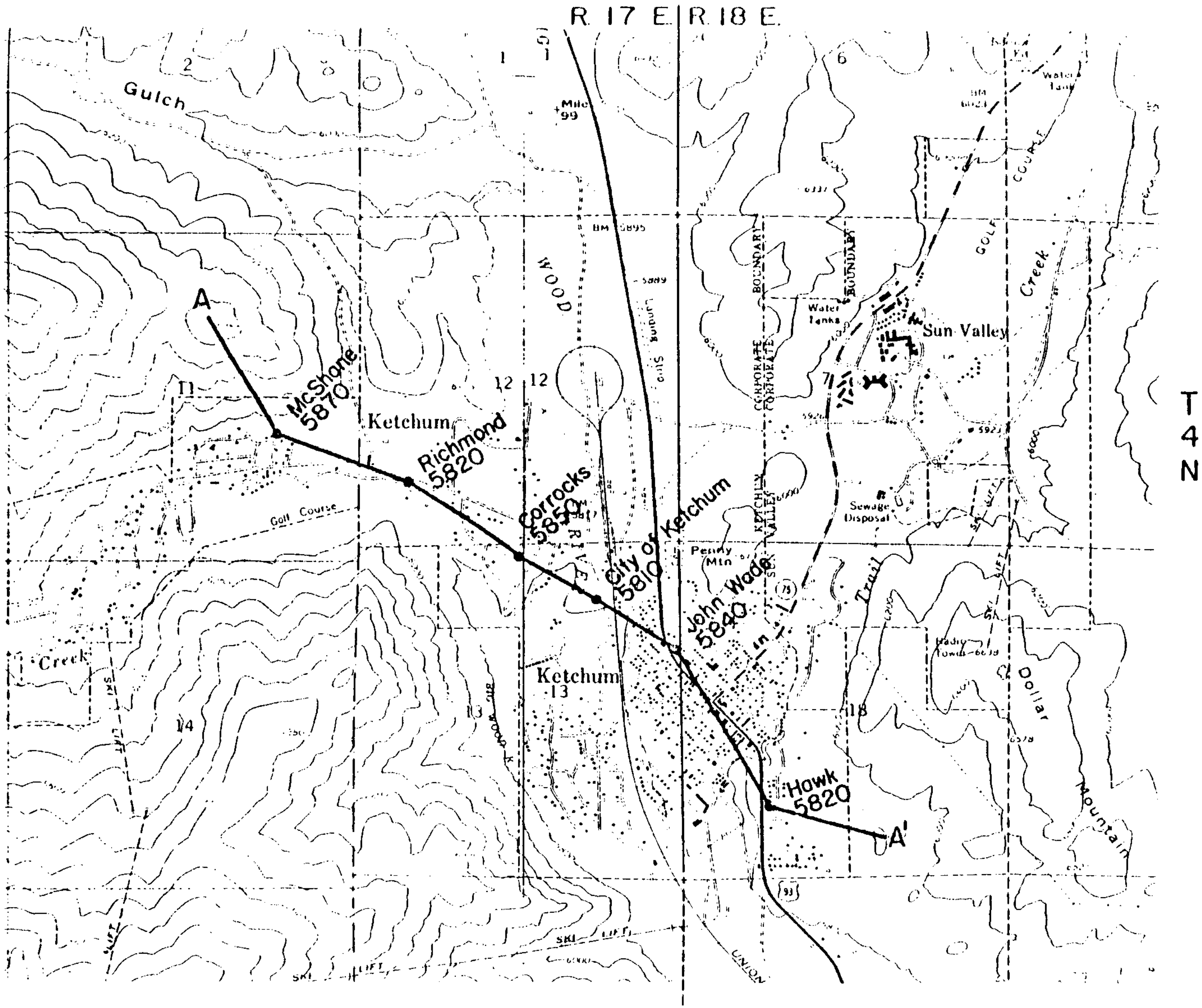


Figure 2.6.2



Location of detailed geologic cross-section of Big Wood River Valley at Ketchum.

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The groundwater system presently supplies a dependable, constant-quality supply of water for most of the municipal and domestic uses in the basin. Whether this continues to be the case will depend almost entirely upon the degree of groundwater development which will occur in the future. Before any meaningful projections can be made regarding potential for development, better estimates for basin yield will have to be obtained.

Another important groundwater consideration is potential for subsurface disposal by injection of geothermal fluid. Presently the only known geothermal heating system disposes of the spent fluid via dumping into the Big Wood River. Environmental Protection Agency Standards probably will prohibit additional dumping of geothermal fluid into the river. Due to the large number of shallow domestic wells in the Warm Springs and Ketchum areas, any plans for subsurface disposal should proceed only after extensive research.

2.6.2 Existing Water Wells Near Ketchum

According to well driller reports on file with the Department of Water Resources, the number of wells drilled in the Sun Valley-Ketchum area exceeds 300. These reports have been required only since 1953 so more wells probably exist in the area. Along the Warm Springs Valley and the West side of Ketchum at least 179 wells are known to exist. Most of the water wells are used for domestic purposes.

Township 4N, Range 17E, Section 15 contains Guyer Hot Springs. This section also contains at least six (6) wells, all less than 18 meters (60 feet) deep. Four of these wells have experienced some drawdown. Any proposed increase in groundwater development near Guyer Hot Springs should include monitoring well levels and spring discharge. The oldest water right in the upper Warm Springs Valley is held by D. C. Brandt, and amounts to 1700 liters per minute (1 CFS) of spring discharge.

2.6.3 Surface Water

The Big Wood River with its major tributaries, Trail Creek and Warm Springs Creek, drains the Ketchum area. Numerous smaller perennial and intermittent streams also contribute water to these major tributaries.

United States Geological Survey records of the total annual mean discharge of the Big Wood River at Hailey for each year from 1958 to 1972 indicate that the 15-year annual discharge is approximately 358,700 acre feet. This quantity is a major portion of the Sun Valley-Ketchum basin yield.

Table 2.6.3 lists miscellaneous discharge measurements made by the Idaho Department of Water Resources at selected sites in the Ketchum area during the period 1972-1974.

3.0 Resource Evaluation

3.1 Regional Geology

The Ketchum area is included within the southern extremity of the Northern Rocky Mountain physiographic province, an area of unique topography, climate, and geology.

Rocks within the Ketchum area can be grouped into two broad categories: 1) unconsolidated fluvioglacial, alluvial and colluvial material, and 2) consolidated rocks of sedimentary and igneous origin. Figure 3.1.1 lists the geologic formations present in the area, their lithologic characteristics, and serves as a legend for Figure 3.1.2, which is a generalized geologic map of the area showing the surface distribution of the various geologic units.

Mountains of the Sawtooth, Smoky and Pioneer Ranges are prominent in the Upper Wood River Basin. Several peaks are over 3400 meters (10,000 feet) in height. Carboniferous sedimentary rocks and Challis volcanics are the dominant rock types present in the mountains, with minor inclusions of granitics and other rocks.

