WATER
for
IDAHO

Idaho Water Resources
Research Institute

Leland L. Mink
Director
Morrill Hall 106
University of Idaho
Moscow, Idaho
83844-3011
Phone: (208) 885-6429
FAX: (208) 885-6431

Al E. Murrey
Associate Director
2110 Ironwood Parkway
Coeur d'Alene, Idaho
83814
Phone: (208) 769-1448
FAX: (208) 769-1404

Paul Jehn
Associate Director
UI Boise Center
800 Park Boulevard
Suite 200
Boise, Idaho
83712
Phone: (208) 334-2999
FAX: (208) 364-4035

November 21, 1994

Dr. Howard Ross
University of Utah Research Institute
391 Chipeta Way, Suite C
Salt Lake City, UT 84108-1295

Dear Howard:

Enclosed is a final draft copy of our geothermal report and a diskette which contains the bibliography (GEOTHERM.bib, in WordPerfect for Windows 5.2) and the geothermal data base (GEOTHERM.dbf, in DBase III Plus) for your review and comment. The Geothermal Resources of Idaho map at 1:1,000,000 will contain all geothermal sites with several inserts at about 1:200,000 for the congested areas. All sites will be numbered with the county and identifier code from the DBase file. A draft of the map should be available in several weeks and I will forward a copy as soon as possible. The final product will be a 3-color map that we hope will be finished by January.

We have attempted to address the comments and concerns you expressed previously, although we have not converted english units to metric units in the data base. Units were entered the way they were presented in the reference, whether english, metric or both. Also, we have not entered a charge balance field. This information was generally not provided, and time did not permit calculating the ratio for those sites where cation/anion values were available. Otherwise I believe we have complied with most of your requests.

Please call me if you have any questions.

Sincerely,

John Kauffman

Enclosures

xc: Roy Mink

OVERVIEW OF GEOTHERMAL INVESTIGATIONS IN IDAHO,

1980 to 1992

by

William J. Dansart
John D. Kauffman
Leland L. Mink

Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho

October, 1994

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Figures and Tables

Acknowledgements

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We would like to thank Howard Ross of UURI, and Paul Lienau and Gene Culver of OIT for reviewing, and for providing comments and suggestions for improving, the products of this project.

We also would like to express our appreciation to Ken Neely of Idaho Department of Water Resources, Boise, for providing additional references for the bibliography and for obtaining information in the USGS geothermal data base .

Disclaimer

Abstract

The Idaho Water Resources Research Institute has compiled available geothermal resource data for the State of Idaho generated since the last state assessment published in 1980 by the Idaho Department of Water Resources. Data sources include state and federal agency reports, organizations under contract with the U. S. Department of Energy, company reports, research theses, and Idaho Department of Water Resources Well Driller's Report forms. This report summarizes the characteristics, occurrences and uses of thermal waters in Idaho which are documented by resource investigations conducted since 1980. Recommended areas for further investigation are briefly discussed.

Additional products of this compilation include a *DBase III Plus* data set, a bibliography of Idaho geothermal resources, and a 1:1,000,000-scale geothermal resource map of Idaho. The data set includes 1556 entries for 1539 individual wells and springs; this information was derived from a variety of reports on geothermal investigations, from previous compilations and from well drillers' reports filed with the state between 1979 and 1993. The bibliography lists over 750 references on Idaho geothermal resources. The map presents the distribution of geothermal wells and springs included in the data set of this report.

OVERVIEW OF GEOTHERMAL INVESTIGATIONS IN IDAHO, 1980 to 1992

Introduction

The Idaho Water Resources Research Institute (IWRRI) has compiled available geothermal resource data for the State of Idaho focusing on data generated since the last state assessment published by the Idaho Department of Water Resources (IDWR)(Mitchell and others, 1980). Sources of information include state and federal agencies, organizations under contract to the Department of Energy, and individual authors. The report outlines the characteristics, occurrences and uses of thermal waters in Idaho which are documented by resource investigations conducted since 1980.

In addition to well data from other reports, the DBase files include data from nearly 200 water wells, up to 924 meters (3030 feet) in depth, drilled in Idaho from 1979 to 1993, for which drillers logs have been filed with the Idaho Department of Water Resources (IDWR). Temperatures in these wells range from 20°C to 82°C (68°F to 180°F). Approximately 50% of these wells were drilled for geothermal applications (municipal and domestic heating, greenhouses, fish farming, bathing resort facilities); the remainder were domestic and irrigation wells that encountered warm water. Geographically most drilling has occurred in Twin Falls, Boise, Owyhee, and Ada counties; approximately 75% of warm-water wells drilled in Idaho since 1979 are located in these four counties.

Funding for this project was provided by the United States Department of Energy, Geothermal Division under subcontract with EG&G Idaho, Inc., Task Order No. 77, Subcontract C85-110544.

Report Scope and Format

The scope of this report is to present a summarization of geothermal data in Idaho compiled by various individuals, companies and organizations since the IDWR report of 1980 (Mitchell and others, 1980); the reader is referred to the cited references for detailed information. Attached to the report are a diskette containing data on 1539 thermal wells and springs (GEOTHERM.dbf) and a comprehensive bibliography of over 750 references compiled on Idaho geothermal investigations (GEOTHERM.bib). Also attached is a geothermal map of Idaho (in pocket), compiled at a scale of 1:1,000,000, that presents locations for thermal wells and springs. Identifier numbers for each site on the map correspond to the county (CO) and identifier (ID) fields in the DBase file.

In this report, geothermal resources are discussed by county in alphabetical order. Named wells or springs are listed by name and/or township, range, section and subsection with their county and DBase identifier (field 2, CO; and field 3, ID) in **bold** parentheses. Unnamed wells and springs are given location identifiers following the format used by the U. S. Geological Survey and IDWR (see Figure 1) and also identified with the DBase ID. Units of measurement are presented as metric units with English Standard units in parentheses.

Compiled geothermal data have been entered in *DBase III Plus* in the data set GEOTHERM.dbf (attached diskette). This file contains information for wells and springs from published reports or unpublished documents. The focus of this compilation is on information developed since 1980; however, basic information on name, location, type, and temperature has been included for all thermal wells and springs in Idaho. Reference sources (field 25) for data are designated by an asterisk (*) in the *References Cited* section of this report. Fifty-seven data fields are contained in file GEOTHERM.dbf; these fields are listed in Table 1. Counties (field 2) are listed by a two-digit numeric code corresponding to their alphabetical order as shown in Table 2. Subsections (field 7) for some wells or springs may differ slightly from some published locations in other reports. Generally this is the result of different subsection listings for the same well or spring described in different publications. Whenever possible, the discrepancy was resolved by locating the thermal occurrence on a 7.5-minute quadrangle topographic map and determining the subsection position. Published latitude-longitude positions were used when available. When published positions were not available or when errors were apparent in published locations, the geothermal occurrence was located on a 1:100,000-scale topographic map and its position was measured manually. Appendix A lists the geothermal sites, locations and temperatures included in the DBase III file.

This report and the accompanying *Bibliography of Idaho Geothermal Resources* (Dansart and others, 1994) have been composed in WordPerfect for Windows 5.2. The report and bibliography are available in either hard copy or disk format; the DBase file is available only on disk. The map accompanying the report is also available separately. Requests for all these items may be made through the Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho 83844-3011, (208) 885-6429.

Record Checking

Some duplication of geothermal sites in the DBase file is inevitable when dealing with different reference sources and sometimes incomplete location information. We have attempted to minimize duplication by sorting routines designed to identify sites with identical locations, and by cross-checking names/locations from different sources. However, unnamed sites, particularly from Parliman and Young (1992), may duplicate some named sites from earlier reports which have slightly different subsection and/or latitude-longitude designations; this is especially true in the Boise area. When sites with slightly different locations were determined to be the same, they were given the same identifier (ID field) number in the DBase file; otherwise they were entered as separate sites with different identifier numbers. When duplicate sites are suspected or when the name is uncertain, the name field (NAME) is queried.

Previous Compilations

Water Information Bulletin No. 30, Part 9 (Mitchell and others, 1980) is a compilation of Idaho geothermal resource data available at that time. The publication contains

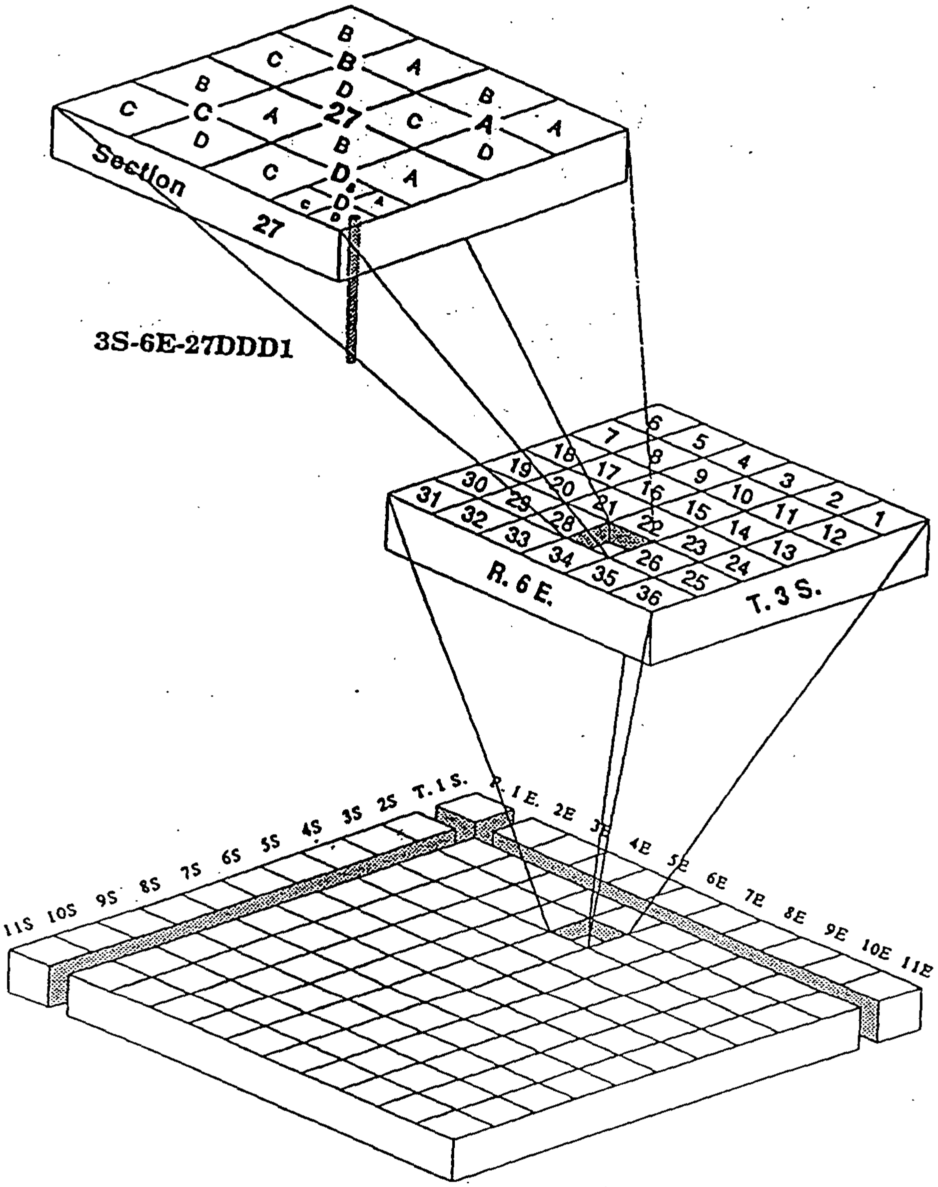

Figure 1. Well and spring location and numbering system (after Parliman and Young, 1992, Figure 1, p. 2).

Table 1. DBase file GEOTHERM.dbf data fields.

Field #	Name	Description
1	NAME	well/spring name or location code
2	CO	county code #; see Table 2
3	ID	site identifier
4	TWN	township
5	RNG	range
6	SEC	section
7	SUB	subsection(s); see Figure 1
8	LAT	latitude, in decimal degrees
9	LONG	longitude, in decimal degrees
10	DATE	date of information source or sample
11	TYPE	well (W) or spring (S)
12	TEMP_C	temperature in °C
13	TEMP_F	temperature in °F
14	SAMPLE_C	water sample temperature in °C
15	TEMP_TYPE	surface or downwell water
16	FLOW_GPM	flow rate in gallons per minute
17	FLOW_LPM	flow rate in liters per minute
18	FLOW_LPS	flow rate in liters per second
19	DEPTH_FT	well depth in feet
20	DEPTH_M	well depth in meters
21	DEPTH_OF_C	depth of circulation in meters
22	M_TO_H2O	depth to water in meters
23	ELEV_FT	elevation in feet
24	ELEV_M	elevation in meters
25	REFERENCE	source of information
26	PH	pH
27	SPCOND	specific conductance in micromhos (μmhos)
28	TDS_MGL	total dissolved solids in milligrams per liter (mg/l)
29	NA	sodium (mg/l)
30	K	potassium (mg/l)
31	CA	calcium (mg/l)
32	CACO3	calcium carbonate (mg/l) (hardness)
33	MG	magnesium (mg/l)
34	FE	iron (mg/l)
35	FE_MICRO	iron in micrograms per liter (μg/l)
36	AL	aluminum (mg/l)
37	SIO2	silicon dioxide (mg/l)
38	B	boron (mg/l)
39	B_MICRO	boron (μg/l)
40	LI	lithium (mg/l)

Table 1. (continued)

Field #	Name	Description
41	LI_MICRO	lithium (μg/l)
42	HCO3	bicarbonate (mg/l)
43	SO4	sulfate (mg/l)
44	NO2_NO3	nitrite plus nitrate (mg/l)
45	CL	chloride (mg/l)
46	F	fluoride (mg/l)
47	AS_MICRO	arsenic (μg/l)
48	RESTEMP	reservoir temperature in °C
49	RS_NA_K_CA	reservoir temperature with Na/K/Ca geothermometer in °C
50	LOG_ARAG	log saturation index - aragonite
51	LOG_CALC	log saturation index - calcite
52	LOG_DOLO	log saturation index - dolomite
53	LOG_TALC	log saturation index - talc
54	LOG_TREMOL	log saturation index - tremolite
55	CL_TO_NA	Cl:Na molar ratio
56	SILICA_DEG	silica geothermometer temperature in °C
57	PCO2	partial pressure of CO_2 gas (atmospheres)

Table 2. County codes used in DBase files (after Parliman and Young, 1992, Table 2, p. 10).

County	Numeric code
Ada	01
Adams	03
Bannock	05
Bear Lake	07
Bingham	11
Blaine	13
Boise	15
Bonneville	19
Butte	23
Camas	25
Canyon	27
Caribou	29
Cassia	31
Clark	33
Custer	37
Elmore	39
Franklin	41
Fremont	43
Gem	45
Gooding	47
Idaho	49
Jefferson	51
Jerome	53
Latah	57
Lemhi	59
Lincoln	63
Madison	65
Oneida	71
Owyhee	73
Payette	75
Power	77
Teton	81
Twin Falls	83
Valley	85
Washington	87

information on the properties, characteristics, and origins of 899 thermal water occurrences with surface temperatures of 20°C (68°F) or higher within the state. Included with this study is a state geothermal resource map (NOAA, 1980). The report lists chemical analyses of 357 sites. Other reports on statewide geothermal potential include: Stearns and others (1937); Waring (1965); Ross (1971); Nichols and others, (1972); Warner (1972; 1975); and Young and Mitchell (1973).

Since publication of Water Information Bulletin No. 30, Part 9, in excess of 350 papers have been written addressing Idaho geothermal resources. Notable assessments which encompass areas hosting most geothermal occurrences in Idaho include those by Blackwell (1988) and Mabey (1983). In addition, a compilation of data from Idaho thermal water [sample] analyses performed at USGS laboratories between 1921 and 1991 is presently available (Parliman and Young, 1992); this reference was used extensively to compile data for our study.

Regional studies include: Blackwell and others (1992) and Smith (1980), Snake River Plain; Lewis and Young (1980b), Payette River Basin; Lewis and Young (1982b), Boise River Basin; Young and Lewis (1982b), Salmon River Basin; Young (1985), Idaho batholith; Batdorf and others (1980), Ralston and others (1981) and Souder (1985), southeast Idaho; Young and Lewis (1982a) and McClain (1980), southwest Idaho.

Environmental assessments of seven Known Geothermal Resource Areas (KGRA's) were conducted by EG&G, Idaho (Spencer and Russell, 1979a-e; Spencer and others, 1979a-b). Areas evaluated are: Vulcan Hot Springs, Crane Creek, Castle Creek, Bruneau, Mountain Home, Raft River, and Island Park/Yellowstone KGRA's.

Summary of Geothermal Studies Since 1980

Geothermal resources are discussed below by county whenever practical. The scope of some reports extends across several counties; in these instances, the reports are discussed under the county in which the geothermal resource dominates. Associated geothermal sites that occur in adjacent counties are noted by their ID code. Portions of some reports are excerpted in their entirety for summary purposes; these have been referenced for proper credit.