The unconsolidated material forms the valley fill and is generally characterized by its coarse-grained, highly permeable nature. Geologic cross-sections of the Big Wood River at Hailey, Ketchum, and North Fork indicate coarse alluvial fill bounded by generally impermeable bedrock. Figures 2.6.1 and 2.6.2 in the groundwater section of this report show detailed geologic sections of Ketchum based on drillers' reports.

The depth of alluvial fill, inferred from the local geology, appears to range between 12 meters (40 feet) and 24 meters (80 feet). Drillers' logs of wells along Warm Springs Creek indicate depths to bedrock as shallow as 9 meters (30 feet) below land surface. Conversely, in Trail Creek, one well was drilled to a depth of 179 meters (586 feet) without penetrating bedrock.

The geologic structure in the area is poorly known, but is believed to be very complex. Extensive folding and faulting makes interpretation difficult. Knowledge of the structure is important, in that it helps to determine the depth of alluvial fill, which may be a locally important aquifer, and may also create barriers to ground water accumulation and movement which are not apparent at land surface. Umpleby, Westgate and Ross (1930) also pointed out that faulting, although not evident at the surface, probably exerts great control on the drainage pattern of the Big Wood River system.

TABLE 2.6.3

DISCHARGE MEASUREMENTS AT SELECTED SITES
IN THE SUN VALLEY-KETCHUM AREA
(ALL VALUES IN CUBIC FEET PER SECOND)

No.	Discharge Measurement Site Description	Site Location	9/72	4/73	7/74	9/73	12/73	2/74
1	Big Wood River at Easley Hot Springs	SW¼NW¼ sec.10 T.5N R. 16E	85.6	52.4	85.2	54.0	34.4	26.3
2.	Lower Trail Creek at Skier's Parking Lot	NW¼NW¼ sec.19 T.4N R. 18E	10.80	9.96	10.4	6.57	5.23	6.65
3.	Upper Warm Springs Creek	NW¼NW¼ sec.21 T.4N R. 17E	44.1	----	49.5	26.3	----	-----
4.	Lower Warm Springs Creek	NE¼NW¼ sec.13 T.4N R. 17E	48.2	47.9	56.5	27.4	25.3	22.01
5.	Big Wood River at Ketchum Sewage Treatment Plant	SW¼SE¼ sec.19 T.4N R. 18E	221	189	243	135	107	111
6.	U.S. Geological Survey Gaging Station at Hailey Bridge west of Hailey	NE¼SW¼ sec.9 T.2N R. 18E	284	251	327	150	151	159

FIGURE 3.1.1

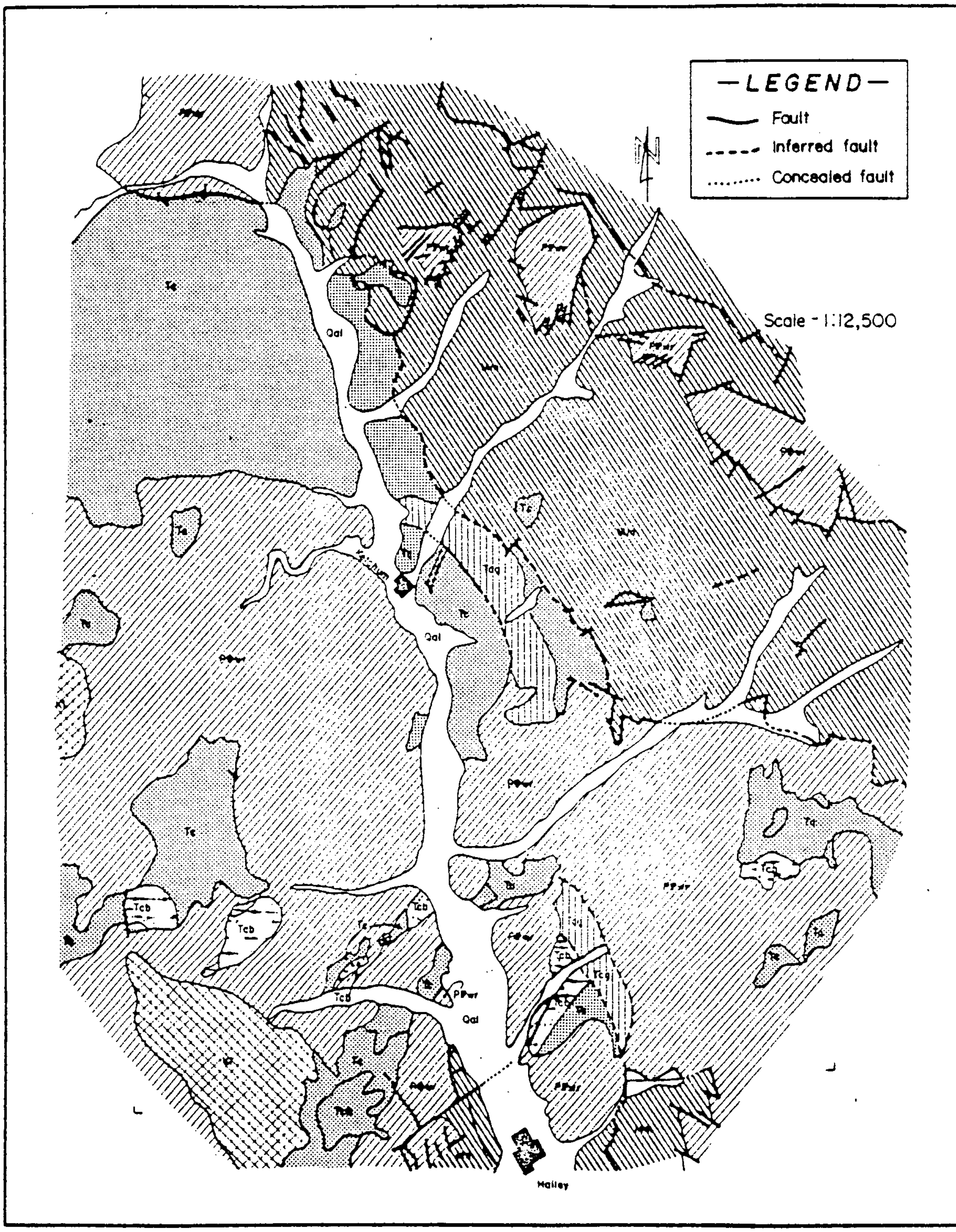
Period		GEOLOGIC UNIT	LITHOLOGIC DESCRIPTION
Quaternary		Qal Quaternary alluvium undifferentiated	Gravel, sand and silt of flood plains, fans, and terraces; includes fluvioglacial sediments and partially eroded older deposits.
Tertiary	Tcu Challis volcanics undifferentiated	Tcr Rhyolitic rocks	Lava and welded tuff, largely rhyolite and quartz latite.
		Tcb Basaltic rocks	Lava, dominantly basalt or calcic andesite.
		Tcg Germer tuffaceous member and associated rocks	Clastic tuff and some welded tuff, travertine, sandstone, siltstone and conglomerate.
Cretaceous		Ki Idaho batholithic rocks	Granitic rocks with varied composition, but chiefly quartz monzonite.
Pennsylvanian		PPwr Wood River formation	Quartzitic sandstone and siltstone, some limestone and conglomerate.
Mississippian		Mm Milligen formation	Gray and black carbonaceous shale and argillite with some sandy and quartzitic beds and limestone.