Ada County (01)

Boise Area

Hot springs on the north side of Boise near the base of the foothills were the earliest indicators of a geothermal resource in the Boise area. The City of Boise has been utilizing geothermal resources since the 1890's for heat and hot water. The first commercial district heating system was built in Boise in the 1890's and supplied the state penitentiary facilities with geothermal water for space heating, showers, and a laundry complex for over 80 years. Warm water was supplied by two 122 m (400 ft) wells drilled in 1890 **(1-90, 1-91)**; this venture eventually became the Boise Warm Springs Hot Water district. In the 1930's hot water was provided to approximately 400 residences, small commercial businesses, and a well-known natatorium (swimming and health facility). Use of geothermal heat from the system began to decline in the late 1930's when low cost natural gas and electricity became readily available. In 1974 the State of Idaho initiated a study of heating ten State office buildings in downtown Boise. Shortly thereafter, the City of Boise, in cooperation with the United States Department of Energy, formed the City Energy Office and began developing feasibility studies for a major downtown district heating system. Major expansion of Boise's geothermal resource use began with a successful retrofit of the State Health Laboratory, as a pilot project, in 1977. In 1979, a new agency was created called Boise Geothermal to coordinate activities between the City of Boise and Boise Warm Springs Water District. In 1980 and 1981, the State of Idaho drilled two wells to service the Capitol Mall heating system. One of these became the production well **(1-76)**; the other became the injection well. The 71°C (160°F) water heated over 74,320 m^2 (800,000 ft^2) of office space (Austin and others, 1984), flowing at a maximum rate of 3028 l/min (800 gpm) during peak heating system (Berkeley Group, 1990). In 1981, Boise Geothermal drilled three production wells (BGL-2, BGL-3, and BGL-4)**(1-80, 1-82, and 1-83)** to service a 7.2 km (4.5 mi) heat distribution system in downtown Boise. Through the cooperative efforts of the City of Boise, the Boise Warm Springs Water District, the Department of Energy, and the Economic Development Administration, a major refurbishing of the Warm Springs pipeline system was completed and a new district heating system was built in order to serve downtown Boise (Mickelson, 1985). The Boise City District Heating system became operational in 1983, and in 1985 was capable of delivering 15,140 l/min (4000 gpm) or 2.2 million therms to the heating system (Mickelson, 1985). Twenty-one buildings were connected by March, 1985. These buildings represent 77,107 m^2 (830,000 ft^2). The 21 buildings include private offices, a library, a hospital, several public buildings, a veteran's home, and a commercial laundry. The system has the capacity to service four to five times the connected area (Mickelson, 1985).

In addition to space-heating, the geothermal system is used to treat tree root infestation within the sewer system. Geothermal water is also used by the local highway district to clear inlets and drains; and to melt ice at stream undercrossings (Mickelson, 1985).

The Boise project is a technical success having completed several heating seasons. Buildings formerly heated with oil, natural gas and electricity have been converted to geothermal heat. The resource appears to have a bright future in Boise.

An extensive review of data and evaluation of the Boise Geothermal Aquifer was conducted by the Berkeley Group (1990) under contract to the Idaho Department of Water Resources. The Berkeley Group evaluated an area extending from approximately 2.4 km (1.5 mi) southeast of the State Capitol building to 0.8 km (0.5 mi) northwest along the Boise Front. Pressure and temperature response modeling was conducted. The report concluded that: 1) geothermal production wells along the Boise Front fault communicate readily and 2) interference occurs between production wells and affects water levels along the fault in general. The effects of development on the geothermal aquifer and aquifer longevity cannot be predicted without further hydrologic, geophysical and geochemical investigation. The report outlined needed monitoring and recommended methods for further investigation.

Locations of slim hole observation wells were proposed, along with identification of existing wells for temperature and water level monitoring. Recommendation of a long-term flow test was also made, along with installation of accurate total flow devices on selected production wells. Regular geochemical sampling of major pumping wells and tracer testing of injection wells was also suggested (Berkeley Group, 1990).

Geologic mapping and data from geothermal water wells have provided information to delineate late Cenozoic geologic units and structures important to understanding the geothermal system of Boise as it is currently being developed (Wood and Burnham, 1983). The main geothermal aquifer is a sequence of rhyolite layers and minor arkosic and tuffaceous sediments of the Miocene Idavada Group. The aquifer is confined by a unit of impermeable basaltic tuffs. The aquifer has sufficient fracture permeability to yield 65-77°C (150-170°F) hot water at a rate of 2271 to 4542 l/min (600 to 1200 gpm) from wells drilled in the metropolitan area north of the Boise River. In this area the rhyolite lies at a depth of 274 to 610 m (900 to 2000 ft). A conceptual model of recharge assumes percolation to a depth of 2.13± km (7000± ft) beneath the granitic highlands northeast of the city driven by topographic head. Heated water convects upward through the northwest-trending range-front faults.

Underlying the Idavada Group, granitic rocks of the Idaho batholith have been intersected by at least two deep wells; one of these wells has the highest flowing temperature, at 82°C (180°F)(**1-98**), of any well in the Boise area. The granite is not usually a drilling target because of assumed low permeability. However, along the Boise Front fault zone, the granite can be relatively shallow and exhibit a high degree of fracture permeability. An unconformity separates the Idavada Group from the overlying sediments and basalts of the Idaho Group. Wells completed within the Idaho Group provide domestic water for Boise residents; water temperatures and chemistry from the lower portions of the Idaho Group indicate that some leakage from the underlying geothermal aquifer is occurring (Berkeley Group, 1990).

An analysis of drawdown and production data by Waag and Wood (1987) suggests that the Boise Geothermal Aquifer system was at or near equilibrium prior to 1983. A decline in water levels was recognized in the vicinity of production wells. The rate of decline appeared to be increasing without a coincident increase in production. The main unreinjected production comes from wells owned by Boise Warm Springs Water District and Boise Geothermal Limited. These two well fields are completed within fractures of the Boise foothills fault zone (Bffz) along the boundary between the Boise foothills and the SRP. Capitol Mall, owned by the State of Idaho, produces from and reinjects fluid into fractured rhyolites and interbedded sediments beneath the SRP approximately 914 m (3,000 ft) southwest of the Bffz. Water levels within the system are cyclical and fluctuate between a low in late February and a high in early September. Although other factors may play a minor role, the principal cause of the cyclicity is withdrawals from the aquifer in response to demand for hot water. In the late 1890s the artesian head in the Warm Springs area was at approximately 858 m (2815 ft) elevation (Lindgren and Drake, 1904). By 1983, maximum recovery declined to approximately 843 m (2,765 ft) and in 1987 to 832 m (2,730 ft). Prior to 1982-83 the system seems to have been at or near equilibrium. However, in 1983-84 unreinjected production peaked at approximately 1722 million liters (455 million gallons) and equilibrium was disturbed. Although withdrawals by the two major producers which do not reinject have decreased to an average of 1514 million l/yr (400 million gal/yr) recovery levels in the Boise vicinity have declined at rates increasing from 0.4 to 3.65 m/yr (3 to 12 ft/yr). The evidence suggests interconnection and interference between the wells of the major producers (Waag and Wood, 1987).

In addition to investigations previously cited, other evaluations of the Boise Geothermal Aquifer include those by Wood and Burnham (1983), Mayo and others (1984), Young and others (1988), and Mariner and others (1989).

Other areas in Ada County

A study was conducted for Boyd Anderson near Mora, Idaho to assess the technical and economic feasibility of integrating a geothermally heated anaerobic digester with a fuel alcohol plant and cattle feedlot. It was determined that sufficient quantities of biogas can be produced through the anaerobic digestion of tillage and manure collected from a cattle feedlot to provide approximately 14,000 of the 30,000 Btu required to produce each gallon of alcohol (Austin, 1981).

The geothermal potential of the Mora area is probably similar to that of the Nampa-Boise area. Information on the temperature potential at depths greater than 610 m (2000 feet) was obtained by an analysis of the well logs from the J.N. James No. 1 well **(1-111)** (T4N, R1W, section 27), a 4.27 km (14,000 ft) oil test well drilled about 24 km (15 mi) northwest of Mora. The bottom hole temperature in this well (recorded 11.5 hours after circulation) was 177°C (350°F), yielding a gradient of about 40°C/km (2.5°F/100 ft). Whether or not sufficient quantities of water are available at these greater depths is questionable.

Bannock County (05)

Tyhee Area

According to Corbett and others (1980) it appears that warm water suitable for space heating may be available in the Tyhee area if structures controlling thermal water movement can be identified at depth. Highest estimate of subsurface temperature at drillable depth is 80°C (176°F); a low of 41°C (106°F) is represented by surface discharge in the area.

The area studied by Corbett and others (1980) includes approximately 72 km^2 (28 mi^2) of the Tyhee portion of Bannock County,immediately northwest of Pocatello, Idaho. The Tyhee area is marginal to the SRP and located at the main boundary separating the SRP from the adjacent Bannock Range block. Gravity and magnetic studies, geochemical surveys, temperature gradient measurements, well log compilation, geologic mapping and Landsat imagery interpretation was conducted. These data were used to create a model for the Tyhee area.

Temperature gradient measurements were made in seven unused wells in the Tyhee and adjacent areas. These wells ranged in depth from 30 to 230 m (98 to 754 ft). The temperature gradients measured were inconsistent and variable; reliable overall temperature gradients for the Tyhee area could not be determined. The gradients range from nearly isothermal to a maximum of 190°C/km (11.4°F/100 ft). Most gradients were above normal (33°C/km [2.8°F/100 ft]). Four of the wells from which gradients were obtained exhibited a lower gradient in the upper section of the well and a steeper gradient in the deeper parts of the well bores. Possible causes include thermal conductivity changes in underlying sediments and rock, vertical or lateral groundwater movement, topographic effects, seasonal fluctuations and/or irrigation practices.

Hot waters of the area appear to be both spatially and genetically related to the major faults present, primarily at fault intersections. Recurrent fault movement probably created permeable zones for water circulation; these zones most likely control hot water occurrence. The quartz chemical geothermometer and a mixing model indicate that thermal water equilibrated last at a temperature of between 63°C and 80°C (145°F and 176°F). Geothermal gradient measurements indicate a gradient of 60°C/km (4.3°F/100 ft) and speculative thermal conductivity values indicate heat flow of from 1.2 to 3.0 HFU with a probable value of about 3 HFU for the area.

Pocatello

Trans Energy Systems (1981) studied the potential application of low temperature geothermal heat to a barley malting process. The study focused on the Great Western Malting Company facility at Pocatello, Idaho; the plant utilized natural gas. Trans Energy Systems estimated the presence of a geothermal resource yielding 3785 to 5678 l/min (1000 to 1500 gpm) at 65.5°C to 121°C (150°F to 250°F) in the area. Based on this estimate, the viability of seven different processing systems utilizing geothermal heat was evaluated. Preliminary analysis indicated payback on the installation of a system to utilize the resource would occur in under 2 years.

Bear Lake County (07)

A hydrogeologic investigation of geothermal systems in the vicinity of the Bear River Range was conducted by Baglio (1983). This was a reconnaissance level examination of regional geologic controls and hydrochemical characteristics of thermal and nonthermal groundwater systems in the area. Fifty three selected springs and shallow wells were characterized. These sites are located in Bear Lake, Caribou and Franklin counties but are discussed here because the majority of the area examined is in Bear Lake County.

Thermal springs in the vicinity of the Bear River Range occur in the Bear Lake, Gem, and Cache valleys and the Blackfoot Lava Field. Limited, small scale use of the geothermal resources has occurred; development has been primarily at discharge sites.

Baglio's (1983) research was conducted within the region bordered by the Blackfoot River to the north, Gem and Cache valleys to the west, and the Idaho state line to the south. The eastern boundary extends from the Blackfoot River Reservoir to the southeastern corner of the state. This 4,700 km^2 (1815 mi^2) area of southeastern Idaho is characterized by north- and northwest-trending mountain ranges and valleys. Linear ranges of predominantly Paleozoic and Mesozoic marine carbonate strata are separated by wide intermontane basins filled with thick deposits of continental ash, conglomerate, and limestone. The surfaces of the basins are covered by Quaternary basalt, alluvium, colluvium, and lacustrine sediments.

Three regional hydrochemical groups were identified: two groups represent thermal ground water systems and the other includes the nonthermal ground water systems of the area. The following description of the geothermal systems is excerpted from Baglio's report (1983).

Geographical and geological similarities of the springs and wells sampled were examined to understand physical conditions that control the ground water discharges. The hydrochemical data were examined statistically to group the springs and wells by chemical characteristics. The resulting hydrochemical groups were then compared with physical settings to identify and conceptualize regional ground water flow systems, specifically geothermal flow systems.

The sites selected for analyses represent thermal and selected nonthermal hydrogeologic regimes in the area. Temperatures measured ranged from 5°C (41°F) at Trout Creek Spring in Caribou County to 75°C (167°F) at Maple Grove Hot Spring **(41-6)** in Franklin County.

Conclusions drawn by Baglio (1983) are:

1. The locations of nonthermal ground water discharges, particularly in the Bear River Range, appear to be controlled chiefly by stratigraphic relationships; the locations of thermal discharges throughout the area appear to be controlled by predominantly major normal or tear faults.

2. Thermal spring and well discharges with surface temperatures contribute a negligible volume of water to the overall hydrologic budget of the area.

3. The ground water flow systems emanating at the surface as both nonthermal and thermal discharges are probably meteoric in origin.

4. The thermal systems probably derive heat by thermal conduction from rock at depth; the depths of ground water circulation are estimated from 300 m to 3,000 m.

5. Two end-members of hydrochemical types present within the study area are: a) water with calcium or magnesium and bicarbonate as dominant ions; and b) water with sodium and chloride as the dominant ions.

6. Three hydrochemical groups of ground waters delineated by the chemical characteristics represent: a) nonthermal ground water systems throughout the area; b) thermal systems in the Soda Springs/Blackfoot Lava Field area; and c) thermal systems in the lower Gem Valley area.

7. Nonthermal ground water systems throughout the area have cold surface temperatures, low dissolved solids concentrations, and are chemically uniform with calcium and bicarbonate as the dominant ions. Nonthermal systems specifically within the Bear River

Range are controlled by predominantly karstic conditions and discharge from carbonate formations located stratigraphically above the Brigham Quartzite.

8. Thermal systems in the Soda Springs area have warm surface temperatures, high dissolved solids concentrations, and have primarily calcium and bicarbonate as dominant ions. The unique chemical characteristics of these discharges appear, in part, to be the result of external inputs of CO_2 into the flow systems at some depth. The variations in temperature and dissolved solids concentrations appear to be related to differences in the structural controls of the discharges.

9. Thermal systems in lower Gem Valley have warm to hot surface temperatures, moderate dissolved solids concentrations, and evolve hydrochemically from having calcium and bicarbonate as dominant ions to having sodium and chloride as dominant ions. This evolution occurs from north to south along the trace of the West Gem Valley fault. The cause of the hydrochemical evolution is suspected to be the dissolution of halite.

Blaine County (13)

The geology of several hot spring sites has been mapped in varying detail by Anderson and others (1985); Blackett (1981b); Struhsacker and others (1983) and Leeman (1982). Individual systems that have been investigated are Magic Hot Springs **(13-3)**(Struhsacker and others, 1983; 1984) and Guyer Hot Springs **(13-17)**(Blackett, 1981b; Burkett and Litke, 1989). Assessments that include the geothermal resources of Blaine County have been made by personnel from the U.S. Geological Survey (Sammel, 1978; Mariner and others, 1983).

Geochemical studies of thermal springs in Blaine County were conducted by Zeisloft and others (1983) and Foley and others (1983). Foley and Street (1985a-b; 1986; 1988) discussed the nature and occurrence of the thermal resources and associated elevated fluoride levels and have prepared a field guide addressing individual spring sites and regional geothermal potential.

Zeisloft and others (1983) integrated the results of previous geological and geochemical studies with the results of their study to develop a target model for hydrothermal resources on the margin of the Idaho batholith. Samples of thermal and non-thermal water were collected from selected springs and wells during this study, and analyzed for major and trace element constituents.

Several studies have described the individual hot spring or well sites in detail (Anderson and others, 1985; Blackett, 1981b; Mitchell, 1976; Mitchell and others, 1980; Struhsacker and others, 1983; and Foley and Street, 1988).

Wood River Drainage

The Idaho Department of Water Resources studied hydrothermal systems in the Wood River drainage (Anderson and others, 1985; Street, 1990). Anderson and others (1985) concluded that geothermal resource potential in the Wood River Drainage is limited to isolated thermal water reservoirs in the vicinity of fault controlled hot springs. None of the rock units in the area have the necessary permeability and transmissivity to serve as thermal water aquifers. Water temperatures indicate suitability for direct uses like space heating, bathing and fish culture, but elevated fluoride concentrations will complicate commercialization of the resource.

A geochemical investigation of both thermal and nonthermal springs in the Wood River area by Street (1990) was conducted to determine possible flowpaths, ages of the waters, and environmental implications of development. Seven thermal springs and five cold springs were sampled for major cations and anions along with arsenic, lithium, boron, deuterium and oxygen-18. Eight rocks, representative of outcrops at or near the thermal occurrences were sampled and analyzed for major and trace elements. Street (1990) reported that Wood River area hydrothermal springs are dilute $Na\text{-}HC0_3\text{-}SiO_2$ type waters. Calculated reservoir temperatures do not exceed 100°C (212°F), except for Magic Hot Springs Landing well **(13-2)**(108°C [226°F] with Mg correction). The isotope data suggest that the thermal water is not derived from present-day precipitation, but from precipitation when the climate was much colder and wetter.

Anderson and others (1985) studied a 3626 km^2 (1400 mi^2) area within the Wood River Drainage with emphasis on seven different sites with thermal springs. In addition to the surface and subsurface geologic surveys, a limited geochemical and isotope survey was conducted in order to obtain more information on thermal history. Shallow subsurface geologic and hydrologic data were obtained from existing well logs to determine aquifer potential and shallow geologic structure. Temperature gradient profiles were obtained from measurements taken in existing unused drill holes to assist in determining potential aquifer temperatures.

Anderson and others (1985) discuss the geology and related geothermal systems for each hot spring area proceeded by geographic location from south to north within the study area as follows:

Magic Hot Springs **(13-3)**

The Magic Hot Springs area is located in the southern portion of the study area on the north edge of Magic Reservoir in T1S, R17E, section 23aab. The geothermal development at this location presently consists of a 79 m (259 ft) well **(13-2)** that has an artesian flow of 57 l/min (15 gpm) of 74°C (165°F) water. This well was drilled near the former site of Magic Hot Springs, which had a surface discharge of 492 l/min (130 gpm) at a temperature of 36°C (97°F) (Ross, 1971). As a result of the drilled well, the springs ceased flowing.