(Modified from Ross, 1963)

Associated geologic map on following page.

Lithologic description of geologic units in the Sun Valley-Ketchum area.

FIGURE 3.1.2



Generalized geologic map of the Sun Valley-Ketchum area. (After Umpleby, Westgate and Ross, 1930, and Ross, 1963.)

3.2 Guyer Hot Springs

Guyer Hot Springs have been utilized for space heating homes and recreational pools since the 1880s. The main springs discharge at the rate of 3785 liters per minute (2.22 CFS) and have a surface temperature of 70°C (159°F). Numerous seeps and vents are located in the vicinity of the main spring. Water from the spring is diverted into two (2) small holding reservoirs and then directed into a pipeline and conveyed to homes, businesses, and recreation areas for heating purposes. The length of the system, from Guyer Hot Springs to Bald Mountain Hot Springs Resort, is 4.7 kilometers (2.9 miles).

Bald Mountain dominates the topography of the Guyer Hot Springs area. Elevations range from 1804 meters (5920 feet) at Guyer Hot Springs to 2790 meters (9151 feet) at the Bald Mountain lookout station. The City of Ketchum, located 1780 meters (5840 feet) above sea level, is approximately 24 meters (80 feet) lower than the hot springs. There are no major topographic barriers between Guyer Hot Springs and downtown Ketchum.

Guyer Hot Springs' structural setting is typical of the Hot Springs in Central Idaho: many occur near the confluence of streams, indicating fault or similar structural control for them. Guyer Hot Springs occurs on a curvilinear zone connecting Hailey Hot Springs, Clarendon Hot Springs, Warfield Hot Springs, Easley Hot Springs, and Russian John Hot Springs (Mitchell et al, 1979). It is not known at present which structures or structure control the occurrence of thermal water at Guyer Hot Springs. In order to confirm the size and exact location of the geothermal reservoir for space heating additional buildings and residences, it will be advisable to evaluate, in some detail, reservoir characteristics to determine the amount and properties of geothermal water which could be withdrawn for use. This would be done by drilling observation wells and running well tests and perhaps drilling exploration holes to see if existing water flows could be augmented or a new source found closer to Ketchum.

3.3 Warfield Hot Springs

Warfield Hot Springs are located 13.7 kilometers (8.5 miles) west of Ketchum on Warm Springs Road. The two spring vents are currently used only for recreation purposes. While no flow rate has been measured, the surface temperature of the springs has been recorded at 51°C (123°F).

Limited geological work has been done at Warfield Hot Springs. Ross (1971) mentioned the site in her assessment of geothermal potential in Idaho. More recently, Mitchell and others (1979) report that the aquifer at Warfield Hot Springs is thought to be pre-Tertiary undifferentiated rocks.

The topography at Warfield Hot Springs is similar to that at Guyer Hot Springs. Structural controls like those at Guyer Hot Springs may exist at Warfield but only additional research will provide such information.

The largest inhibiting factor to development of Warfield Hot Springs is its distance away from Ketchum. The high costs of transmission systems, specifically pipe costs, prohibit current low temperature resource geothermal developments beyond several miles from a site. A recent study concluded that for space heating 5 miles is the maximum piping distance to be economically feasible.

3.4 Geochemistry

Table 3.4.1 lists the chemistry of the thermal springs located near Ketchum, Idaho. The chemical concentrations in the Guyer thermal waters are relatively low compared to other Idaho thermal waters. Total dissolved solids are low and the pH is close to neutral. The range of fluoride levels exceeds present EPA standards. The fluoride levels will probably require alternative waste disposal practices other than the one currently employed, direct discharge into the Big Wood River. These disposal alternatives could conceivably be through either injection wells or dilution with additional groundwater.

The geochemical thermometer temperatures predicted for the thermal source are listed in Table 3.4.2. The concentration of certain chemical constituents dissolved in thermal waters can be used to estimate water temperatures in the thermal aquifer. However, these geochemical thermometers may give anomalously high or low results depending on the lithological controls which influence the water chemistry. In Idaho those geochemical thermometers which are most reliable are: 1) silica temperature assuming quartz equilibrium and adiabatic expansion at constant enthalpy, 2) silica temperature assuming equilibrium with chalcedony and conductive cooling, 3) NA-K-Ca temperature, and 4) NA-K-Ca temperature corrected for PCO_2. In Table 3.4.2 these geochemical thermometers are T_2, T_4, T_5 and T_6, respectively.

Geochemical thermometry indicates temperatures in the Guyer Hot Springs area between 88°C and 125°C might be encountered by deeper drilling. Aquifer temperatures as high as 131°C might be encountered at Warfield Hot Springs.

Table 3.4.1 also includes data from two nearby wells located in similar geological environments. A chemical analysis of Russian John Hot Springs located 22.4 Km (14 mi.) northwest of Ketchum indicates similar water chemistry as Guyer Hot Springs. Clarendon Hot Springs located 14.4 Km (9 mi.) southwest of Ketchum also has a similar geochemistry.

TABLE 3.4.1

CHEMICAL ANALYSIS OF KETCHUM, IDAHO THERMAL SPRINGS
(Chemical Constituents in milligrams per liter)

Sample Location	Depth of Well (Feet)	Temperature (^{o}C)	Silica (Si)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Phosphate (P)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Specific Conductance	pH (Filtered)
4N-17E-15AAC (Guyer H.S.)	0	70	86	2.9	0.0	84	2.1	51	25	72	0.02	11.0	16	0.06	421	8.0
4N-16E-36AAC (Warfield H.S.)	0	51	97	2.6	0.0	67	1.9	55	37	35	0.01	8.1	14	0.0	370	6.7
*6N-16E-33CCA	0	38	54	2.3	0.1	70	0.6	25	29	46	0.01	6.5	19	0.0	0	8.8
**3N-17E-27DCB	0	52	80	2.2	0.1	81	1.7	29	30	68	0.00	11.0	15	0.06	0	8.2

* Russian John Hot Springs, located 22.4 Km (14 mi.) NW of Ketchum

** Clarendon Hot Springs, located 14.4 Km (9 mi.) SW of Ketchum

Source: Idaho Department of Water Resources
Bull. 30, Part 2, 1979.