Another well located approximately 400 m (1312 ft) due east of the Magic well, in TlS, R17E, section 23aaa **(13-1)**, was drilled to a depth of 117 m (384 ft). This well, penetrated granite from 96 m (315 ft) to total depth, does not flow, and has a temperature of 37°C (98.6°F).

The rocks exposed at or near the surface in the immediate area of the Magic Hot Springs are mostly basalt, rhyolite, and rhyolitic ash-flow tuff that are in places covered by Quaternary sediments. The youngest rocks in the area are Quaternary-age basalt flows. Leeman (1982) suggests rhyolite is the "basement" rock for much of the Magic Reservoir area. Quaternary sediments are locally exposed in the area, and may have a combined thickness of nearly 80 m (262 ft) as indicated by water well data at the hot springs site.

The area is cut by numerous, normal faults that trend northeast, northwest, and west. The northwest- and west-trending faults appear to be the dominant structures, forming a horst block in the hot springs area. Data from water well logs in the area and temperature gradient profiles suggest the resource is fault controlled. Those wells not intersecting major structural features or related permeable zones have isothermal temperature gradients and yield little water. Those wells drilled on or near major structural features have higher temperature gradients and higher water yields.

The geothermal resource at Magic Hot Springs is probably controlled by deep, convective circulation of waters along major faults, being heated by an unknown heat source at depth, eventually migrating upward and discharging at the surface at or near the intersection of these major structures.

Hailey Hot Springs **(13-10)**

Hailey Hot Springs is located about three kilometers west of Hailey on the north side of Croy Creek in Democrat Gulch, T2N, R18E, section 18dbb. The geothermal resource at this location consists of several tightly grouped spring discharges, with a cumulative flow of 265 l/m (68 gpm) at 59°C (138°F). Prior to their development, these springs discharged through the alluvial material of Democrat Gulch. Just a few feet west of the springs is an exposure of highly jointed Milligen Formation carbonate rocks which presumably is an outcrop of the thermal water conduit.

Much of the area of spring discharge has been enclosed by a concrete headbox with the hot water funneled into a buried pipe distribution system for swimming pool and space heating use in Hailey at the Hiawatha Hotel. The hotel burned leaving the subsequent use of the resource questionable.

The rocks exposed in the area of Hailey Hot Springs are carbonate and argillite of the Milligen and Wood River Formations overlain on the west by Challis Volcanics. The alluvium-covered valley floor is nearly 210 meters wide at the springs and is flanked on the east by a narrow deposit of elevated terrace gravels. The subsurface geology in the area of the hot springs is relatively unknown as only limited well drilling has been done in the area. This resource appears to be structurally controlled because rock permeabilities are generally low.

McLain and Eastlake (1979) conducted a site specific analysis of Hailey for the Idaho Office of Energy in order to characterize its suitability for space heating systems. They identified three practical space heating applications: 1) spaceheating of greenhouses at the hot springs location; 2) spaceheating a new subdivision development somewhere between the hot springs and the city of Hailey; and 3) spaceheating residential and commercial buildings in Hailey. They concluded a city owned district heating system had the highest potential for economic success, with start up capital being the biggest obstacle.

Clarendon Hot Springs **(13-13)**

Clarendon Hot Springs is located in T3N, R17E, section 27dcb. The spring is located on the west side of Deer Creek, just above the Clarendon Hot Springs Resort. The geothermal resource at this location consists of a spring discharging 378 l/m (100 gpm) at 47°C (116.6°F) (Mitchell and others, 1980). This spring is currently utilized at the adjoining ranch which includes swimming facilities. It was proposed to use these waters for space heating at an adjoining recreation area under development.

Rocks exposed in the Clarendon Hot Springs area are Cretaceous granitic intrusives, sandstone and quartzite of the Wood River Formation, and argillite of the Milligen Formation. Alluvium covers the narrow valley floor. The subsurface information and surface geology indicate rock and formation permeabilities are low with the thermal occurrence most likely structurally controlled.

Limited shallow well drilling in the area has met with varied success. Producing wells are used to support the resort facilities.

Guyer Hot Springs **(13-17)**

Guyer Hot Springs are located on the south side of Warm Springs Creek near the western city limits of Ketchum in T4N, R17E, section 15aac. The geothermal resource at this location is privately owned, and consists of several springs with a cumulative discharge of about 3,780 l/m (1,000 gpm). Temperatures vary from one discharge point to another ranging from 55°C to 70°C (131°F to 158°F). Much of the spring area has been capped by enclosed concrete headboxes. The thermal water is funneled into a single distribution system for local space heating and swimming pool use in Ketchum. Sifford

(1984) reported approximately 60 homes and businesses utilizing this warm water distribution system.

About 640 m (2100 ft) east of Guyer Hot Springs is Grayhawk Hot Springs **(13-16)** which discharges at nearly 8 l/min (2 gpm) through the alluvium-covered valley floor at 55°C (131°F).

Rocks exposed at Guyer Hot Springs are folded, faulted, and locally highly jointed Paleozoic sediments of the Wood River Formation. Just east of the hot springs, the narrow valley floor broadens significantly, forming wide alluvial flats flanked by terrace gravels. Faulting appears to control the migrating thermal waters. Secondary mineralization found along a northwest-trending fault system just east of the intersection with a north-south-trending fault system suggests previous migration of thermal waters. The subsurface geology in the area of the hot springs is relatively unknown as only limited drilling has been done in the area.

This resource seems to be structurally controlled because formation permeabilities are generally low. Water chemistry data suggest Guyer and Greyhawk Hot Springs may originate from the same source.

Warfield Hot Springs **(13-15, 13-19)**

Warfield Hot Springs, also known locally as Frenchman's Bend Hot Springs, is located west of Ketchum about 17.5 km (10.9 mi) up Warm Springs Creek. The geothermal resource at this location consists of two main spring discharges and several minor discharges. One spring **(13-15)** located in T4N, R16E, section 36aac, discharges from locally highly jointed granitic rock at about 378 l/min (100 gpm) at 65°C (149°F). This spring, like the others, discharges below the high water mark of Warm Springs Creek and flows directly into it. The other spring **(13-19)**, located in T4N, R17E, section 31bbc, is a major seep. This seep discharges through highly fractured carbonate rocks at 62°C (143.6°F) and is approximately 305 m (100 ft) downstream from the spring. Other smaller seeps, discharging through a thin veneer of alluvium covering the carbonate rocks, are visible for a short distance (90 m [295 ft]) south of the main seep along Warm Springs Creek. The area is easily accessible from Ketchum by an improved gravel road. Facilities at the site consist of several hand-dug bathing pools and a small change house. A few summer recreation cabins are located nearby.

Rocks exposed in the Warfield Hot Springs area consist of a moderately weathered and jointed Cretaceous granite and highly jointed carbonate rocks of the Wood River Formation. A veneer of alluvium covers the narrow valley floor. The thermal surface discharges of the area appear controlled by the major jointing found in the granite and dolomite. Discharges appear to occur along northwest- and northeast-trending joint sets which create enough permeability to allow migration of thermal waters. Major faulting in the area is not well defined. As no wells have been drilled in this area, the subsurface geology is unknown. Rock permeabilities appear to be low. The thermal occurrences seem to be structurally controlled and confined to avenues of fracture permeability.

Easley Hot Springs **(13-22)**

Easley Hot Springs is located in the northern portion of the study area in T5N, R16E, section l0dbc (Mitchell and others, 1980). The spring occurs on the south side of the Big Wood River valley floor very near the southern boundary of the Sawtooth National Recreation Area.

The geothermal resource at this location consists of a spring with a discharge rate of approximately 68 l/min (18 gpm) at 37°C (98.6°F). The spring is located just a few feet above the valley floor, discharging from a highly jointed exposure of Tertiary Challis Volcanics. Just below the spring, within the alluvium-covered valley floor, a shallow marshy pond is fed by thermal water migrating upward through what appears to be the same joint system. Presently, the spring is almost fully diverted for use.

Facilities at Easley Hot Springs consist of a large camping area including a modern outdoor swimming pool fed by the spring. This area, along with newly constructed support facilities, is managed by the First Baptist Church of Idaho.

The rocks exposed in the Easley Hot Springs area are primarily Challis Volcanics and Quaternary alluvium. Angular volcanic float and remnant terrace gravels cover much of the steep slopes flanking the valley floor.

The surrounding area has not been drilled, and subsurface geology is relatively unknown. Easley Hot Springs is likely structurally controlled as rock permeabilities are low.

Russian John Hot Springs **(13-23)**

Russian John Hot Springs lies within the Sawtooth National Recreational Area. The specific location is unsurveyed, but has been reported as T6N, R16E, section 33cca (Mitchell and others, 1980). The area is just west of State Highway 75 and Russian John Guard Station.

The geothermal occurrence at this location consists of a seep of about 4 l/min (1 gpm) with a surface temperature of 35°C (95°F). This spring discharges from Quaternary alluvial material; there are hand-dug shallow bathing pools constructed at the site. About 245 m (804 ft) to the east, in the valley plain, there are some shallow marsh-like ponds that have a surface temperature of 18-20°C (64.4-68°F). The ponds appear to be connected to the system as they rarely freeze during winter.

The main rocks exposed in the immediate area of Russian John Hot Springs are Quaternary alluvium and terrace gravels. Many of the stream valleys in the area have fragmental gravel terraces at different elevations along their flanks with extensive floodplain deposits in the bottom. These deposits primarily consist of quartzite, sandstone, and volcanic rocks with minor fragments of porphyritic volcanic units. The gravels are generally well rounded and contain some boulders up to three feet in diameter.

Little is known about the subsurface geology; no wells have been drilled in the area. Surface geology indicates that rock permeabilities are low. The thermal occurrence found here is most likely controlled by the convective circulation of water, heated at depth, migrating upward along structurally controlled avenues of higher permeability.

Anderson and others (1985) concluded that the chemistry and temperature of thermal water occurrences in the Big Wood River drainage generally are typical of other thermal waters found in or near rocks associated with the Idaho batholith. These waters likely originated as precipitation 11,000 to 22,000 years ago. The narrow range for oxygen-18 depletion shown by the thermal waters suggests very similar thermal histories. Meteoric water likely occurred during a cooler period and was elevated to similar temperatures at depth. Variations in deuterium may indicate separate recharge areas and flow systems for the thermal springs in the area. Other published data indicating specific water chemistry and thermal histories for individual hot springs associated with the Idaho batholith support this theory.

The standard geothermal model for the area and similar thermal water occurrences along the northern edge of the SRP suggests recharge in the upland with downward migration of water along deep faults to depths of 2 to 3 km (6560 to 9840 ft). The heat source at these depths is generally considered to be related to the granitic rocks of the Idaho batholith. The water is probably heated by simple conductance prior to its return to the land surface through fault generated permeable zones. The upward rate of flow is controlled by thermal gradients and hydrostatic pressure as well as the transmissivity of the permeable zone. The limited data in the Wood River drainage area suggest a geothermal gradient of approximately 30°C/km (2.6°F/100 ft).

It is likely that the resource consists of relatively small isolated thermal water reservoirs with limited development potential. None of the hot springs in the area have large discharges.

None of the rock units in the area, except the recent alluvium and Quaternary glacial deposits, have the necessary permeability and transmissivity to serve as thermal water aquifers. Production wells in the Wood River drainage have to intersect the fault that controls the upward movement of thermal water. Mapping fault traces at the surface is the logical first exploration step. Infrared aerial photography may be useful in identifying fault traces associated with thermal water. Resistivity profiles taken at right angles to fault traces may be an appropriate geophysical tool. Correlation testing should be conducted along faults known to be associated with hot water (Anderson and others, 1985). Published geochemical thermometer data for the region (Mitchell and others, 1980) indicate water of moderate temperature suitable for direct uses such as space heating, bathing, and fish culture. The elevated fluoride concentrations (>12 mg/l) in the thermal water will complicate commercialization of the resource. These waters do not meet state or federal standards for drinking water, so regulatory agencies are unlikely to approve surface discharge of spent thermal water in amounts greater than the existing spring flows.

Ketchum

A site-specific analysis of Ketchum was initiated by the Oregon Institute of Technology (OIT) Geo Heat Center (Dellinger and others, 1982). It was later determined that the analysis could not contribute to further geothermal development due to several physical, legal, and institutional factors that included limited resource quantity, ownership considerations, and environmental concerns. Sifford (1984) reported approximately 60 homes and businesses utilizing a warm water distribution system originating at Guyer Hot Spring, a 70.5°C (159°F), 3785 l/min (1000 gpm) resource.

Warm Springs Creek

During 1987, ground water and surface water studies were conducted in the Warm Springs Creek area by Burkett and Litke (1989) for the Idaho Department of Health and Welfare. The ground water research was designed to characterize the valley aquifer and ground water flows, to assess background fluoride levels and sources of fluoride to the aquifer, and to determine the effect of pipeline leaks on the ground water and domestic well contamination. Surface water research was designed to assess water quality impacts due to existing geothermal discharges as well as to evaluate potential impacts from proposed geothermal developments. Warm Springs Creek, Trail Creek, and the Big Wood River were included in this research. Ground water monitoring documented fluoride levels in excess of the current state Maximum Contaminant Level (MCL) of 2.4 mg/l at several public and private wells. The research indicated that leakage from the pipeline does enter the Warm Springs Creek valley aquifer, and that it has a demonstrated effect on fluoride levels in several public community drinking water systems. Removal of the leakage was projected to reduce fluoride levels in these wells by 1-2 mg/l on average, and possibly as much as 5 mg/l during periods when the pipeline is pressurized. The report recommended that this leakage be eliminated to protect public health from fluoride impacts. The report also made recommendations for surface and ground water quality protection of the Warm Springs Creek area relative to future geothermal development.

Boise County (15)

According to Blackwell and others (1992), in the southern part of the Idaho batholith there are major effects on the heat flow regime associated with deeply circulating ground water. Hot springs are common in the southern part of the Idaho batholith and occur along major topographic lows, spaced a few kilometers apart. Estimates of heat loss from the hot springs within this area correspond to 10 to 20% of the regional heat flow, significantly affecting the conductive transport pattern. The average "background" values for gradient and heat flow are about 26°C/km (2.4°F/100 ft) and 75mWm^{-2}, respectively; this is due to heat generation in the granitic rocks in the batholith. High heat-flow values (greater than 85mWm^{-2}) coincide with hot spring locations, lineations, or the margin of the SRP. These hot springs have been described by Ross (1971), Mitchell and others (1980), and Lewis and Young (1980b, 1982b). Heat-flow losses from these hot springs have a major effect on the conductive transport pattern of regional heat flow.

Garden Valley Area

Several greenhouses, resort facilities, and numerous homes use geothermal resources to provide hot water and space heating needs in Boise County, particularly in the Garden Valley-Crouch area. Logs for 31 warm water wells **(15-17, 15-21, 15-23, 15-24, 15-26 through 15-44, and 15-46 through 15-53)** were filed with the Idaho Department of Water Resources for the period 1980 to 1992. Water temperatures recorded ranged from 27°C to 84°C (81°F to 183°F); 24 of the wells showed temperatures greater than 55°C (131°F).

According to Blackwell (1988), the area with the most well documented geothermal gradient and heat-flow data is just west of Garden Valley along the South Fork of the Payette River. The hot springs all exit along the banks of, or in, the South Fork of the Payette River at elevations of about 1000 m (3280 ft). Measured spring temperatures range from 41-61°C (105.8-141.8°F)(Mitchell and others, 1980). Detailed geochemical information for the springs have been discussed by Lewis and Young (1980b). High heat flow values are found 3-4 km (1.9-2.5 mi) from the Payette River near Grimes Creek (T8N, R6E) in mineral exploration holes at elevations of over 1800 m (5900 ft). Even higher heat flow is found at Reservoir Creek (reported as T8N, R5E, section 16bcc but shown in section 21 on Figure 8 [Blackwell, 1988]) about 1.5 km (0.9 mi) from the river and its topographic lineament. Blackwell (1988) also reports that four holes were drilled along Wash Creek (T8N, R4E) approximately perpendicular to, and south of, the Payette River to explore the size of the thermal anomaly [no temperature information could be located for the these wells or the well on Reservoir Creek and therefore they are not included in the accompanying data base]. Results clearly indicated an area of several tens of square kilometers in size that has anomalous temperature gradients and heat flow. Estimated reservoir temperatures of the hot springs sampled range from a low of 56°C (132.8°F) to a high of 122°C (251.6°F). The existence of high heat flow values over such a broad area rules out the theory of very local circulation systems around hot springs or lineaments. Lewis and Young (1980b) found no simple geochemical correlation between thermal and nonthermal water. The nature of the geothermal system is still unknown and further studies are needed. There may be significant potential for development of some of these systems for space and/or process heating where nearby developments exist (Blackwell, 1989).

Payette River Basin

Lewis and Young (1980b) characterized 31 thermal springs in the Payette River basin. Water temperatures ranged from 34°C to 86°C (93.2°F to 186.8°F), with estimated reservoir temperatures of 53°C to 143°C (127.4°F to 289.4°F). Tritium analysis indicated that sampled geothermal waters are at least 100 years and possibly more than 1000 years old.

Six hot spring areas along the South Fork of the Payette River were examined in detail by two Washington State University graduate students, Reed (1986) and Dingee (1987). Geothermometers give estimated reservoir temperatures of 68°C to 150°C (154.4°F to 302°F). Reservoir volume and temperature appear sufficient to support localized direct-use applications.

Much of the study area(s) is underlain by plutonic rocks of the Cretaceous Idaho batholith. Tertiary dike swarms and granitic plutons transect the areas. Northeast- and northwest-trending major fault zones cut this lithology and control the course of the South Fork of the Payette River.

West of Lowman

Reed (1986) studied four hot spring areas located along the South Fork of the Payette River, between the towns of Lowman and Banks. The purpose of this investigation was to determine the detailed geologic, geochemical, and hydrologic setting of the thermal springs.

According to Reed (1986) the four thermal spring areas are located along major fault zones and were divided into two types. The Goller **(15-6)**, Corder **(15-7)**, and Pine Flat **(15-14)** Hot Spring areas are associated with Tertiary dike swarms related to the Idaho porphyry belt. Hot spring vent locations are controlled by the dikes having the highest hydraulic conductivity. SiO_2 and Na:K:Ca geothermometry yielded source temperatures of 71°C (159.8°F) which, combined with a measured geothermal gradient of 80°C/km (5.4°F/100 ft), suggests a 1 km (3280 ft) circulation depth. The Deer Creek Hot Spring **(15-15)** area is distinct geologically and geochemically from the other three areas. Situated in an area lacking dikes, the hot water rises 2 km (6560 ft) along the intersection of two major faults from a thermal aquifer at 142°C (287.6°F). The two types of geothermal systems share several common features. Recharge, with cold meteoric water, occurs along the major fault zones with long (9,000-28,800 years) residence times for waters in the system. Little or no mixing of thermal and nonthermal waters occurs during ascent. Recurrent fault movement has maintained open conduits otherwise plugged by the gradual precipitation of minerals by the rising thermal water.

Reed states that residents of the study area use the hot spring water for bathing, space heating of homes and greenhouses, and for medicinal purposes. The few wells drilled for hot water in the study area have been shallow (<75 m [<246 ft]) and flowrates (up to 240 l/min [62.4 gpm]) of water at temperatures similar to nearby springs have been obtained. It appears that sufficient hot water is present in this sparsely populated area to accommodate increased development of this resource for most direct use applications. In addition, the scenic setting of the hot spring areas and their proximity to a major population center (Boise) suggests that careful development of these areas for tourism and recreation may ultimately yield the greatest economic returns from this resource.

East of Lowman

Dingee (1987) investigated three hot spring areas--Kirkham **(15-22)**, Bonneville **(15-54)** and Sacajawea **(15-55)** hot springs--located east of Lowman, Boise County, Idaho along the South Fork of the Payette River. The objectives were to determine the detailed geologic, hydrologic and geochemical setting of these hot spring areas. A summary of Dingee's report follows.

The SiO_2, Na/K and Na:K:Ca geothermometers were applied to hot spring waters from each of the areas. Estimated aquifer temperatures for Bonneville and Sacajawea hot springs are 130-150°C (266-302°F), while those of Kirkham Hot Springs are 70-90°C (158-194°F). Using the silica heat flow method, an average geothermal gradient of 50°C/km (3.7°F/100 ft)was calculated. The Bonneville and Sacajawea hot springs areas have an estimated aquifer source about 2-3 km (6560-9840 ft) below the surface while the Kirkham Hot Springs reservoir is about 1-2 km (3280-6560 ft) deep.

Hot spring vents in all areas are located along faults and fault zones and discharge from fractures in granite/granodiorite; they are frequently associated with dikes. On a regional basis, each geothermal area occurs where northwest-trending Basin-Range style faults terminate against the trans-Challis fault system. Recharge is thought to occur along Basin-Range faults; thermal waters migrate in a northerly direction along these faults and ascend to the surface when the trans-Challis fault system is encountered.

Hot spring waters from the area of investigation are moderately alkaline (pH 9.2 to 9.4); temperatures range from a low of 50°C (122°F)(Kirkham Hot Springs) to a high of 85°C (185°F)(Bonneville Hot Springs). Temperatures are uniform for the larger discharge vents at each hot springs area. Discharges are variable at each hot spring; vents with larger discharges usually have the highest temperatures for each hot springs complex.

The geothermal systems examined in Dingee's (1987) study produce waters suited for direct use applications. The geothermal system may be quite large and possess quantities of hot water able to sustain direct use development. The hot springs areas are located on U.S. Forest Service land, precluding commercial development, in sparsely populated areas with relatively low energy requirements. The hot springs of the area are presently used for recreational bathing and swimming. They will remain a recreational resource unless there is a change in local energy demands and U.S. Forest Service policies.

Bonneville County (19), Caribou County (29), Jefferson County (51), and Madison County (65)

Unlike the SRP ground water system, there has been relatively little study of the hydrology of the southeastern Idaho Basin and Range province. Ralston and Mayo (1983) summarized geothermal gradients from temperature logs and bottom hole temperature (BHT)measurements in oil wells. The BHT data is of questionable quality but gives some idea of geothermal gradients. Blackwell and others (1992) collected BHT data from wells drilled since 1983. Well sites are both north and south of the SRP and estimated BHT values range from just over 100°C (212°F)at 4 km (13,120 ft) to almost 180°C (356°F) at 5 km (16,400 ft) depth. One well studied, the Gentile Valley #29-1 **(19-18)**(shown as GENVA1-9 in Table 3b, Blackwell and others, 1992), was drilled by CONOCO in 1979 and was later taken over by Phillips Geothermal. The well has an average gradient of 60°C/km (4.3°F/100 ft) to a depth of 3 km (9840 ft) with a bottom hole temperature of 190°C (374°F). This BHT is best fit by a heat flow of 127 mWm^{-2} for the whole well. The heat flow is significantly above the expected Basin and Range background in this area 50 km (31 mi) from the edge of the SRP.

Based on sketchy data, there may not be significantly elevated heat flow in the area north of the South Fork of the Snake River. Two unidentified wells south and east of the South Fork of the Snake River have apparent average geothermal gradients of over 50°C/km (3.7°F/100 ft) to depths of 3-4 km (9840-13,120 ft); these values are considered anomalous for this area. Available information suggests highly variable heat flow in southeast Idaho. There is a very large area of elevated geothermal gradient in the vicinity of Grey's Lake and Blackfoot Reservoir. The Gray's Lake/Soda Lake area heat flow in deep wells ranges from 50 to 120 mWm^{-2}. The area has been thought to have significant geothermal potential based on the geologic setting. Gradients in this area are distinctly anomalous with respect to those elsewhere in the southeastern Idaho Basin and Range province (Blackwell and others, 1992).

The Hubbard #25-1 (SUNHUB 25) well **(29-18)**(T7S, R41E, section 25) is near Blackfoot Reservoir. Numerous Quaternary rhyolite and basalt volcanoes are found in this vicinity. Geochemistry of ground water shows no evidence of high temperature geothermal systems. Maximum temperature recorded on a poor quality temperature log is 68°C (154.4°F) at 2300 m (7544 ft). Based on a typical limestone thermal conductivity of 2.7 $Wm^{-1}K^{-1}$ an upper limit for the heat flow is 82 mWm^{-2} (Blackwell and others, 1992).

Caribou Range Area

Hubbell (1981) described geothermal flow systems in the vicinity of the Caribou Range in southeastern Idaho. He characterized 23 springs and two wells in addition to describing area geology. The study analyzed thermal and nonthermal flow systems based upon hydrogeologic and chemical data collected at selected spring and well sites.

The springs inventoried in the study area are divided into three groups for discussion purposes: 1) thermal springs that discharge highly mineralized water; 2) thermal springs or wells that discharge water with relatively low concentrations of dissolved solids; and 3) nonthermal springs. Descriptions of thermal occurrences by Hubbell (1981) follow.

<u>Heise Hot Spring</u> **(51-1, 51-2)**

This 48°C (118.4°F) spring is located at the foot of a 300 m (984 ft) escarpment. It has deposited a 10-m (33-ft) high travertine mound which is being eroded at its base by the Snake River. Heise Hot Springs resort, located 0.2 km (0.1 mi) northeast of the springs, has used water from this spring since the late 1800's for recreational purposes.

Heise Hot Spring is located in a structurally complex area. This spring is associated with two faults. The Heise fault, a major northwest-trending normal fault, runs through the spring site, and a smaller fault intersects the Heise fault less than 100 m (328 ft) to the east of the spring. The area south of the Heise fault is covered by alluvial sediments deposited by the Snake River. The smaller northeast-trending fault north of the Heise fault separates Tertiary rhyolitic tuff to the northwest and undifferentiated Mesozoic and Paleozoic rocks to the southeast. The spring flows from the Tertiary rhyolite covered at this site by a mantle of travertine and colluvium (Proskta and Embree, 1978). The spring site is located near older sedimentary rocks as indicated by a 100-m (328-ft) deep well drilled about 100 m north of the springs in limestone (Stearns and others, 1937).

Heise Hot Spring deposits travertine, gypsum, and free sulfur and has a hydrogen sulfide odor. The mineralized water has a specific conductance of 6500 mhos/cm and a pH of 6.7 (Young and Mitchell, 1973). Sodium and chloride are the dominant ions in this water. A subsurface temperature of 79°C (174.2°F) was estimated using a silica geothermometer (Mitchell and others, 1980).

<u>Fall Creek Mineral Springs</u> **(19-2, 19-3)**

Several springs and seeps discharge water along a 1.2 km (0.75 mi) reach of Fall Creek. The warmest spring is 24°C (75.2°F) and flows from a travertine deposit located next to the creek. Travertine deposits fill the valley floor along the entire length of the springs. The springs discharge from the Mission Canyon Limestone and are associated with the northwest-trending Snake River fault.

The springs deposit free sulfur and travertine and give off a strong hydrogen sulfide odor. Two other large deposits of travertine are located at a higher elevation on a ridge 0.5 and 1.6 km (0.3 and 1.0 mi) west of the springs. There are no springs associated with these deposits and their surface elevation ranges from 1680 to 1840 m (5510 to 6035 ft). The waters from Fall Creek Mineral Springs have specific conductance values of 7800 and 6800 mhos/cm and a pH of 6.2. The dominant ions are sodium and chloride. The subsurface temperature may be as high as 40°C (104°F) as indicated by the quartz geothermometer (Mitchell and others, 1980).

Alpine Hot Springs **(19-13)**

These springs were located on both sides of the former channel of the river but are presently submerged in Palisades Reservoir. The data presented are based upon an investigation of the site prior to the creation of the reservoir and during a visit when the water level was low in the reservoir. The springs flow from Quaternary alluvium and are associated with the Snake River fault (Gardner, 1961).

Six springs on the west side of the river had temperatures ranging from 31°C to 62°C (87.8°F to 143.6°F). This cluster of warm springs formed calcareous, sulphurous, and saline deposits. Many small springs escaped along the bank for a distance of 90 m (295 ft) or more; the deposits varied in color. The highest temperature observed here was 62.2°C (144°F); low temperature was 31.1°C (88°F). On the east side of the river there were two main springs and several smaller ones with temperatures ranging from 49°C to 66°C (120.2°F to 150.8°F)(Stearns and others, 1937). The wide range of temperatures in these springs indicate that warm and cold ground water is mixing before reaching the surface.

Unnamed Springs, TlN, R40E, section 4abc **(19-4)**

These springs are located in the bottom of a canyon formed by Willow Creek. The springs discharge water at a temperature of 21°C (69.8°F) from rocks of the Gannett Group. They flow from fractures in an outcrop of chert pebble conglomerate at the base of the Ephriam Conglomerate. A northeast-trending fault intersects this site from the north displacing the Peterson Limestone, placing Bechler Conglomerate against the Ephriam conglomerate. The geology is complicated by rhyolite tuff, basalt, and Salt Lake Formation units, which together conceal most of the older sedimentary rocks except where they have been exposed by erosion along Willow Creek.

Travertine deposits are located in rocks of the Bechler Formation west of the present springs. Saline deposits surround the springs. These springs have a high specific electrical conductance of 11,000 mhos/cm and a pH of 6.6. The dominant ions are sodium and sulfate.

Brockman Hot Springs **(19-10, 19-11)**

These springs flow from several small seeps and a 1.2-m (4-ft) diameter pool into Brockman Creek. The springs have a temperature of 35°C (95°F). Travertine deposits surround the springs and an inactive travertine mound is located a short distance to the south.

The area around the springs is folded and faulted. The springs flow out of Quaternary alluvium overlying Bechler Conglomerate or Peterson Limestone. Several minor faults cross the area, the nearest of which is 200 m (656 ft) to the north (Gardner, 1961). A major northwest-trending fault is located 1.7 km (1.1 mi) northeast of the spring.

The major spring has a specific electrical conductance of 8,800 mhos/cm and a pH of 6.6. The dominant ions in this water are sodium and sulfate. The subsurface temperature may be as high as 38°C (100.4°F) as indicated by the chalcedony geothermometer (Mitchell and others, 1980).

Elkhorn Warm Spring **(65-1)**

Elkhorn Warm Spring is located 2.8 km (1.7 mi) northwest of Heise Hot Springs **(51-1, 51-2)**. This spring is located on the escarpment formed by the Heise fault at an elevation of 40 to 70 m (131 to 230 ft) above Heise Hot Springs. The intrusive body suggested by Mabey (1978) to be under Heise Hot Springs is also believed to underlie Elkhorn Warm Spring. The spring emerges from relatively flat-lying rhyolite tuff on the southern edge of the Rexburg Caldera Complex (Proskta and Embree, 1978). The spring does not have associated travertine deposits and does not give off any gaseous odors.

Elkhorn Warm Spring has a specific conductance of 390 mhos/cm, a temperature of 20°C (68°F), and a pH measurement of 6.6. The dominant ions are calcium and bicarbonate.

Unnamed Spring, T3N, R41E, section 32bbd **(19-15)**

This 23°C (73.4°F) spring discharges from a densely welded ash-flow tuff. This tuff may only form a thin covering overlying older Mesozoic and Paleozoic rocks. A 9.3-km (5.8 mi) long, northeast-trending fault is located 0.2 km (0.1 mi) to the south of this spring site (Protska and Embree, 1978). This spring has a specific electrical conductance of 650 mhos/cm and a pH of 7.2. The dominant ions in the water are calcium and bicarbonate.

Dyer and Anderson Wells **(19-5 and 19-6)**

These two wells are representatives of a group of warm water wells located in a subdivision called Rim Rock Estates on the bench east of Idaho Falls. The wells are located 1.6 km (1.0 mi) apart with the Dyer well located northeast of the Anderson well. They have temperatures of 21°C and 20°C (69.8°F and 68°F), respectively. Tertiary Salt

Lake Formation is mapped at the well sites with outcrops of rhyolite welded tuff and associated ash nearby (Mansfield, 1952). The Salt Lake Formation mapped in this area appears to be a thin covering overlying the welded tuff. The drill log for the Dyer well indicates that the water is obtained from fractured rhyolite. There is a northwest-trending fault mapped 0.2 km (0.1 mi) west of this well. In the Anderson well, the driller's log reports that the water is coming from sandstone or rhyolite.

The chemistries of these wells are similar. The specific electrical conductivity values are 520-530 mhos/cm and the pH is 7.7. The dominant ions present are calcium and bicarbonate.

Conclusions

The major thermal discharges within Hubbell's (1981) study area are located along structural features with the hottest water associated with deep normal faults along the Swan, Grand, and Star valleys. The combination of their locations relative to major faults, elevated temperatures, and high total dissolved solids lead to the following hypotheses for ground water flow:

1) Recharge occurs in the mountain ranges and moves vertically downward facilitated by the intense structural deformation in these areas. The ground water moves laterally along bedding planes to the faults bordering the Swan, Grand, and Star valleys. The faults allow upward migration of the thermal ground water to the surface.

2) Recharge occurs along some portions of the fault systems along the Swan, Grand, and Star valleys that allow deep migration of the ground water. The thermal ground water then moves upward along the fault zones to the surface some distance from the recharge site.

3) Thermal springs with high total dissolved solids are located in the Willow Creek Hills. Their high temperatures, high total dissolved solids, and location relative to minor faults suggest that the ground water supplying these springs circulates to depths where they are heated, then move upward to the surface following minor faults.

4) Thermal flow systems associated with caldera structures in this area have temperatures less than 24°C (75.2°F) and low specific electrical conductivities indicating shallow ground water flow systems. Recharge in surrounding areas moves to shallow depths where it is heated. The ground water then moves to the surface following minor faults. Nonthermal springs in the area probably represent relatively shallow ground water flow systems controlled by the complex lithology and structure in the area.

5) The chemistry and physical setting of Heise Hot Springs relative to Elkhorn Warm Spring indicates that the ground water flow system represented by Heise Hot Springs is unrelated to Elkhorn Warm Spring. Heise Hot Springs appear to be closely related to the

springs controlled by normal faults in the sedimentary system and not to the rhyolite caldera system to the north and west.

6) The small total discharge of springs with temperatures above 39°C (102.2°F) indicates there is very little deep movement of ground water.

7) Temperature data in three of the four oil exploration wells drilled in this area indicate a higher than normal geothermal gradient. The maximum depths of circulation for thermal springs with high specific electrical conductivities are estimated to be from 600 to 2400 m (1968 to 7872 ft). The maximum depths of circulation for thermal springs with low specific electrical conductivities are estimated to be 200 to 300 m (656 to 984 ft).

Camas County (25)

The Camas Prarie/Mt. Bennett Hills area is not clearly part of the Idaho batholith or the SRP terrains. Walton (1962) calculated an average gradient for the area of 92°C/km (6.4°F/100 ft). Holes sampled are in low thermal conductivity clays, but estimated heat flow values (100-123 mWm^{-2}) are significantly above those in the adjacent Idaho batholith. Faulting of Quaternary basalt in the province demonstrates active volcanism and tectonism within the last few million years. Mitchell (1976) reports geochemical data from a 79 m (259 ft) well with a flowing temperature of 74°C (165.2°F) near Magic Reservoir; he suggests a possible subsurface temperature as high as 200°C (392°F). Gradients of over 125°C/km (7.8°F/100 ft) occur along the west side of Magic Reservoir over a 7 km (4.35 mi) stretch; the area may contain a major geothermal system at depth. Unfortunately all holes examined by various investigators are relatively shallow; little is known about deep thermal conditions. The heat source appears to be either deep ground water circulation in the typical SRP margin thermal setting, remnant heat associated with the young basaltic volcanism, unusually deep circulation associated with the most recent faults, a very young silicic intrusion with no surface manifestations, or some combination of these possibilities (Blackwell and others, 1992).