TABLE 3.4.2

GEOTHERMAL TEMPERATURES

Springs or Well Identification	Discharge l/m	Known Temp. °C	Aquifer Temperature Predicted by Geochemical Thermometry °C							
			T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
4N-17E-15AAC	1000	70	128	125	9	101	88	88	64	88
4N-16E-36AAC	100	51	135	131	15	108	85	85	72	85
*6N-16E-33CCA	1	38	105	105	-10	75	52	52	7	52
**3N-17E-27DCB	100	52	125	122	6	97	87	45	53	87

T_1 = Silica temperature assuming quartz equilibrium and conductive cooling (no steam loss)
T_2 = Silica temperature assuming quartz equilibrium and adiabatic expansion at constant enthelpy (maximum steam loss)
T_3 = Silica temperature assuming equilibrium with amorphous silica
T_4 = Silica temperature assuming equilibrium with chalcedony and conductive cooling (no steam loss)
T_5 = Na-K-Ca temperature
T_6 = Na-K-Ca temperature corrected for PCO_2
T_7 = Na-K-Ca temperature corrected for Mg
T_8 = Na-K temperature

* Russian John Hot Springs, located 22.4 Km (14 mi.) NW of Ketchum
** Clarendon Hot Springs, located 14.4 Km (9 mi.) SW of Ketchum

Source: Idaho Department of Water Resources Bull. 30, Part 9, 1979

Geochemical thermometry at all four sites indicates approximately the same range of potential reservoir temperatures. The similarity between these sites is consistent with the idea of a curvilinear zone connecting the sites as put forth by Mitchell (1979). All four sites plus Hailey Hot Springs and Easley Hot Springs form a pattern trending NW-SE and each site occurs at an intersection with a stream valley.

Aquifer temperature estimates based on geochemical thermometry do not consider possible contamination due to mixing or lithology and should be considered as tentative only.

4.0 Site Specific Application

Following is a preliminary outline of a geothermal heating system for the city of Ketchum, Idaho, which makes use of the geothermal resource in the area known as Guyer Hot Springs.

The system envisaged in this report has five production wells, a transmission system to carry geothermal water about the town, and a set of return pipes which carry used geothermal water to a set of three 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 should be given to ways to help individuals defray or spread these costs over time.

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 geothermal space heating for Ketchum 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 BTUs available from the geothermal resource is sufficient to cover probable heat demand one can

Table 4.0

CAPITAL COST BREAKDOWN

I.	Transmission System		
	(see 4.5.1)		
	Pipeline to town	$520,000	
	Town perimeter	225,000	
	To River Run	83,750	
	Laterals	251,250	
			$1,080,000
II.	Production System		
	(see 4.5.2)		
	5 wells	$125,000	
	5 pumps	90,000	
			$ 215,000
III.	Disposal System		
	(se 4.5.3)		
	Pipeline	$247,750	
	3 wells	70,650	
	3 pumps	54,000	
			$ 372,400
		TOTAL	$1,667,400*

*Amortized over 30 years at 10% requires yearly debt service of $176,875.

Table 4.1

HEAT SUPPLY vs. HEAT DEMAND

	Peak (BTU/hr)	Annual (BTU/yr)
Heat Supply (5 wells at 700gpm and 190^{o}F)	$7.7x10^{7}$	$6.7452x10^{11}$
Heat Demand	$7.7x10^{7}$	$2.63x10^{11}$

then move on to examining the actual cost and potential profitability of using geothermal heat instead of more conventional fuel sources.

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 Ketchum. The number of BTUs 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 4.6.4) 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:

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

with an $88^{o}C$ ($190^{o}F$) resource this gives a temperature drop (Δt) of $25^{o}C$ ($44^{o}F$). The quantity of heat available from a single 700 gpm well is given by the equation:

$$Q = 500\ (\Delta t)\ \dot{w}, \quad Q = \text{quantity in BTU/hr}$$
$$\Delta t = \text{temperature drop}$$
$$\dot{w} = \text{flow in gpm}$$
$$Q = 500\ (44^{o}F)\ (700\ \text{gpm})$$
$$= 1.54 \times 10^{7}\ \text{BTU/hr}$$

Multiplying this peak heat supply by 8760 hours per year gives the total yearly amount of heat available, 1.349×10^{11} BTUs per year.

4.4 Heat Load Estimates for Ketchum

Heat load estimates were based on a breakdown of sewer users compiled by the city of Ketchum in 1977. It was felt that this fairly comprehensive list of users broken down into residences, commercial establishments, trailers, offices, multiple dwellings, and schools would provide better estimation than some technique which merely based heat load on population. The specific detail of the sewer users' list was broken down into the categories above so that the estimates of heat load were as follows:

Residences - 620	5.208×10^7 BTU/hr
Schools - 2	1.4×10^6 "
Commercial - 103	5.4075×10^6 "
Offices - 24	3.36×10^5 "
Multiple dwelling - 160	7.7175×10^6 "
Trailers - 36	1.296×10^6 "

This estimate used EG&G, Idaho's Rules of Thumb, which provided heat loss figures per square foot per degree Fahrenheit. Residential figures are for an 1800 square foot house with average insulation. This peak heat load estimate was arbitrarily rounded up to 7.0×10^7 BTU/hr, then increased by 10% to reflect change in number of heating units in Ketchum since the survey of sewer users.

Multiplying the peak load estimate of 7.7×10^7 BTU/hr by 8760 hours per year gives maximum yearly usage. This figure was then corrected for an average utilization of 39%, which is the utilization figure based on 9986 heating degree days and a 70°F design temperature difference. Estimated yearly heat load was then 2.63×10^{11} BTUs. (See Table 4.1)