The Camas Prairie, especially the Magic Reservoir area, has above average geothermal potential. Temperatures are certainly in the range of 30-40°C (86-104°F) at depths of 300± m (984± ft) and may be high enough for commercial electric power production in the most favorable case. High gradients are also indicated along the north and south edges of the Mount Bennett Hills (Blackwell, 1989).

An evaluation of the Magic Reservoir area was conducted by University of Utah Research Institute (Struhsacker and others, 1983). The authors attempted to place the Magic Reservoir volcanic rocks in the regional stratigraphic framework and heat flow regime of the SRP and identify the structures that control geothermal fluid circulation. The Magic Reservoir area straddles the Camas-Blaine county line in south-central Idaho and is described under the Blaine County section of this report.

Fairfield

The Fairfield area was selected for a site development analysis by the Idaho Office of Energy (McClain and others, 1979) regarding potential for spaceheating public buildings and industrial applications. Three locales with good geothermal potential were identified; recommendations for exploration and potential applications were made. Five sites on the Camas Prairie were selected by the Idaho Office of Energy for the purpose of estimating cost of geothermal development. A summary of the report follows.

Fairfield, Idaho, is a small agricultural community located on the Camas Prairie in central Idaho. The community is located at an elevation of 1544 m (5,065 ft) in an east-west-trending intermountain basin which is surrounded by mountains of the Idaho batholith and Mt. Bennett Hills. The area is a transition zone between the granitic rocks of the batholith and the volcanic rocks of the SRP. The Camas Prairie area has been classified by the Idaho Department of Water Resources as a Geothermal Resource Area. Hot springs located in the area vary in temperature from 32.2°C to 71°C (90°F to 160°F).

The Camas Prairie consists of poorly sorted sediments of Pliocene to Holocene age derived from the mountains to the north and ranging in size from clay to boulder. A bedrock of Cretaceous granite exists at a depth of 152 to 167 m (500 to 550 ft) near the center of the prairie. The Soldier Mountains to the north and part of Mt. Bennett Hills to the southwest are made up of Cretaceous granitic rocks of the Idaho batholith whose main body lies further to the north. Part of the Soldier Mountains consists of Challis Volcanics which crop out along the north-central part of the basin. These volcanic flows and lower Pliocene volcanic rocks are also found along southern portions of Camas Prairie. Other basalt flows are found along the southeastern and western edges. The structural control of the Camas Prairie Basin is to a large extent unknown.

The movement of ground water in the Camas Prairie generally parallels Camas Creek and its tributaries. The major source of ground water is the Soldier Mountains to the north with minimal input from the Mt. Bennett Hills to the south. Two major aquifers composed of fine-grained sand and gravel exist in the valley fill at depths of approximately 61 to 121 m (200 to 400 ft).

Geothermal Potential

There are several hot springs in and around the Camas Prairie. Barron's Hot Springs **(25-16, 25-18)** are located approximately 12 km (7 mi) southwest of Fairfield. A surface temperature has been recorded of 72°C (163°F) with a predicted reservoir temperature of 125°C (257°F). The springs issue from the valley fill material. Two other hot springs in the area show strong evidence of a moderate temperature geothermal resource existing below the valley fill. Hot Springs Ranch (Wardrop Hot Springs)**(25-1 through 25-4)** and Elk Creek Hot Springs **(25-5 through 25-7)** both have discharge temperatures above 54°C (130°F).

Most of the irrigation wells in the area have higher than normal water temperatures. Two areas stand out as geothermal anomalies. One is the area southwest of Fairfield, just north of Barron's Hot Springs. Wells with temperatures near 21.1°C (70°F) are common in this area and Barron's Hot Spring is the high point at 71.1°C (160±°F). A temperature gradient of 146°C/km (8°F/100 ft) has been calculated for the area to the southwest of Fairfield around Barron's Hot Springs. The second anomalous area is centered approximately 3.2 km (2 mi) south of Fairfield. Temperatures at 91.4 m (300 ft) below ground level above 21.1°C (70°F) occur in an area 9.6 km (6 mi) long (E-W) and 1.6 km (1 mi) wide (N-S).

McLain and others (1979) concluded geothermal resources of Fairfield and the Camas Prairie area can be developed economically if the specific development site can be located reasonably close (3.2 to 4.8 km [2 to 3 mi]) to a large user facility. Camas Prairie appears to be a shallow depression, but the shallow geothermal fluids appear to be dependent upon faults for their upward migration. There is likely lateral movement of the geothermal water whenever permeable beds are encountered by the zones. However, for maximum production and highest temperature, the area faults zones should be explored by drilling.

There are three areas around Fairfield that appear to offer excellent geothermal exploration targets. The area around Barron's Hot Springs, on the downdip (east) side of the fault, appears an excellent target for both shallow and deep exploration. This includes the area between Barron's Hot Springs and Hot Springs Ranch. A second area, also rated excellent for shallow exploration is located south of Fairfield and enclosed by the 21.1°C (70°F) contour shown on Figure 3.4 of McClain and others (1979). The third area rated as a very good locality for deep exploration is along the downdip (east) side of the north-south-trending inferred fault passing just to the east of Fairfield. Fairly deep (244-610 m [800 to 2000 ft]) geothermal exploration wells must be drilled into fault zones in order to encounter permeable zones that will result in maximum production and temperature. Geophysical (electromagnetic VLF radio and earth magnetic) surveys should be conducted to pinpoint the existence and attitude of faults in the valley that extend into the granitic basement (McLain and others, 1979).

Canyon County (27)

Numerous warm water wells and favorable geologic conditions indicate that the Nampa area has good potential for using geothermal energy in direct applications. Many existing warm water wells are in the 24-38°C (75-100°F) temperature range. Nampa is an agricultural service center 28.8 km (18 mi) west of Boise with a population of about 25,000 people. There are numerous warm water wells in the town and the surrounding areas. The combination of a thermal water resource matched with a community of considerable size spurred an investigation of the geothermal energy potential.

The rock units in the Nampa area are composed of basalt of Miocene to early Pliocene age. Several widespread sandstone aquifers overlie the basalt. These sandstone aquifers are projected to yield good flows of 30°C (86°F) to 60°C (140°F) water from depths of 305 to 670 m (1,000 to 2,200 ft). The sandstone aquifers are better targets than the basalt because of greater anticipated permeability (Dellinger and others, 1982).

Two analyses of potential direct resource use in the Nampa area were performed by OIT Geo Heat Center (Dellinger and others, 1982). One evaluation dealt with retrofitting of Parkview and Lakeview schools to use an existing hot water source of 32°C (90°F) for heat pump conversions; in this particular instance, the conversions were not economically practical relative to cheap coal prices. The second evaluation examined a geothermal conversion for Mercy Medical Center; the economic feasibility looked favorable.

The Idaho Department of Water Resources (IDWR) conducted an integrated geological, hydrological, geochemical and geophysical survey for the purpose of evaluating the geothermal potential of the Nampa-Caldwell area (Mitchell, 1981a-b). Recommendations for resource definition and development were outlined. A summary of the report follows.

The area studied by the IDWR included approximately 925 km^2 (357 mi^2) of the Nampa-Caldwell portion of Canyon County, an area within the central portion of the western SRP immediately west of Boise, Idaho. Geologic mapping, hydrologic, geochemical, and geophysical surveys were run. In addition, existing magnetotelluric and reflection seismic data were purchased and incorporated into the investigation.

Shallow subsurface geologic and hydrologic data were obtained from existing water well logs to determine the number and extent of shallow aquifers and shallow subsurface structural configuration. Enhanced Landsat false-color infrared imagery was also studied to detect evidence of major structural features which could control thermal water in the area and provide possible migration paths for recharge to thermal and nonthermal water. Temperature gradients and heat flow data were obtained from existing unused drill holes.

Within the graben-like basin known as the western SRP geophysical studies have revealed complex basin structures. A large basin exists in the Nampa-Caldwell area, and another in the Meridian-northwest Boise area. These basins are separated by a structural high.

Idaho Group and Snake River Group rocks of Pliocene-
Pleistocene age are exposed within the Nampa-Caldwell area. These rocks consist of terrace gravels of the Boise River drainage, basalt of the Pleistocene Snake River Group and basalt, sand, silt, and claystone of the Pliocene Glenns Ferry Formation.

The Glenns Ferry Formation is underlain by the lower Idaho Group in the subsurface beneath the western SRP in the Nampa-Caldwell area. Beneath the Idaho Group is a thick section of basalt and sediments. Silicic volcanic rocks of the Idavada Group are notably absent to a depth of 4.3 km (2.7 mi) in a deep well just east of Nampa. Three geologic units have been identified as important cold water aquifers within the middle to upper Glenns Ferry and overlying formations. Within the middle Glenns Ferry Formation, a "blue clay" unit acts as an aquitard that separates the three upper cold water aquifers from lower aquifers containing warm water (>20°C [>68°F]). Unconformities within the upper Glenns Ferry Formation may mean this formation is thin, or absent in the Boise front area.

Six permeable zones which may contain hot water are suspected to exist at depths of approximately 91-213 m (300-700 ft), 457 m (1,500 ft), 640 m (2,100 ft), 1037 m (3,400 ft), 1311 m (4,300 ft) and 1677 m (5,500 ft). Oil company logs for many of the oil and gas wells in the area indicate subsurface temperatures for the six suspected permeable zones to be 30°C, 43°C, 49°C, 58°C, 66°C and 75°C (86°F, 109.4°F, 120.2°F, 136.4°F, 150.8°F and 167°F), respectively. These temperatures are thought to be minimum due to cooling effects of drilling fluids circulated within boreholes during drilling operations. Thicknesses of the permeable zones probably vary but estimates are, respectively, about 15 m (50 ft), 40 m (131 ft), 31 m (100 ft), 100 m (330 ft), 61 m (200 ft) and 75 m (245 ft).

Geochemical studies using stable isotopes of hydrogen and oxygen show that thermal water in the Nampa-Caldwell area is depleted in deuterium and in oxygen-18 relative to cold water. Indications are the water may be either rain or snow water that fell more than 11,000 years ago or evaporated river water which has undergone isotopic exchange of oxygen with aquifer minerals. The geothermal parent water in the Nampa-Caldwell area appears, from isotope data, to be identical to parent geothermal water in the Bruneau-Grand View and Boise areas of the western SRP, or to have a similar source(s) and/or age. Little is known about present day recharge. Chemical data and mixing models, which correlate well with isotope data, indicate geothermal waters may be migrating upward from deeper permeable zones with 75°C to 95°C (167°F to 203°F) temperatures.

A detailed heat-flow contour map of the western SRP was produced from 65 temperature gradients measured in the region. The western SRP is a region of recognized convectively induced high heat flow outlined by a 3.0 HFU contour. Thermal conductivities of 247 samples, selected from well cuttings, drill cores and rock outcrops, were determined to calculate heat-flow values. In addition, 60 previously measured temperature gradients and 85 previously determined thermal conductivities from surrounding areas and from within the area were used. Measurement sites were relatively evenly dispersed, averaging one per 43 km (17 mi).

The average thermal conductivities determined for the major rock units were: granite = 6.01 ± 0.50 TCU; sand and clay = 3.49 ± 0.90 TCU; clay = 2.79 ± 0.51 TCU; silicic volcanics = 4.54 ± 0.24 TCU; basalt = 3.62 ± 0.85 TCU. The average temperature gradient for the area was 78°C/km (4.29°F/100 ft) and the average heat-flow value was 2.55 HFU.

The oil well survey in the Nampa-Caldwell area shows that high temperatures can exist near the surface where there are no visible structures and in areas of low heat flow. This area's low heat flow is caused by infiltration of irrigation water which masks shallow (to 91 m [300 ft]) temperature gradient measurements.

Geothermal gradients in the Nampa-Caldwell area are consistently in excess of 30°C/km (2.6°F/100 ft)down to a depth of at least 3 km (10,000 ft). At a depth of 1,000 m (3,300 ft), temperatures in excess of 45°C (113°F) are expected over most of the area. Development of commercial amounts of geothermal water will be limited by the presence of good intergranular or fracture permeability at depth. Subsurface geological and geophysical data suggest two situations which might yield good flows to wells: 1) Youthful major fault zones which cut the uppermost part of the stratigraphic section and have the largest displacements should retain good fracture permeability, particularly where they cut hard brittle formations at depth. These fault zones are known as the "Eagle-West Boise fault zone, the Middleton fault zone, and the Lake Lowell fault zone." 2) Deep sand aquifers within the lower Idaho Group, and possibly within the older basalt section, may also be good producers of hot water. None of these confined sand aquifers have been tapped by wells for water, but it is likely they would yield hot artesian waters. Sand aquifers of the lower Idaho Group were encountered in two deep wildcat wells in the Meridian area, but have not been encountered in more recently drilled geothermal wells in the Boise area, nor do they occur in the deep wells between Meridian and Middleton. These sand aquifers are probably best developed in the area northwest of Nampa, but their extent is not known. Electrical log interpretation suggest good permeability in these deep sand units.

In summary, geothermal waters of moderate temperature suitable for space heating can be expected at depths of 450 to 1200 m (1,500 to 4,000 ft) over most of the Nampa-Caldwell area. Oil and gas wildcat wells have explored the subsurface, but the deep water-bearing units have not been tested to assess their water producing capacity. The most favorable drilling targets are along the major youthful faults detected by a seismic reflection survey. Areas of proven warm water wells at shallower depths, 200 to 300 m (600 to 1,000 ft), generally lie in the area around Lake Lowell and south to the Snake River. North of this area few warm water wells have been drilled, and locations of warm water wells are spotty. These anomalously warm wells are probably located near fault zones with fracture permeability that serve as conduits for ascending warm waters.

Cassia County (31)

The Raft River Known Geothermal Area (KGRA) in southern Idaho has been the subject of more evaluation than any other area in Idaho. A geothermal exploration program was begun during 1973 by the U.S. Geological Survey in cooperation with the U.S. Department of Energy. Results of these early programs were summarized by Williams and others (1975). Covington (1980) later described the subsurface geology and factors contributing to the convective hot water system based upon drilling data from deep exploration and production wells. A report presenting and interpreting the geological, geophysical, geochemical, and hydrologic data was subsequently compiled by Dolenc and others (1981). Startup of a 5MW(e) pilot geothermal plant occurred in the fall of 1981; final shutdown occurred during June 1982 (Bliem and Walrath, 1983). The plant, built by the Idaho National Engineering Laboratory, successfully demonstrated the technical feasibility of using a moderate temperature (135-149°C [275-300°F]) to generate electrical power in an environmentally acceptable manner. The plant used a dual-boiling binary cycle with isobutane as the working fluid. Seven deep geothermal wells were drilled to support the project, including five production and two injection wells **(31-91, -94, -97, -98, -106, -107 and -108)** in addition to several geothermal gradient and monitor holes. A vast amount of information was obtained on the characteristics of a fracture-controlled geothermal system with respect to production and injection. Fracture-flow analysis was conducted by Rashrash and Ralston (1988) utilizing borehole televiewer logs to identify fractures. Blackett and Kolesar (1983) described geological and mineralogical data from the Raft River geothermal system. The purpose of the study was to characterize the subsurface stratigraphy and geothermal mineral assemblages present in the Raft River system that could ultimately affect the results of injection research studies. Successful non-electric experiments included agriculture, aquaculture, biomass production, wetland studies, and space conditioning (Mink and others, 1982). Reports generated are too numerous to list, but are included in the Idaho geothermal bibliography available through IWWRI (Dansart and others, 1994).

The Raft River KGRA lies in south-central Idaho, near the Utah border, in a valley bounded by mountains on three sides and opening northward to the SRP. The KGRA is located near the south end of the valley. The Raft River Valley is a down-dropped sedimentary basin composed primarily of Tertiary-age siltstone, tuffaceous sandstone, and conglomerate units of the Salt Lake Formation. The overlying Pleistocene Raft River Formation consists of several hundred meters of alluvium and lacustrine sediments. The Bridge fault, trending northward along the west side of the valley, is believed to control upward migration of thermal fluids. The Bridge fault, which dips 60° to 70°, is cut off to the north by the younger Narrows fault zone.

The geothermal reservoir is fracture dominated; hydraulic conductivity is greatest parallel to the Bridge fault zone. Tritium data indicate very young (60 to 70 years old) thermal fluids. Water chemistry indicates the deep geothermal system is hydraulically connected with the shallow aquifer system.

Experiments related to direct and secondary geothermal fluid utilization were conducted at Raft River. The effects of using expended geothermal water for irrigation on selected crops was studied; these crops showed growth rates, yields, and nutritional values comparable to those irrigated with non-geothermal waters (Stanley and Schmitt, 1980). Fluidized bed potato waste drying experiments demonstrated the feasibility of using low-temperature (< 145°C [< 293°F]) geothermal water as a heat source to dry slurry-like industrial products; the system could also be modified to dry solid vegetable products

(Cole and Schmitt, 1980). Biomass production and chemical cycling were studied in a man-made wetland utilizing geothermal water (Breckenridge and others, 1983). Successful experiments raising catfish, carp, and shrimp in geothermal waters were also completed (Mink and others, 1982). Wells RRGP-4 **(31-98)** and RRGP-5 **(31-91)** were selected for hydraulic fracture stimulation experiments, but the desired results were not achieved.