4.5 Proposed Facilities

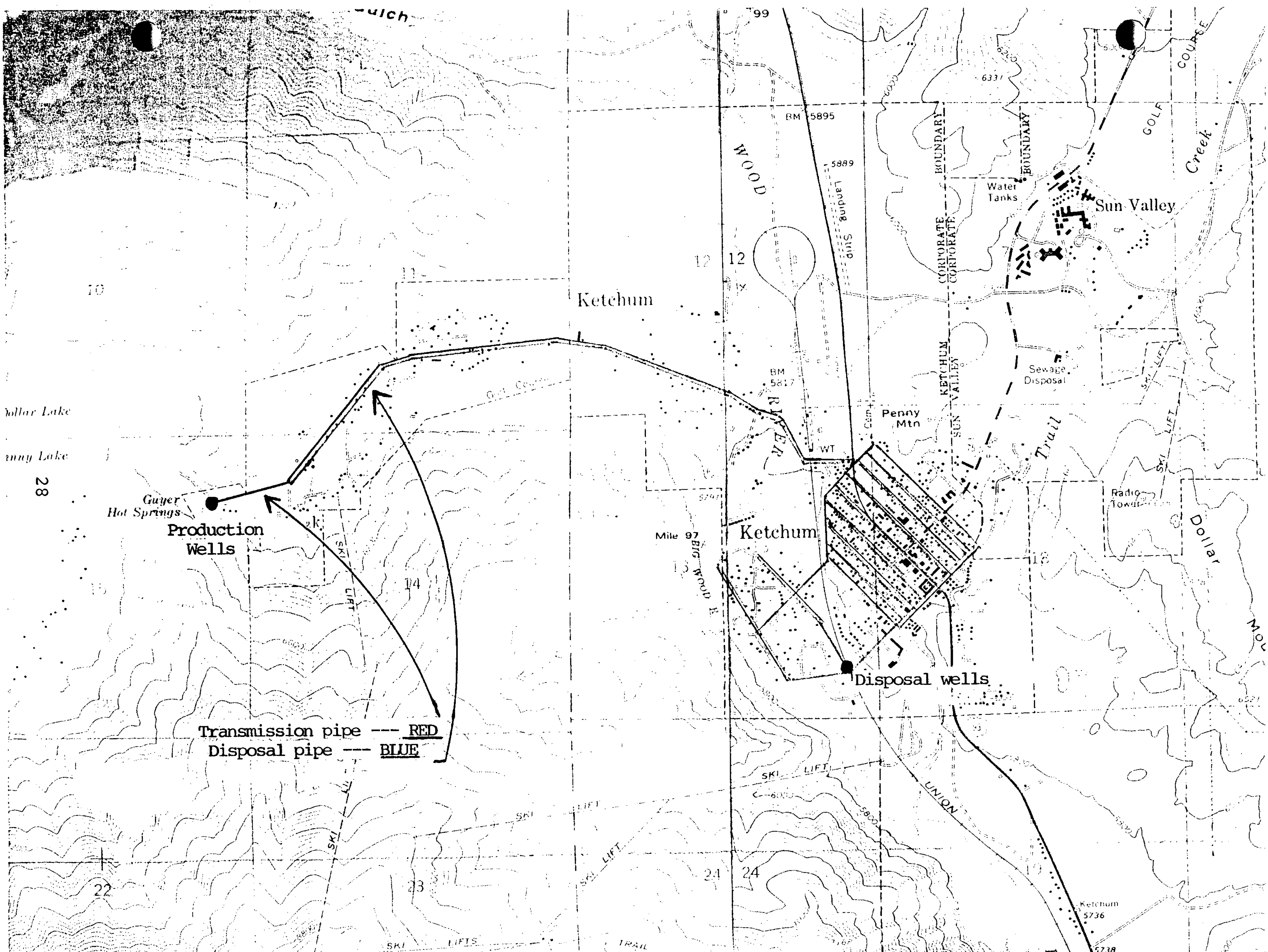
4.5.1 Transmission Systems

The transmission system is made up of four distinct parts. A large main line will run from the well site to town, capable of carrying the entire 3500 gpm needed for peak heating load. This pipe will be 3962m (1300 ft.) long and 35.6 cm (14 in.) in diameter and costs $131 per meter ($40 per ft.). At the edge of town the pipeline will describe a rectangular perimeter. This line, capable of carrying 1500 gpm, will be 2743m (9000 ft.) in length and 20.3 cm (8 in.) in diameter, at a cost of $82 per meter ($25 per ft.). There will be a separate smaller main delivering up to 500 gpm to the River Run area, a distance of 533m (1750 ft.), in 15.4 cm (6 in.) pipe costing $56 per meter ($17 per foot). Finally there will be laterals in the main town and at River Run with a total distance of 1372m (4500 ft.) of 7.6 cm (3 in.) pipe costing $39 per meter ($12 per foot) and 5105m (16750 ft.) of 10 cm (4 in.) pipe costing $49 per meter ($15 per foot). The transmission pipe network is outlined in Figure 4.5.1.

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

4.5.2 Supply System

Five 2650 liters/min. (700 gal./min.) wells would be drilled near the site of the present Guyer Hot Springs. The



Production Wells
Guyer Hot Springs
Ketchum
Ketchum
Sun Valley
Disposal wells
Transmission pipe --- RED
Disposal pipe --- BLUE
Penny Mtn
Water Tanks
Sewage Disposal
Radio Tower
WOOD RIVER
Landing Strip
Mile 97
BIG WOOD R.
CORPORATE BOUNDARY
KETCHUM SUN VALLEY
Trail Creek
GOLF COURSE
Dollar
UNION
SKI LIFT
SKI LIFTS
BM 5895
BM 5817
WT
Ketchum 5736
5738

FIGURE 4.5.1

wells are assumed to be 152m (500 ft.) deep in order to encounter the 88°C (190°F) resource. Each well is to be drilled 35.6 cm (14 in.) to 30.5m (100 ft.) with 25.4 cm (10 in.) casing, then 30.5 cm (12 in.) to the 152m (500 ft.) level with 20 cm (8 in.) casing.

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 per well drilled to an estimated $25,000, or $50 per foot for a drilled and cased well.

Downhole vertical turbine pumps of 30 horsepower are to be used to supply the geothermal fluid from the wells through the distribution system. Each of these pumps with its associated fittings and installation is estimated to cost $18,000. Each pump could consume 196,049 Kwh per year. At an average cost of 2¢ per Kwh and a 39% load factor this means $12.233 per pump.

4.5.3 Disposal System

Three 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 15m (50 ft.) and cased with 40.6 cm (16 in.) casing. Drilling of a 35.6m (14 in.) hole would continue to 152m (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 423,550 per disposal well.

The disposal pipeline is indicated by the blue line in Figure 4.5.1 Due to elevation changes between Guyer Hot Springs area and the city of Ketchum the disposal system should be able to operate on gravity flow. The disposal lines have been planned so that there is considerably less pipe required than for supply. The pipe itself is uninsulated and thus cheaper and, with the exception of the final mains to the disposal wells, it will be buried in the same trenches with the supply pipe. This factor too means lower cost per foot. The main from the supply well area to town will run 3505m (11,500 ft.) through 20.3 cm (8 in.) pipe at a cost of $26m ($8 per ft.). Laterials at Ketchum and River Run will be 1372m (4500 ft.) of 7.6 cm (3 in.) pipe at $9.84m ($3 ft.), 762m (2500 ft.) of 15.2 cm (6 in.) pipe at $19.68 m ($6 ft.) and 4343m (14,250 ft.) of 10 cm (4 in.) pipe at $13m ($4 ft.). Final mains leading to the disposal wells will run 686m (2250 ft.) in 10 cm (4 in.) pipe at $29.5m ($9 ft.) from River Run and 610m (2000 ft.) in 35.6 cm (14 in.) pipe at $45.92m ($14 ft.) (305m (1000 ft.) at $72m ($22 ft.) for the singly-buried part) for the main from Ketchum to the disposal wells.

4.6 Cost Analysis

A 20-year projection of geothermal costs per 10^6 BTUs 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 $1,667,400) plus operations and maintenance expense plus electric power to run the pumps. This total cost is allocated over yearly usage of 2.63×10^{11} BTUs to arrive at a figure which allows for easy comparison with conventional fuel costs.