Custer County (37)

Stanley

The Idaho Energy Office completed a site specific development report for Stanley in 1979. The results of this study were favorable for development of a district heating system. The OIT Geo Heat Center (Dellinger and others, 1982) conducted a site specific development analysis of the Stanley area. It was concluded that a geothermal district heating system for Stanley was technically feasible and economically attractive. The reservoir area has significant potential for production of large amounts of thermal water; silica geothermometer estimated temperature is 75°C (167°F). A synopsis of this study follows.

Stanley is situated in a valley surrounded by the Sawtooth and White Cloud mountains in central Idaho. Elevations range from 1865 to 3000 m (6,120 to 9,840 ft). The community is contained within the Sawtooth National Recreation Area which is managed by the U.S. Forest Service. Summers are cool and winters are cold with heavy snowfall (239 cm [94 in] average annual). The temperature falls below 0°C (32°F) more than 300 days a year. This climate necessitates space heating year round. A geothermal district heating system in Stanley would displace some use of electricity, propane, and wood.

The Stanley Basin is a structurally controlled intermountain valley which trends northwest and contains the upper watershed of the Salmon River. The White Cloud Range to the east of Stanley is composed primarily of Cretaceous granite of the Idaho batholith. Younger granite of the Sawtooth batholith is found along the western margin of the valley. The contact between these two batholiths strongly controls the structure of the valley.

A major structure that influences the location of a series of thermal springs known as the Sunbeam Hot Springs district has been named the Mormon Bend fault. The fault lies along the northern boundary of the Stanley Basin and is east-west trending. The fault also controls the course of the Salmon River east of Stanley. Several thermal springs that occur along the Salmon River Canyon, including Sunbeam Hot Springs **(37-17)**, Slate Creek Hot Springs **(37-10)**, Sullivan Hot Springs **(37-21)**, Mormon Bend Hot Springs **(37-16)**, and USFS Campground Hot Springs **(37-15)**, all discharge along the Mormon Bend fault. Many of these springs occur near drainage confluences or ridge points that protrude into a stream.

Stanley Hot Springs **(37-9)** is just north of town at the confluence of Valley Creek and the Salmon River. The spring discharges about 150 gpm of water ranging in temperature from 31°C to 41°C (88°F to 106°F). The water quality of Stanley Hot Springs is good. The spring water is low in total dissolved solids, but relatively high in fluoride (14 mg/l). The drinking water standard for fluoride is 2 mg/l. This fluoride level may limit the available disposal options for a geothermal application. The potassium level at Stanley Hot Springs is significantly lower than most other thermal springs in the area. The low potassium level affects some geochemical measurements which are used to predict reservoir temperatures. The most reliable geothermometer under these conditions is the silica geothermometer which predicts a reservoir temperature of 75°C (167°F). The reservoir area appears to have significant potential for production of large amounts of thermal water.

Based on Stanley's character and the nature of the geothermal resource, potential applications include a spa complex to complement other tourist facilities, greenhouses for local produce, and space heating for homes and businesses. Private interests have discussed developing a spa near Stanley Hot Springs. The community has expressed strong support for the development of a district heating system, and an interest in greenhouses.

Stanley offers the opportunity to develop an existing geothermal resource for the benefit of a community and to serve as an educational tool for the thousands of people who visit the city each year. Numerous other communities in the Northwest have geothermal district heating potential, but few are as advanced in planning as Stanley. Financing is the key to implementing the development of Stanley's geothermal district heating system (Dellinger and others, 1982).

Mackay

Water samples from springs in the Mackay, Idaho area were collected by the University of Utah Research Institute (UURI) to investigate potential of a direct-heat geothermal resource. Geothermometry results suggested that subsurface temperatures for spring waters is not significantly above the measured surface temperatures. The potential for finding a shallow geothermal reservoir with temperatures much above 22°C (71.6°F) appears slight (Sibbett and Capuano, 1984).

Other Sites

The Challis subsection of the southern Idaho batholith appears to have 10-20% higher heat flow than the main portion of the Idaho batholith. Gradients are also significantly higher because the volcanic rocks in the Challis subsection have lower thermal conductivity than the main batholith granite. Significant high heat-flow anomalies occur in the Bayhorse Mining District and along the Salmon River. This part of the Salmon River flows along a major hot springs lineament. Geothermal heat-flow and gradient data of the Bayhorse Mining District suggest the presence of a blind geothermal system (Blackwell and others, 1992).

Elmore County (39)

Mountain Home

The 37 km^2 (14.3 m^2) Mountain Home Known Geothermal Resource Area (KGRA) is located in Elmore County in south-central Idaho about 80 km (50 mi) southeast of Boise and about 16 km (10 mi) east of Mountain Home (Spencer and Russell, 1979d). The KGRA is located between Tertiary and Cretaceous granitic rocks to the east, and the Tertiary and Quaternary rocks of the SRP to the west. Mountain Home lies on the northwest-southeast-trending fault that marks the relatively abrupt transition zone northwest of the KGRA. The major hot springs in the area are controlled by faulting.

Although there are many permanent streams in the area, almost all of them have been diverted for agricultural use. Thermal water is abundant in the area. Temperatures range from 57-68°C (134.6-154.4°F) in springs and in irrigation wells 150-300 meters (492-984 ft) deep. The water is fresh with a TDS content of about 300 ppm.

The OIT Geo Heat Center (Dellinger and others, 1982) conducted a site specific analysis of the Mountain Home Air Force Base. The study was an investigation of the engineering and economic feasibility of developing a heating system to service 1500 housing units on the base. The report concluded more resource assessment was needed to define the limits of resource capability. A summary of the OIT (Dellinger and others, 1982) study follows.

Mountain Home Air Force Base is about fifty miles south and east of Boise, in Elmore County. The base is bordered to the northeast by the Mountain Home KGRA and on the southwest by the Bruneau-Grand View KGRA. The City of Mountain Home had a 1981 population of 7,000; approximately 10,000 people lived on the Air Force Base.

The geologic setting in the area of Mountain Home Air Force Base is favorable for the existence of geothermal resources. This potential has yet to be proven. The geology in the area of the base consists of Pliocene and Pleistocene sediments, Pleistocene basalt and Tertiary rhyolite. These units overlie Cretaceous granite. The rhyolite and granite may have significance in the search for geothermal resources, but their suitability as thermal water reservoirs is unknown. The rock units mentioned above are underlain by the Idavada Volcanics, about 914 m (3,000 ft) thick in the area, which may be a source of hot water.

There are numerous thermal wells and a few hot springs near Mountain Home Air Force Base. Several warm wells are situated just to the west and several miles to the east of the base. Surface temperature of the wells range from 20-25°C (68-77°F). The deepest known well in the area is the Bostick 1-A **(39-71)**. The well was drilled by Union Oil to almost 2743 m (9,000 ft) before casing problems halted further work. It produced 3785 l/min (1,000 gpm) of flowing 132°C (270°F) water. Geothermal gradients indicate that temperatures suitable for space heating could be obtained at depths between 914 and 1219 m (3,000 and 4,000 ft).

Water quality analysis from thermal wells in the area show low levels of total dissolved solids, but somewhat high levels of fluoride. The fluoride may restrict a geothermal project from surface disposal of waste water.

A 1342 m (4403 ft) test hole **(39-52)** was subsequently drilled by the Air Force on the Mountain Home Air Force Base for geothermal exploration. The purpose was to determine the availability of water from geothermal aquifers to supply energy for space heating of military housing and other base facilities. A temperature of 45°C was recorded during sampling; maximum temperature recorded during temperature logging was 93°C (199.4°F) at a depth of 1207 m (3960 ft)(Lewis and Stone, 1988).

Evaluation of an area near Mountain Home as a hot dry rock prospect was performed by Arney and others (1980). A favorable target was identified. Temperatures of 200°C (392°F) were projected at 3 km (9840 ft) depth, with granitic rocks to be intersected at a depth of 2 to 3 km (6560 to 9840 ft). Geothermometry data from nearby shallow wells give predicted reservoir temperatures of 127°C (260°F); this indicates that the water sampled had not been in contact with the higher temperature rocks reported in the Bostic 1-A well (195°C [383°F] BHT). Wells along fracture systems in the area flow at rates up to 18,925 l/min (5000 gpm) with temperatures to 60°C (140°F), indicating a highly productive and permeable zone in the upper portion of the reservoir.

Franklin County (41)

The geology and hydrology of the southeastern Idaho Basin and Range province is complicated. Relatively little study of the ground water system has occurred. It is an area of high topography and extensively faulted, predominantly carbonate rocks. There are several hot springs in Franklin County, most notably Cleveland **(41-4)**, Maple Grove **(41-6)**, Squaw **(41-15)**, and Battle Creek (Wayland)**(41-13)** hot springs (Mitchell and others, 1980). Geochemistry of the thermal water suggests reservoir temperatures of 150-200°C (302-392°F) for some of the hot springs; however, the chemistry of the water is not the most suitable for applications of chemical geothermometers and these estimates are likely high. There have been several geothermal test wells drilled in this province. Well 15S-39E-6ca (SUN-1001)**(41-11)** is about 2 km (1.2 mi) from Battle Creek Hot Springs and about 3.5 km (2.2 mi) from Squaw Hot Springs. The temperatures in this well are dominated by shallow lateral flow of hot water (almost 110°C [230°F] at this location) in the shallow ground water aquifer recharged by upflow of hot water (Blackwell and others, 1992).

Fremont County (43)

Hoover and others (1985) postulated that the Island Park area is underlain by a solidified but still hot pluton that represents a significant hot dry rock resource. Exploration and development activities have been retarded by a lack of surface thermal features, evidence of hydrothermal systems, and environmental concerns. Deep drilling is necessary to substantiate the interpretation and provide heat-flow data.

The Island Park-Yellowstone National Park region comprises a complex caldera system which has formed over the last 2 million years. The caldera system has been estimated to contain 50% of the total thermal energy remaining in all young igneous systems in the United States. The Island Park system contributes 32% of the total thermal energy remaining in the complex and contains twice as much energy as the next largest system, the Valles caldera in New Mexico. These considerations make the Island Park region an excellent site for geothermal exploration, yet there is essentially no activity in the region today. Although development is not permitted within Yellowstone National Park, neither exploration nor development is progressing in the caldera complex outside the park. Environmental concerns have in part caused this, but the lack of surface thermal manifestations and the lack of evidence for hydrothermal systems within the Island Park part of the caldera complex is also responsible. As the result of a reexamination of the data and recent electrical work in the area, Hoover and others (1985) postulate that much of the area where the first- and second-stage calderas developed is underlain by a solidified but still hot pluton. That pluton represents a significant hot dry rock resource for the United States.

Thermal manifestations are notably absent within the Island Park region. Only a few minor warm springs are known; the nearest flowing warm spring is at Ashton Hot Spring **(43-21)**, 20 km (12.5 mi) south of Henrys Fork caldera. Ashton Hot Spring has been measured at 41°C (105.8°F), and is the only spring where geochemical thermometers indicate reservoir temperatures over 90°C (194°F)(Hoover and others, 1985). A 300 m (984 ft) test hole, HFT-19 (OXY-19)**(43-25)**, was drilled near the center of the caldera, reported to be in T12N, R42E, section 36ccb (Blackwell, 1988). In this hole the gradient increases systematically from 27°C/km to 66°C/km (2.5°F/100 ft to 4.6°F/100 ft) with increasing depth; heat flow of the lower half of the hole is 109 mWm^{-2}. These data suggest areas of high heat flow in the caldera. A significant geothermal anomaly may be located at the northwestern edge of the caldera in T13N, R42E, sections 24 and 25. Two 38 m (125 ft) holes near the shores of Island Park Reservoir show uniform and high gradients. Hole WW-IPB2 in section 24 has an average gradient of 189°C/km (11.3°F/100 ft), while hole WW-IPB1 in section 25 has an average gradient of 102°C/km (6.6°F/100 ft). These gradients imply heat-flow values of about 310 and 200 mWm^{-2}, which are distinctly anomalous with respect to regional values and document the presence of a geothermal anomaly in the area. The wells were so shallow that the area had not been recognized to have anomalous temperatures; bottom hole temperatures were below 13°C (55.4°F). A high gradient was encountered just south of the caldera rim in hole

OXY-8, T9N, R43E, section 11bda; a gradient of 155°C/km (9.5°F/100 ft) was measured between depths of 60 and 135 m (197 and 640 ft); bottom hole temperature was below 11°C (52°F)(Blackwell, 1988, 1989; Blackwell and others, 1992).

The absence of surface thermal features at Island Park has been cited as evidence for lack of a hot dry rock resource. According to Hoover and others (1985), this has little significance relative to the presence or absence of a geothermal resource at depth. Large volumes of ground water flow occur in the Island Park area. In the porous upper volcanic units the ground water flow would mask any thermal anomaly associated with conductive cooling of an unfractured pluton. The lack of seismicity of the region also indicates that no major brittle fracturing is occurring by which hydrothermal systems might gain access to the central and hottest part of the pluton.

Active volcanic systems similar to Island Park and in which no thermal manifestations are present within the calderas have been recognized. The existence of systems with no surface expression has been documented at Magic Reservoir, Butte City, and in the vicinity of the Champagne Mine. Data support mostly high heat-flow values (many over 120 mWm^{-2}) on the margins and low values (mostly in the range of 30 to 20 mWm^{-2}) in the SRP aquifer. Low heat-flow areas result from crustal thermal conductivity contrasts as well as from regional aquifer motion. Geothermal and ground water aquifer systems have a major effect on the distribution of surface heat flow along the margins of the SRP aquifer. Based on evidence, geothermal systems appear to be as common along the northern edge of the SRP as along the southern margin (Hoover and others, 1985).'

The size (500 km^2 [193 mi^2]) of the possible hot dry rock system present at Island Park implies a significant geothermal heat source. If the heat source is present in Island Park then development of the resource should pose little risk to Yellowstone National Park because of the lack of permeability in the Island Park pluton, the presence of an apparent structural boundary along the Madison fault zone, and a ground water flow direction toward the south and west away from the park.

Idaho County (49)

Kuhns (1980) and Youngs (1981) studied geothermal areas in the Bitteroot lobe of the Idaho batholith and integrated geologic and hydrologic investigations.

Lochsa Geothermal System

Kuhns (1980) outlined the structural and chemical aspects of the Lochsa geothermal system near the northern margin of the Idaho batholith. Heat-flow data suggest a geothermal gradient of 50°C/km (3.7°F/100 ft)with circulation depth estimated at 3 to 4 km (9840 to 13,120 ft). Kuhns postulated a potential geothermal reservoir 300 to 400 km^3 (72 to 96 mi^3) in size exists along the Lochsa River.

The geothermal system investigated is located near the northern margin of the Idaho batholith (Bitterroot Lobe), north of the Selway-Bitterroot Wilderness Area about 32 km (20 mi) west of Lolo Pass, Idaho. U.S. Highway 12 and the Lochsa River traverse the area.

Hot spring vents are found where a northeast-trending dike intersects north- or northwest-trending shear zones. This suggests that circulating thermal fluids moving along the shear zone intersect an impermeable barrier (dike) and ascend along this barrier. All hot spring vents in the study area follow this pattern. Main hot spring vents are located along Weir Creek at Colgate Licks **(49-14)**, and on Warm Springs Creek at Jerry Johnson Hot Springs **(49-16)**. The springs are currently used for recreation and bathing by people traveling along U.S. Highway 12. Eight water samples were collected at vent sites.

According to Kuhns (1980), maximum source temperatures of 170°C to 200°C (338°F to 392°F) are predicted from the chemistry of thermal waters using cation ratios (Cl, Mg, Fe, Mn, Mg/Ca, Na/Ca, Na/Li, Cl/F, Cl/B) and geochemical thermometers (SiO_2, Na/K and Na:K:Ca). Heat-flow data suggest a gradient of 50°C/km (3.7°F/100 ft) exists in the Lochsa area. Geothermometer and heat-flow data combined indicate a reservoir depth for circulating thermal fluids of three to four kilometers. The depths, temperatures, and the low chloride concentrations suggest that a wet steam geothermal field exists under the Lochsa River area. Presently the remoteness and ruggedness of the study area, coupled with the low population density make the area a low priority geothermal resource. Space heating and domestic uses are certainly possible and could benefit local residents along the Lochsa and Clearwater Rivers.

Running Springs Geothermal System

Youngs (1981) characterized the geology and geochemistry of the Running Springs geothermal area. The maximum temperatures indicated by geothermometry are in the 80-90°C (176-194°F) range. Given the low temperature, small probable size and relative isolation of the system, there is little immediate economic potential. A summary of Youngs'(1981) report follows.

The Running Springs geothermal system consists of two major vents (discharge above 100 l/min [25 gpm]) and three minor vents (discharge below 20 l/min [5 gpm]) in the drainages of Warm Springs Creek and Running Creek. Youngs' (1981) investigation encompasses the petrologic, structural, and geochemical aspects of these springs and the 30 km^2 (11.6 mi^2) surrounding area. The study area is located within the central portion of the Bitterroot Lobe of the Idaho batholith, on the eastern margin of the Selway-Bitterroot Wilderness Area. The major thermal springs examined are located approximately 40 km (25 mi) east of the town of Elk City, Idaho, in section 14, T29N R12E, **(49-8)** along the drainage of Warm Springs Creek. One additional thermal spring vent is located in the same section.

The most widespread rocks in the study area are Cretaceous quartz monzonite and Tertiary granite of the Idaho batholith; some Precambrian gneiss is also exposed. Three varieties of rhyodacite dikes and two varieties of rhyolite dikes have intruded the granitic rocks. One of the minor and both of the major thermal spring vents were located in rhyodacite dikes.

The geochemical survey of the Running Springs area consisted of sampling the water at each of the five recognized thermal springs at the same time discharge measurements were made. One nonthermal spring was also sampled.

Application of SiO_2, Na:K, and Na:K:Ca geothermometers indicate maximum source temperatures of 40°C to 80°C (104°F to 176°F). This, combined with a geothermal gradient of 40°C/km (3.2°F/100 ft)(calculated from the heat generation traits of local rocks), suggests a depth of circulation of 1 to 2 km (3280 to 6560 ft). The low source temperatures and geographic isolation of the Running Springs geothermal system suggest little economic development potential.

Jefferson County (51)

Heise Hot Springs (51-1, 51-2)

See discussion under **Bonneville County.**

Lemhi County (59)

Big Creek Hot Springs (59-15)

An evaluation of Big Creek Hot Springs as a source of electrical power for the Blackbird Cobalt Mine was conducted by Struhsacker (1981a-c). Big Creek Hot Springs is one of the hottest known geothermal systems in Idaho, with a surface temperature of 93°C (199°F). Geothermometer estimates of reservoir temperature range from 137°C to 179°C (279°F to 354°F). It was concluded that Big Creek Hot Springs is an excellent geothermal prospect. A suggested exploration program, engineering and economic analyses, and appraisal of institutional factors was outlined.

Big Creek Hot Springs is located approximately 13 miles north of the Blackbird Mine. Reservoir rocks are likely competent Precambrian metamorphic and metasedimentary rocks, with fractures serving as hot water conduits. The system consists of a linear set of spring vents trending N40-45W that intersect Hot Springs fault. The heat source is probably deep circulation of meteoric water. There may be potential for buried thermal anomalies along the entire length of Hot Springs fault.

Several institutional factors complicate the development potential of Big Creek Hot Springs; it lies on U. S. Forest Service land and is close to the River of No Return

Wilderness Area. The distance from population centers precludes development at present of electrical generation potential.

The engineering feasibility study modeled an 11 MWe binary power plant, utilizing propane (95%) and hexane (5%) as the mixed working fluid. It was determined a power plant could be located along Panther Creek; power would be transmitted 20.8 km (13 mi) to where it would tie into the Idaho power grid that services the town of Cobalt (Struhsacker, 1981a-c).

Shoup Geothermal Area

The geology and geochemistry of three hot springs systems in the Shoup geothermal area was investigated by Vance (1986). The study area is located in the region adjacent to the southeastern border zone of the Bitterroot Lobe of the Idaho batholith and west of Shoup, Idaho. Big Creek Hot Springs **(59-15)** is 9.6 km (6 mi) southwest of Shoup, at latitude 45°18'37"N and longitude 114°20'17"W, along Hot Springs Creek. Owl Creek Hot Springs **(59-14)** is 16.1 km (10 mi) west-southwest of Shoup, at latitude 45°20'40"N and longitude 114°27'44"W, along Owl Creek. Horse Creek Hot Springs **(59-16)** is 20.9 km (13 mi) northwest of Shoup, at latitude 45°30'12"N and longitude 114°27'46"W, along Horse Creek.

In addition to structural and petrologic analysis, Vance's study determined physical and chemical conditions for waters from the thermal vent systems and for local and regional nonthermal spring sites. The data obtained from the thermal waters were used to compute temperature of equilibration using various geothermometers.

The geothermal convection systems are contained in permeable fracture zones within impermeable crystalline country rocks. Big Creek Hot Springs and Owl Creek Hot Springs are located in Precambrian rocks. Horse Creek Hot Springs is located in the Tertiary Painted Rocks Lake pluton.

The use of various chemical geothermometers give reasonable agreement and indicate temperatures of equilibration for the three systems studied as follows: Big Creek Hot Springs, 181°C (357.8°F); Owl Creek Hot Springs, 127°C (260.6°F); and Horse Creek Hot Springs, 40°C (104°F) for the vents on Horse Creek and 70°C (158°F) for the vents on Lindgren Creek. The estimated geothermal gradients at Hot Springs Creek, Owl Creek, and Horse Creek of 51°C/km (3.8°F/100 ft), 44°C/km (3.4°F/100 ft), and 51°C/km (3.8°F/100 ft), respectively, give depths of circulation for the thermal waters of 3.4 and 2.4 km (11,152 and 7872 ft) at Hot Springs Creek and Owl Creek, respectively. The shallow high-flow portion of Horse Creek extends to a depth of 0.5 km (1640 ft) and the low-flow portion along Lindgren Creek to a depth of 1 km (3280 ft)(Vance, 1986).

Due to the isolation of the area and the location in National Forest ladn adjacent to primitive areas, economic development of the existing hot spring systems does not appear to be practical.

Lemhi Range

The central Idaho Basin and Range province differs geologically and tectonically from the remainder of the provinces north of the SRP. Heat-flow values in the bedrock of the Lemhi Range are 55-59 mWm^{-2}, significantly below average values elsewhere in the greater Northern Rocky Mountain province. On the other hand the gradient in a deep hole in the adjacent Lemhi River valley is 84°C/km (5.6°F/100 ft) and the estimated heat flow is greater than 105 mWm^{-2}. As is the case with the southeastern Idaho Basin and Range province, deep drill holes are needed to evaluate the intrinsic thermal characteristics of this province. The only deep thermal data are bottom-hole temperature measurements from several hydrocarbon exploration wells drilled near the Idaho/Montana border in the vicinity of the Lima Anticline and two wells drilled in Birch Creek and Lemhi valleys. Unlike some of the wells described in the southeastern Idaho Basin and Range province, none of these wells appear to have gradients in excess of 40°C/km (3.2°F/100 ft). The deepest well, the EXXON Meyers Federal Unit #1 **(33-8)**, located in adjacent Clark County, reaches an uncorrected bottom-hole temperature of 197°C (386.6°F) at 5.7 km (18,696 ft)(Blackwell and others, 1992).

Madison County (65)

Madison County has an agricultural environment in the upper Snake River valley of eastern Idaho. Rexburg, the county seat, has a population of approximately 11,000, plus 6,000 students that attend Ricks College (Kunze and Stoker, 1979).

In the summer of 1980, a 1202 m (3943 ft) well **(65-10)** was drilled at the edge of Rexburg in a region that had been tested by shallower holes. The goal of the project was to identify a geothermal resource suitable for heating several large buildings in the Rexburg area (Kunze and Marlor, 1982) as well as supply industrial food processing energy for a large potato granule plant. Temperatures measured near the bottom of the hole were far below what was predicted or needed and drilling was halted.

The area investigated is within a 30 km (19 mi) radius of Rexburg roughly outlined by a complex of about eight Pliocene calderas known as the Rexburg Caldera Complex (Prostka and Embree, 1978). The complex straddles the northeast-trending boundary between the eastern SRP and the Basin-Range province. The calderas were the source of several major rhyolitic volcanic deposits along the southeast margin of the eastern SRP. Rhyolite flows of the Rexburg Caldera Complex unconformably overlie highly deformed miogeosynclinal sedimentary rocks of Paleozoic and Mesozoic age that are well exposed in the Snake River Range, the Caribou Range, and in the Big Hole Mountains. The rocks apparently do not play an important role in the geothermal system of the area. The rhyolite flows are unconformably overlain by tuffaceous clastic sediments, basalt lava flows, pyroclastic deposits, and rhyolitic ash flow tuff. The various rock types (mainly basalt, rhyolite, and interbed zones) which lie beneath Rexburg act as a common aquifer, although individual well performance varies considerably in different rock types.

No surface manifestations of a geothermal resource exist in the local Rexburg area. A higher than normal geothermal gradient is suggested on the Rexburg Bench, a structural and topographic feature. Thermal springs and anomalies are located along the eastern edge of the SRP. Several geologic features of the Rexburg area constitute evidence for geothermal potential (Prostka and Embree, 1978). High precipitation in the mountains recharges the ground water system which eventually discharges into the Snake River aquifer. The Rexburg Caldera Complex is ideally situated to intercept ground water flow and channel it downward along fault zones. Water may then be heated and stored in closed-basin reservoirs related to caldera subsidence and/or faults of the Basin and Range type. Secondly, continuing tectonic extension may reactivate faults, many of which constitute channels for circulating geothermal water. Finally, the high regional heat flow of the SRP and Basin and Range provinces (Sass and others, 1976) is augmented by Pliocene and Pleistocene rhyolitic volcanism and continuing Quaternary basaltic volcanism, and has facilitated transfer of mantle heat to high crustal levels.

The distribution of hot wells and springs in the Rexburg area is concentrated along major late Cenozoic linear and arcuate fault zones, and especially at the intersections of these zones.

Estimated aquifer temperatures were calculated by using the silica and Na-K-Ca geothermometers of well water samples. The water chemistry and temperature data indicate the existence of a reservoir with a probable temperature in the range of 100-200°C (212-392°F)(Stoker and Kunze, 1980).

Relatively high thermal gradients are to be expected in the Rexburg area at depths where the movement of ground water is not affecting the temperatures. Reported gradients range from 47.8°C/km to 86°C/km (3.6°F/100 ft to 5.7°F/100 ft)(Blackwell and others, 1992).

Elkhorn Warm Spring **(65-1)**

See **Bonneville County** discussion.

Owyhee County (73)

According to Blackwell and others (1992), thermal data collected within the western SRP generally fall into two categories. These categories correspond to areas of relatively high gradient and heat flow (approximately 100°C/km [6.4°F/100 ft] and 120 to 150 mWm^{-2}), and areas of moderate gradient (about 40°C/km [3.2°F/100 ft]) and average heat flow values (60-80 mWm^{-2}). Most of the gradients range between 45°C/km and 85°C/km (3.4°F/100 ft and 5.6°F/100 ft). Heat-flow values range from 50-150 mWm^{-2} with a 100$\pm$10 mWm^{-2} average. Areas of high heat flow are distributed in two bands along the northern and southern margins of the western SRP. Lower gradients and heat flow are found along the axis of the SRP between Caldwell and Mountain Home. Deep drilling in the Boise area and in the Bruneau-Grand View region has demonstrated that the high heat-flow values there are related to intermediate temperature (40-80°C [104-176°F]) geothermal systems and relatively local geothermal anomalies. Typical temperature-depth curves in the Boise front geothermal system and in the Bruneau-Grand View geothermal system show isothermal or low gradient sections starting between 80 and 280 m (262 and 918 ft) with temperatures of 40°C to 80°C (104°F to 176°F). Geochemistry suggests that maximum temperatures in the geothermal systems are 70-100°C (158-212°F). This accounts for the high gradients and heat flow that are measured in holes 50-200 m (164-656 ft) deep and range up to 80°C (176°F). This pattern of heat flow and gradient is due to systematic regional flow of ground water toward the edges of the SRP from the higher elevation margins. Very low heat flow that may represent part of the recharge system occurs south of the Bruneau-Grand View area. At the edge of the SRP hydraulic boundaries cause upflow, which gives rise to the geothermal systems at the various locations. Average heat-flow values are on the order of 50-100% above regional background values. Outside the areas of most active fluid flow, temperature-depth curves are linear to depths of at least 400-500 m 1312-1640 ft).

High gradients and heat flows are also found in holes drilled in granitic rocks on both margins of the SRP. The high heat flows are related to crustal deformations along the SRP margins. Heat flow is 25% to 50% higher along the margins of the SRP than at the center. The regional heat flow south of the SRP is about 100 mWm^{-2}, about 75 mWm^{-2} north of the SRP and approximately 60 to 75 mWm^{-2} in the central SRP (Blackwell and others, 1992).

Large areas of the western SRP have temperatures of over 50°C (122°F) at depths of 500 m (1640 ft) or less. Within the lowest gradient areas of the western SRP a temperature of 40°C (104°F) can be expected at a depth of 500 m (1640 ft). Fluids and temperatures suitable for many low temperature geothermal resource applications exist in most places.

The Owyhee Uplands province is south of the SRP. It is a low relief volcanic plateau built on a largely unknown basement. Its boundary with the SRP is marked by subsurface faults, but is not abrupt at the surface. Gradients range from 16°C/km (1.8°F/100 ft) to over 75°C/km (5.1°F/100 ft); average geothermal gradient is 51$\pm$4°C/km (3.8$\pm$1.2°F) and the average heat flow is 98$\pm$7 mWm^{-2}. These values are significantly above those in central and northern Idaho; the low values may be due to regional downflow. The gradient average for the Owyhee Plateau is less than the western SRP, but the difference in heat flow is not significant. The rocks encountered in the drill holes are mostly silicic volcanic rocks with higher average thermal conductivity values than the sedimentary rocks in the western SRP, thus lower gradients for a similar heat flow (Blackwell and others, 1992).

Bruneau-Grand View Area

According to Mabey (1983), the largest hydrothermal system in Idaho is in the Bruneau-Grand View area of the western SRP with a calculated reservoir temperature of 107°C (225°F). More information is needed to define the extent of the system and source of hot water; no evidence in the existing data indicates that large volumes of water hotter than that indicated by geothermometers will be found within 3 km (9840 ft) of the surface.

The Bruneau-Grand View area occupies about 2850 km^2 (1,100 mi^2) on the southern margin of the SRP in northern Owyhee county. The area has a rural population dependent on ground water for irrigation. Temperature of the ground water ranges from 15°C (59°F) to more than 80°C (176°F). Ground water for irrigation is obtained from flowing and pumped wells. Discharge of thermal ground water from 104 irrigation wells and 5 hot springs in 1978 was about 62,266,500 m^3 (50,500 acre-ft)(Young and others, 1979).

Young and others (1979) divided the Bruneau-Grand View area into four geographic units: Castle Creek, Grand View, Little Valley, and Bruneau Valley. The investigators inventoried 104 irrigation wells and 5 hot springs, made measurements or estimates of their discharges and pumping levels, and measured or reported water temperatures throughout the 1978 irrigation season.

According to Young and others (1979), heat from the Bruneau-Grand View system is discharged convectively by hot water which discharges naturally from hot springs or artificially through pumped or flowing wells. Prior to any development in the area, all convective heat flux was by hot spring discharge. Presently, almost all convective heat flux is by hot water discharge from irrigation wells.

Historic data from Stearns and others (1937, p. 148) show 11 hot springs or groups of hot springs within the boundaries of the four geographic units included in the Young and others (1979) study. Temperatures of the springs ranged from about 38°C to 49°C (100.4°F to 120.2°F), and discharges ranged from about 95 to 6814 l/min (25 to 1,800 gpm). From these data, the natural convective heat flux from the Bruneau-Grand View area was estimated to be about 9x10^6 cal/s. Total convective heat flux from the Bruneau-Grand View area was about 4.97x10^7 cal/s in 1978. Only about 1 percent of this total was natural discharge from the hot springs in the Bruneau Valley unit; 99 percent was contained in water pumped or flowing from wells (Young and others, 1979).

Bruneau Known Geothermal Resource Area (KGRA)

According to Spencer and Russell (1979a), the Bruneau KGRA is located in eastern Owyhee County on the Bruneau River. This KGRA is part of the large thermal anomaly that includes the Castle Creek KGRA. Fluoride levels are high in thermal waters, even in waters of low total dissolved solids.

Bruneau lies just north of the fault zone forming the southern edge of the Snake River graben. Miocene silicic volcanic rocks form the Owyhee Plateau and underlie the KGRA. These may be related to the Idavada Volcanics exposed north of the Snake River graben. Surface geology consists of interbedded lava flows, lacustrine and fluvial sedimentary deposits of the Idaho Group dating from early Pliocene time. Upper Pleistocene terrace gravels are exposed along the margins of the Bruneau Valley, and alluvial deposits form the valley flood plain.

Castle Creek KGRA

The Castle Creek KGRA, as described in Spencer and Russell (1979b), is part of the Bruneau-Grandview thermal anomaly. The area may have potential for greenhouse operations and other low-temperature, direct-heat applications, utilizing warm water from shallow depths. Water from sedimentary aquifers is generally higher in total dissolved solids and has low fluoride levels, while that water produced from the volcanic aquifers has significantly higher levels of fluoride but lower total dissolved solids.

The Castle Creek KGRA lies on the downthrown side of the southern margin of the western SRP graben. The KGRA is associated with the western Idaho fault zone which is suspected to have been recurrently active since middle Miocene. Miocene silicic volcanic rocks occupy the region of the fault zone south of the KGRA in the foothills of the Owyhee Mountains. Idaho Group formations, dating from the Pliocene, constitute most of the rocks exposed at the surface and form badland topography over much of the area. Rock units include basalt lava flows and consolidated lacustrine and fluvial facies. Faults in these formations apparently serve as conduits for the geothermal anomaly (Spencer and Russell, 1979b).

Grand View

OIT Geo Heat Center (Dellinger and others, 1982) conducted an analysis of the Grand View area. A number of thermal wells, ranging from 25°C to 83°C (77 °F to 181°F), are situated within a 4.8-km (3-mi) radius of the town. Several buildings were already heated by warm water. The study concluded that Grand View has good geothermal energy potential, but the economics of a district heating system were not very attractive.

Grand View is a small community along the Snake River, located in Owyhee County at the junction of State Highways 67 and 78 in the Bruneau-Grand View KGRA. The climate is classified as semi-arid, having warm summers and cold to moderate winters. The area around Grand View has been designated as a Known Geothermal Resource Area (KGRA) by the U.S. Geological Survey.

The geology of the Grand View area has been analyzed by a number of authors. The youngest lithologic unit in the area is the Idaho Group. It consists of poorly to well-stratified deposits of unconsolidated to semi-consolidated gravel, sand, silt and clay with numerous layers of ash, basaltic tuff, and thin basalt flows. In the Grand View area, the unit is about 518 m (1,700 ft) thick. The oldest formation within the Idaho Group is the Banbury basalt, 91 to 152 m (300 to 500 ft) thick in the Grand View area. Another important unit is described as consisting of Tertiary silicic volcanic rocks and silicic latite; it underlies the Banbury basalt. The unit has been jointed and fractured near the contact zone with the Banbury basalt.

The consolidated volcanic units are the targets for obtaining thermal waters. Wells in the Grand View area that penetrate the Banbury basalt and the Tertiary silicic volcanics commonly have high artesian pressures. The upper portion of the Idaho Group acts as a cap rock on the ground water system that occurs in the two consolidated lower volcanic units. Wells in the area commonly produce 60°C (140°F) water from depths of 762-915 m (2,500-3,000 ft). Artesian shut-in pressures in some wells are as high as 94 psi at the surface.