Comparison with conventional fuels is carried out in two different forms in Tables 4.6.2 and 4.6.3. Table 4.6.2 makes the comparison in terms of fuel cost per 10^6 BTUs with correction for fuel conversion efficiency. The projected geothermal cost is only 12% of the cost of natural gas and even less compared with the other fuel alternatives. Table 4.6.3 makes the comparison in terms of annual fuel cost associated with using alternative fuel sources to meet Ketchum's total heat load. This represents but a different way of presenting the same information.

The projected geothermal system offers BTUs 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 too low but we use them for lack of a better alternative.

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

Table 4.6.4 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 their present value. The net present value is the total of these discounted savings over the years. The payback period required for discounted savings to recoup capital cost is 1.1 years. The internal rate of return, an interest rate which just equates the present value of a savings stream to investment cost, is 109%, an extraordinarily attractive figure for a potential investor.

Table 4.6.1

20 YEAR PROJECTION OF GEOTHERMAL COSTS

Years	(1) Amortization	(2) Electric Power	(3) Operations & Maintenance	(4) Total Geothermal Cost	(5) Cost per 10^6 BTU
1980	$176,875	$12,233	$16,829	$205,937	$0.78
1981	176,875	13,273	18,007	208,155	0.79
1982	176,875	14,401	19,268	210,544	0.80
1983	176,875	15,625	20,616	213,116	0.81
1984	176,875	16,953	22,059	215,887	0.82
1985	176,875	18,394	23,604	218,873	0.83
1986	176,875	19,958	25,256	222,089	0.84
1987	176,875	21,654	27,024	225,553	0.86
1988	176,875	23,495	28,915	229,285	0.87
1989	176,875	25,492	30,939	233,306	0.89
1990	176,875	27,659	33,105	237,639	0.90
1991	176,875	30,010	35,423	242,308	0.92
1992	176,875	32,560	37,902	247,337	0.94
1993	176,875	35,328	40,555	252,758	0.96
1994	176,875	38,331	43,394	258,600	0.98
1995	176,875	41,589	46,432	264,896	1.01
1996	176,875	45,124	49,682	271,681	1.03
1997	176,875	48,960	53,160	278,995	1.06
1998	176,875	53,121	56,881	286,877	1.09
1999	176,875	57,637	60,863	295,375	1.12
2000	176,875	62,536	65,123	304,534	1.16

(1) Capital cost of $1,667,400 amortized over 30 years at 10%

(2) electricity for pumps, escalated at 8.5% per year

(3) Estimated at ½% of pipe cost plus 3% of well and pump cost, escalated 7% per year

(4) Sum of columns (1), (2), and (3)

(5) Column (4) divided by yearly BTU usage of $2.63 \times 10^{11} \times 10^6$ BTUs.

Table 4.6.2

COMPARISON OF FUEL COST PER 10^6 BTUs

Years	(1) Natural Gas	(2) Electricity	(3) Fuel Oil	(4) Geothermal
1980	$ 6.50	$ 7.01	$11.10	$0.78
1981	7.05	7.61	11.94	0.79
1982	7.65	8.25	12.85	0.80
1983	8.30	8.95	13.83	0.81
1984	9.01	9.71	14.88	0.82
1985	9.77	10.54	16.01	0.83
1986	10.60	11.44	17.23	0.84
1987	11.51	12.41	18.54	0.86
1988	12.48	13.46	19.94	0.87
1989	13.55	14.61	21.46	0.89
1990	14.70	15.85	23.09	0.90
1991	15.95	17.20	24.85	0.92
1992	17.30	18.66	26.73	0.94
1993	18.77	20.24	28.77	0.96
1994	20.37	21.97	30.95	0.98
1995	22.10	23.83	33.30	1.01
1996	23.98	25.86	35.84	1.03
1997	26.01	28.06	38.56	1.06
1998	28.23	30.44	41.49	1.09
1999	30.63	33.03	44.64	1.12
2000	33.23	35.84	48.04	1.16

(1) Residential rate of $.54370 per therm and commercial rate of $.44858 per therm assuming 75% residential load and 25% commercial gives a weighted average of $.51992. This figure is divided by .8 to adjust for conversion efficiency, multiplied by 10 to convert to 10^6 BTU's, then escalated at 8.5% per year, (Dames & Moore).

(2) Residential rate of $.02642 per KWH and commercial rate of .01642 per KWH, weighted as above to average of .02392, multiplied by 293 to convert to 10^6 BTU's, escalated 8.5%.

(3) Price of $1.05 per gallon divided by .7 to adjust for conversion efficiency, multiplied by .74 to get to 10^6 BTU's, escalated 7.6%.

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

Table 4.6.3

20 YEAR COMPARISON OF ANNUAL FUEL COSTS

Years	(1) Electricity	(2) Fuel Oil	(3) Natural Gas	(4) Geothermal
1980	$1,843,235	$ 2,851,224	$1,709,237	$205,937
1981	1,999,910	3,067,917	1,854,522	208,155
1982	2,169,902	3,301,079	2,012,157	210,544
1983	2,354,344	3,551,961	2,183,190	213,116
1984	2,554,463	3,821,910	2,368,761	215,887
1985	2,771,593	4,112,375	2,570,106	218,873
1986	3,007,178	4,424,915	2,788,565	222,089
1987	3,262,788	4,761,209	3,025,593	225,553
1988	3,540,125	5,123,061	3,282,768	229,285
1989	3,841,036	5,512,413	3,561,803	233,306
1990	4,167,524	5,931,357	3,864,557	237,639
1991	4,521,763	6,382,140	4,193,044	242,308
1992	4,906,113	6,867,183	4,549,453	247,337
1993	5,323,133	7,389,088	4,936,156	252,758
1994	5,775,599	7,950,659	5,355,729	258,600
1995	6,266,525	8,554,909	5,810,966	264,896
1996	6,799,180	9,205,082	6,304,898	271,681
1997	7,377,110	9,904,669	6,840,815	278,995
1998	8,004,164	10,657,423	7,422,284	286,877
1999	8,684,518	11,467,388	8,053,178	295,275
2000	9,422,702	12,338,909	8,737,698	304,534

(1) Annual heat load estimate (2,63 x 10^{11}BTU) divided by 3413 BTU/KWH, times average weighted price of .023921 per KWH escalated 8.5%.

(2) Annual heat load estimate divided by 138,500 BTU/gal, times $1.05 per gal., times 1.43 to correct for conversion efficiency, escalated 7.6%.

(3) Annual heat load estimate divided by 100,000 BTU/therm, times weighted average of $.50992 per therm, divided by .8 to adjust for conversion efficiency, escalated 8.5%.

(4) From column (4), Table 4.6.1.

Table 4.6.4

20 YEAR OPERATING COST SAVINGS

Years	(1) Natural Gas	(2) Electric Power	(3) Operations & Maintenance	(4) Geothermal Savings	(5) Present Value (10%)
1980	$1,709,237	$12,233	$16,829	$1,680,175	$1,527,432
1981	1,854,522	13,273	18,007	1,823,242	1,506,812
1982	2,012,157	14,401	19,268	1,978,488	1,486,467
1983	2,183,190	15,625	20,616	2,145,949	1,465,712
1984	2,368,761	16,953	22,059	2,329,749	1,446,591
1985	2,570,106	18,394	23,604	2,528,108	1,427,051
1986	2,788,565	19,958	25,256	2,743,351	1,407,773
1987	3,025,593	21,654	27,024	2,977,005	1,388,795
1988	3,282,768	23,495	28,915	3,230,358	1,369,987
1989	3,561,803	25,492	30,939	3,505,372	1,351,473
1990	3,864,557	27,659	33,105	3,803,793	1,333,206
1991	4,193,044	30,010	35,423	4,127,611	1,315,184
1992	4,549,453	32,560	37,902	4,478,991	1,297,404
1993	4,936,156	35,328	40,555	4,860,273	1,279,862
1994	5,355,729	38,331	43,394	5,274,004	1,262,555
1995	5,810,966	41,589	46,432	5,722,945	1,245,480
1996	6,304,898	45,124	49,682	6,210,092	1,228,634
1997	6,840,815	48,960	53,160	6,738,695	1,212,013
1998	7,422,284	53,121	56,881	7,312,282	1,195,617
1999	8,053,178	57,637	60,863	7,934,678	1,179,439
2000	8,737,698	62,536	65,123	8,610,039	1,163,479

(1) Annual heat load estimate (2.63×10^{11} BTU/yr) divided by 100,000 BTU/therm, times weighted average of .51992 per therm, divided by .8 to adjust for conversion efficiency, escalated 8.5%.

(2) Electricity for pumps, escalated at 8.5% per year.

(3) Estimated at ½% 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.

A rough sensitivity analysis was conducted by doubling investment cost to $3,334,800, doubling electric power costs and raising operations and maintenance costs to $66,696 (2% of the doubled capital cost figure). These drastic increases in projected capital and operating costs affected rate of return and payback period in the expected direction, but still left them very attractive for investors. The recalculated internal rate of return was 57% and the payback period 2.9 years.

4.7 Economic Conclusions

The projected costs and savings seem so dramatic as almost to demand a space heating system for Ketchum. Potential heat load and the cold climate provide a relatively high utilization factor for space heating for a potential resource which appears shallow and close to town. Projected costs for using conventional fuels to meet Ketchum's space heating demand are so high, even assuming small yearly increases in fuel rates, that even a relatively high cost geothermal heating system would appear to be an economically feasible investment. 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. However, the margin of competitiveness is so large that even a much more expensive system than the one envisioned here would offer large savings for users and an attractive business proposition for investors.

5.0 Development Process

The development of geothermal waters at Ketchum, Idaho will require close cooperation between the City of Ketchum, the owner of Guyer Hot Springs, the Idaho Department of Water Resources, and the residents of Ketchum. 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

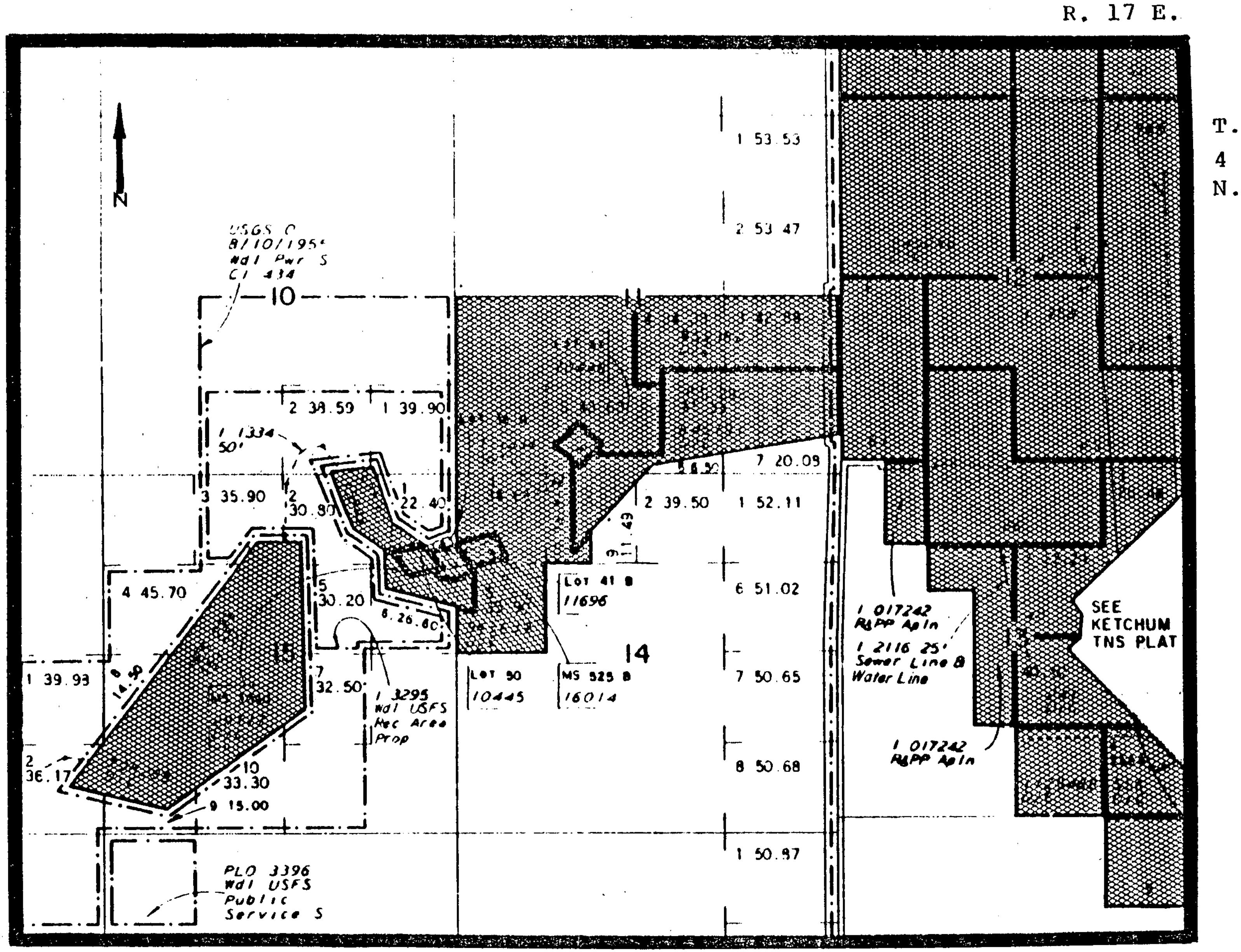
The potential exploration field near Ketchum is a patchwork of federal and private ownership. Figure 5.1 is the Master Title Plat for Township 4 North, Range 17 East and shows the location of federal, state and private land interests.

The main federal interests are the Sawtooth National Forest, a USGS power site withdrawal and a proposed Forest Service recreation area. Under federal law, geothermal resources are included within the mineral estate.

Private land interests are primarily derivatives of patented mining claims and homesteads. It should be noted that homestead patents usually reserved all minerals to the federal government.

FIGURE 5.1

Mineral Ownership and Reservations



Private Mineral Ownership

All Other Federal

Exploration on any parcel of land which has federal ownership or a federal geothermal reservation will require a geothermal lease from the Bureau of Land Management. Because the area has not been classified by the U.S. Geological Survey as a Known Geothermal Resource Area (KGRA), federal geothermal resources can be leased to the first qualified applicant applying for a lease. Exploration drilling on any parcels under state ownership or parcels under which the mineral estate is reserved to the State of Idaho can occur only if a geothermal lease is acquired from the State Land Board. Exploration on private or municipal lands within the area requires permission from the landowner and the appropriate permits from the State of Idaho. As of September 1, 1980, no federal or state geothermal leases existed in the Ketchum region.

The probable drilling locations outlined in this report are located both inside and outside the Ketchum city limits on private land. Title to the geothermal resources underlying these lands is privately held. However, water rights at the sites are an important consideration. The potential for conflicting groundwater uses as a result of geothermal development must be addressed.

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 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 constructing 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 a 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 Ketchum. 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 Ketchum 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.

6.0 Conclusions and Recommendations

The existence of a private space heating system utilizing Guyer Hot Springs water indicates two significant facts. First, the hot springs at Guyer and elsewhere in the Wood River Valley are indicative of the area's geothermal resource potential. Secondly, that a private space heating system has developed confirms the existence of a local market for geothermal energy. Unlike most areas in Idaho, Ketchum is indeed fortunate to have such strong indicators of geothermal resource development.

Resource temperatures are expected to range from a minimum of 70°C (159°F) to 125°C (257°F). Temperatures in this range have proven applications for space heating.

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

Title to the geothermal resources underlying the probable drilling site outlined in this report is privately held. However, strong consideration must be given to existing water rights in the area. Once the water rights issues are resolved, only the appropriate permits from the Idaho Department of Water Resources are required for development.

An engineering analysis is needed to determine the most suitable method for disposing the thermal water. The disposal of thermal fluids by injection will require approval by both the Idaho Department of Water Resources and the Department of Health and Welfare.

There are several public and private mechanisms available to Ketchum to create a space heating district. In addition, public funding via grants or loan guarantees may be possible.

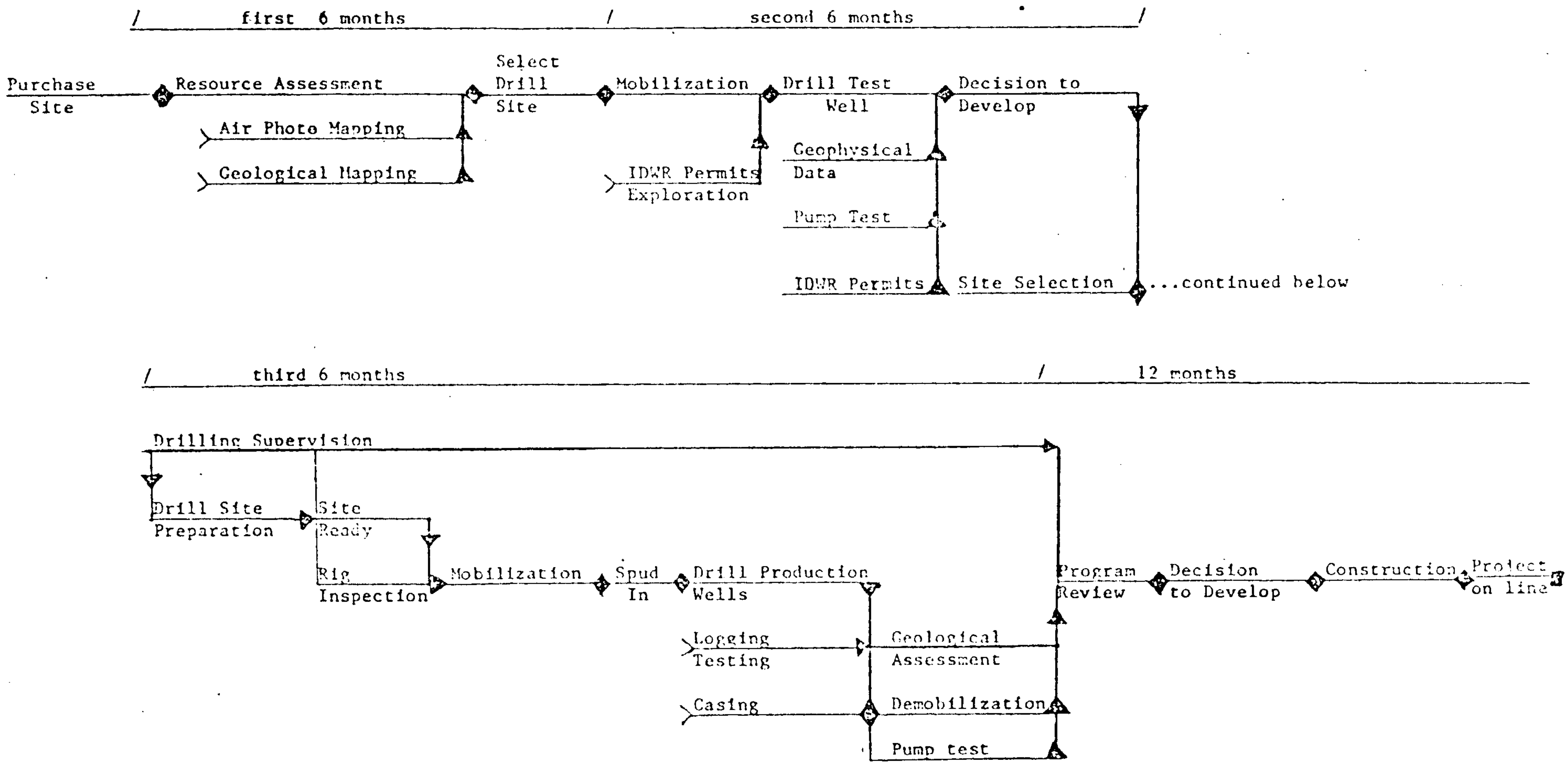
Development of a geothermal space heating system in Ketchum would save energy derived from oil, gas, and wood, would generate substantial savings, and greatly enhance Ketchum's desirability to visitors and residents.

7.0 Conceptual Time Line for Development

Figure 7.0 illustrates a conceptual time line for developing a geothermal district heating and greenhouse heating system. This timeline reflects all activities occurring on private and municipal lands.

FIGURE 7.0

CONCEPTUAL TIMELINE
KETCHUM SPACE HEATING DEVELOPMENT



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