Many geologists believe that recharge to the thermal ground water system occurs as precipitation on the plateau and mountains to the south and southwest.

Dellinger and others (1982) report that water quality analyses were performed for six thermal wells in the Grand View area that range in depth from 396 to 732 m (1,300 to 2,400 ft). However, only five wells are listed with depths from 494 m to 905 m (1620 ft to 2970 ft) (Dellinger and others, 1982, p. 135, Table 1)**(73-89, -91, -95, -97, and -98)**. Overall, the water quality is good. The only constituent which exceeds drinking water standards is fluoride.

Indian Bathtub Area

The Indian Bathtub area is about 96 km (60 mi) southeast of Boise in southwestern Idaho. Young and Parliman (1989) presented physical, chemical and isotopic data collected from 86 thermal water wells and 5 springs in the Indian Bathtub area. These data were collected as part of a study to determine the cause of decreased discharge at Indian Bathtub Hot Springs **(73-273, 73-277)** and other thermal springs along Hot Creek. The data include well and spring locations, well construction and water level information, hydrographs of water levels in 9 wells, hydrographs of discharges in 4 springs, and chemical and isotopic analyses of water from 33 thermal water wells and 5 springs. In addition, Young and others (1990) presented results of test drilling and hydrologic monitoring of the Indian Bathtub area.

More recently, interest in the decline of thermal spring flow and its impact on the threatened Bruneau Hot Springs snail has resulted in studies of the thermal system. Berenbrock (1993) studied the effects of well discharges on hydraulic head and thermal spring discharge in the Indian Bathtub area and determined that a hydraulic head/spring discharge relation exists for two sites at Indian Bathtub Spring and a nearby test hole **(73-273)**.

Twin Falls County (83)

Twin Falls County is located in south-central Idaho between the Snake River and the Nevada border. Surface geothermal manifestations near Twin Falls are limited to three hot springs issuing from faults: Miracle Hot Springs **(83-21)** and Banbury Hot Springs **(83-33)** in western Twin Falls County near the Snake River, and Nat-Soo-Pah Warm Spring **(83-153)** south of Twin Falls. Magic Hot Springs **(83-181, 83-182)** occur in the southeastern corner of the county near the Idaho-Nevada border. Except for development of the Banbury Hot Springs spa around 1910, little use was made of the thermal resource until the 1970's. During the mid-1970's, western Twin Falls County began using the resource, tapped by relatively shallow wells, for aquaculture and space heating. In the late 1970's an increasing number of residents installed wells to utilize the thermal water (Lewis and Young, 1989).

Banbury Hot Springs Area

Lewis and Young (1982a) characterized geothermal resources in the Banbury Hot Springs area. An inventory of wells and 2 thermal springs in the area was completed. Water levels and discharge rates were measured, and chemical analyses were conducted. Estimated age of geothermal water is at least 100 years and possibly more than 1000 years. Reservoir temperature is estimated between 70°C and 100°C (158°F and 212°F). A summary of the Lewis and Young (1982a) report follows.

The Banbury Hot Springs area is located immediately south of the Snake River between Salmon Falls Creek and Deep Creek in Twin Falls County, south-central Idaho. In the early 1970's, several wells that produce thermal water were drilled. Successful use of these wells led to increased development of the resource. In 1982, 26 wells that produce thermal water had been completed. Many residents were concerned that continued development could limit geothermal water available to current users. If continued development reduces flow or causes heads to drop below land surface, the economic advantage of using the resource will be impaired.

Thermal water in the Banbury area is used for residence heating, catfish and tropical fish production, greenhouse operation, swimming pools, and therapeutic baths. In 1979, 12,699,900 m^3 (10,300 acre-ft) of thermal water was utilized. The thermal waters sampled are sodium carbonate or bicarbonate in character and slightly alkaline. Mixing of hot (72°C [161.6°F]) water with local cooler ground water can be shown from various relations among stable isotopes, chloride, and enthalpy.

Lewis and Young's (1982a) study included: 1) inventory of 50 thermal and nonthermal wells and 2 thermal springs in the Banbury Hot Springs area; 2) collection of water level or pressure information and discharge measurements, where possible, at the time of inventory; 3) collection of water samples from 21 thermal wells and 2 thermal springs for chemical analyses, including common ions, silica, and the minor elements of arsenic, boron, lithium, and mercury; and 4) collection of water samples from nine wells and two springs for deuterium and oxygen-18 analyses, four wells and one spring for tritium analysis, and two wells and one spring for sulfate-water isotope analysis. Water level measurements were used to compile a generalized potentiometric map. Discharge measurements and water temperatures at land surface were used to determine the present quantity of thermal water being utilized and the associated convective heat flux. Reservoir temperatures were estimated for all sampled thermal water in the Banbury Hot Springs area and for selected thermal water in the nearby areas using the silica and Na-K-Ca geothermometers. Reservoir temperatures for two wells and one spring were estimated by using the sulfate-water isotope geothermometer. Relations of selected chemical constituents to deuterium and oxygen-18 isotopes and concentrations of tritium were used to distinguish and define the approximate areal extent of the Banbury Hot Springs geothermal reservoir.

Rocks underlying the Banbury Hot Springs area are volcanic and sedimentary in origin and range in age from late Miocene to Holocene. They are divided into: 1) Tertiary silicic volcanics; 2) Tertiary basalt; 3) Quaternary and Tertiary sedimentary rocks; and 4) Quaternary basalt and sedimentary rocks. A large number of the springs in the canyon walls at Thousand Springs occur at the contact between the Tertiary and Quaternary basalt units. Permeability appears to decrease drastically at the contact betweeen the older and younger basalt.

Tertiary silicic volcanics consist chiefly of welded tuff of the Idavada Volcanics of late Miocene age and are exposed locally in the canyon of Salmon Falls Creek and in the uplands southwest of the Banbury Hot Springs area. Total thickness of the Idavada Volcanics in the vicinity of Banbury Hot Springs exceeds 610 m (2,000 ft)(Malde and Powers, 1962). Tertiary basalt, consisting chiefly of olivine basalt flows of the Banbury Basalt of late Miocene age, is the predominant rock unit in the area. This unit is reported to be about 198 m (650 ft) thick. Quaternary and Tertiary sedimentary rocks, consisting chiefly of detrital basin fill deposits of the Glenns Ferry Formation of late Pliocene and early Pleistocene age, are also exposed throughout the area.

Several northwest-trending normal faults have been mapped in the area studied. Most faults have their downthrown side on the northeast. Some graben and horst structures occur southwest of the study area. Most of the faulting probably occurred in late Miocene time, although some faulting continued through Pleistocene time.

Most wells are located in a narrow belt centered along the extension of a northwest-trending fault. Other northwest-trending faults southwest of the study area act as barriers to ground water movement from the southwest. Artesian heads in wells at the time of the study were as much as 110 m (360 ft) above land surface. The hottest water (temperature near 72°C [161.6°F]) occurs in the vicinity of Salmon Falls Creek **(83-12)**. On the basis of available heat-flow data, depth of circulation in the system required to attain water temperatures near 70°C (158°F) is about 1341 m (4,400) feet. Because these temperatures occur in water from wells 128 to 213 m (420 to 700 ft) deep, some convective transport of heat, probably upward along faults, is indicated.

A general increase in concentrations of chloride, fluoride, and boron occurs with an increase in temperature. Indications are that of a mixing of hot water from a single deep source with shallow cooler local ground water to give the range of temperature and chemical makeup evident in the Banbury thermal waters. Concentrations of tritium in samples indicate that most thermal water contains little or no post-1954 water and is probably at least 100 years old and perhaps more than 1,000 years old (Lewis and Young, 1982a).

The Earth Science Lab Division of the University of Utah Research Institute (UURI) provided geologic assistance to Fishbreeders of Idaho, Inc. to locate a thermal well for operation expansion. The study area was located near Banbury Hot Springs in the Hagerman Valley, about 32 km (20 mi) west of Twin Falls (Blackett, 1981a).

Hagerman Valley is the site for much of Idaho's commercial fish industry. Cold water fish species are raised from numerous cold springs that discharge from the canyon wall on the northeast side of the Snake River. Warm water fish species are raised in thermal water produced from wells located southwest of the Snake River. No thermal wells or springs are known to occur on the northeast side of the Snake River and therefore the general course of the river has been considered as the approximate boundary to the geothermal system (Lewis and Young, 1980a).

Goldman (1982) documented the development of the Leo Ray fish farming operation near Buhl, which utilizes geothermal energy **(83-53, 83-54)**. History of development is described and recommendations for future resource evaluation are presented.

UURI conducted an evaluation of exploration methods useful for low-temperature geothermal systems in the Artesian City area (Struhsacker and others, 1983). Each technique was critiqued and a exploration strategy outlined.

Central Twin Falls County

Lewis and Young (1989) characterized the hydrothermal system in central Twin Falls County. The report described the areal extent and thickness of the hydrothermal reservoir and proposed a conceptual model of the system. They concluded the reservoir is approximately 1000 km^3 (240 mi^3), with aquifers contained primarily in the Idavada Volcanics. Aquifer thickness ranges from 213 to 610 m (700 to 2000 feet). Estimated reservoir temperature is 70°C to 80°C (158°F to 176 °F); carbon-14 age dates place samples from 1000 to 10,000 years old. Net heat flux is about 2.2 HFU.

An investigation of the thermal resource in central Twin Falls County was conducted by the Idaho Department of Water Resources. The initial part of the study, completed by Street and DeTar (1987), provided baseline data on geology, historic pressure and temperature fluctuations in the system, and thermal water geochemistry. The second part of the study included continued monitoring of system temperatures and pressures, additional water chemistry and rock geochemistry. This portion of IDWR's investigation was completed by Baker and Castelin (1990); a conceptual model was proposed.

According to Baker and Castelin (1990), the Idavada Volcanics and Paleozoic sedimentary rocks east of Hollister act as part of the geothermal aquifer. A north to northwest flow pattern is implied. Although water level decline is apparent in developed areas, discharge due to pumping does not exceed natural recharge.

Mariner and others (1991) investigated the chemical, isotopic, and dissolved gas compositions of the hydrothermal system in Twin Falls and Jerome counties. It appears thermal waters range in age from 2000 to 26,000 years. Westward-flowing older water, north of the Snake River, may join younger northward-flowing water; main direction of flow in the hydrothermal system seems to parallel surface drainage.

According to Lewis and Young (1989), the artesian pressure of the geothermal system in Twin Falls county has been used to generate electricity for sale to power companies. Low hydraulic head hydrogenerators have been installed on some flowing warm water wells. Discharge from these wells is generally sufficient to produce some electricity, but the heat content of the resource is not efficiently used. Increased utilization of the thermal water has caused aquifer pressures to decline in recent years. Near the city of Twin Falls, pressure declines of up to 15 pounds per square inch since 1984 have been documented, and water levels in some formerly flowing thermal wells have declined to below land surface.

Lewis and Young (1989) state that the thermal water occurs primarily in the silicic volcanic rocks of the Idavada Volcanics. Electrical resistivity soundings indicate that the Idavada Volcanics are continuous beneath most of the area; thickness ranges from about 213 to 915 m (700 to 3,000 ft) and averages about 610 m (2,000 ft). Reservoir volume is about 1000 km^3 (240 mi^3). Temperatures of water sampled range from 26°C (78.8°F) to nearly 50°C (122°F) in wells completed in the upper part of the reservoir; the warmest temperatures occur near Twin Falls.

Most of the thermal water is a sodium bicarbonate type. Carbon-14 concentrations in selected thermal water samples indicate ages of 1,000 to 15,000 years. The water becomes progressively older northward along proposed ground water flowpaths. According to Baker and Castelin (1990), the chemistry of the thermal water appears to be strongly governed by the chemical composition of and exposure time to the rocks that it comes in contact with. The shorter flow paths to the south appear to occur entirely within the Paleozoic rocks, as indicated by the calcium bicarbonate chemistry of the thermal water. As the flow paths become progressively longer towards the north, the thermal waters apparently encounter the silicic volcanics during their ascent. The chemistries of the thermal waters gradually equilibrate to the new host rock conditions and lose their Paleozoic signatures as exposure time increases. Ultimately, the chemistry of the thermal water changes to a sodium bicarbonate type.

The net heat flow for the area is between 2.2 and 3.7 HFU's, depending on variables assigned. The 3.7 HFU is an anomalously high heat flow for south-central Idaho and would be more representative for heat flow in an active geothermal area. The 2.2 HFU is more compatible with values for margins of the SRP published by Sass and others (1971) and Brott and others (1976, 1978) and probably is a better estimate for the Twin Falls area. The more credible lower value requires a system older than 5,000 years and recharge rates considerably less than 0.31 m^3/sec (11 ft^3/sec)(Lewis and Young, 1989).

The mountainous terrain to the south and southeast of the study area is thought to be the recharge area for the geothermal system. Natural discharge from the system occurs primarily through upward leakage to the overlying cold-water system. Where topographic and geologic conditions are favorable, thermal water flows at land surface as springs and seeps. Based on the relative positions of the presumed recharge and discharge areas of the system, a north to northwest direction of flow is implied.

Significant declines have been observed in the potentiometric surface in areas where development of the thermal resource has been most concentrated. Based on observed water-level trends, it appears total discharge does not exceed recharge. Apparently, the amount of upward leakage that naturally took place in these areas has been reduced by approximately the amount of discharge from wells (Baker and Castelin, 1990).

A monitoring network of five wells in the Banbury Hot Springs area was established in the fall of 1983. A similar network of four wells was established for the Twin Falls area in the spring of 1984. It is Street and DeTar's (1987) opinion, based on well testing, similarity of monitoring results, responses to changes in discharge and water chemistry, that there seem to be no barriers to thermal water movement within or between the Twin Falls and Banbury portions of the system. While the Twin Falls and Banbury portions of the system appear hydrologically connected, the source of the heat component at Twin Falls is not clear.

Monitoring of the aquifer has shown that temperatures have remained constant while water levels are still declining and have not reached equilibrium. The seasonal fluctuations indicate response to the decrease in discharge, not necessarily to recharge.

The monitoring also demonstrated that the aquifer responds rapidly to the development and usage of new wells or to the repair and shut-in of existing wells; this indicates good hydraulic interconnection between the Banbury and Twin Falls portions of the system (Street and DeTar, 1987).

Valley County (85)

An environmental analysis of the Vulcan Hot Springs KGRA was completed by EG&G, Idaho (Spencer and Russell, 1979e) as part of a preplanning environmental program related to Known Geothermal Resource Areas in the Snake River Basin. A second report, USGS Open-file Report 80-518, consists of a telluric profile and location map for Vulcan Hot Springs KGRA (Christopherson and others, 1980).

The Vulcan Hot Springs KGRA is one of the more remote KGRA's in Idaho. Vulcan Hot Springs **(85-21)** are composed of 13 vents with a combined discharge of 32 l/sec (507 gpm) and a surface temperature of 84°C (183.2°F). The chemistry of Vulcan Hot Springs indicates a subsurface resource temperature of 147°C (296.6°F). The resource may be a candidate for power generation. Geologically, the Vulcan Hot Springs KGRA is located a few kilometers east of the western margin of the Idaho batholith. The KGRA follows a north-trending lineament which probably controls the presence of the hot springs (Spencer and Russell, 1979e).

Washington County (87)

Washington County has attracted geothermal exploration activity due to the presence of Weiser **(87-18)** and Crane Creek **(87-7)** hot springs. The thermal values from shallow holes are quite scattered with gradients and heat flow values ranging from 20.4°C/km (2.1°F/100 ft) and 32 mWm^{-2} to 84°C/km (5.6°F/100 ft) and 102 mWm^{-2}. The average heat flow value is 57 mWm^{-2} and the average gradient is 45°C/km (3.4°F/100 ft). A nonequilibrium bottom hole temperature for the Christiansen #A-1 well **(87-10)** is 130°C (266°F), resulting in an estimated gradient of greater than 48°C/km (3.6°F/100 ft), and an estimated heat flow of 76 mWm^{-2}. Heat flow and gradient are significantly lower than those found in the western SRP (Blackwell, 1989).

Crane Creek KGRA

The Crane Creek KGRA is located in Washington County in southwestern Idaho. Estimated resource temperature is 166°C (330.8°F)(Na-K-Ca) to 176°C (348.8°F)(quartz). The KGRA is situated along the west side of the north-south-trending Idaho fault zone. An environmental assessment of the area was performed by EG&G, Idaho (Spencer and Russell, 1979c).

Cretaceous Idaho batholith rocks are exposed approximately 20 km (12.5 mi) east of the Crane Creek KGRA. Older Mesozoic and Paleozoic metavolcanic and metasedimentary rocks are exposed approximately 11 km northwest of the KGRA. These rocks are believed to form the basement complex under the Crane Creek KGRA.

The dominant structures in the Crane Creek KGRA are a series of north-northwest-trending high-angle faults that form a narrow structural zone that trends across lower Crane Creek and parallel to the Weiser River. This fault zone coincides with a steep gravity gradient that is suggestive of a major structure in basement rocks at depth. Hot springs along Crane Creek are located on the east side of the fault zone and may be related to hot water rising along a deep-seated basement fault and into younger faults in the overlying lavas. The overlying sandstone units are fractured and displaced by minor faults. Small faults in the sediments may have resulted from continued movement on older faults in the underlying lavas or from subsidence related to hot spring activity. The hot springs in the Crane Creek area are located along the margin of a siliceous sinter terrace or in adjacent sediments covering part of a sinter apron (Spencer and Russell, 1979c).

Weiser and Little Salmon River Drainages

Fifteen thermal springs, two thermal wells, and eight cold springs in the Weiser River and Little Salmon River drainages were sampled for deuterium and oxygen-18 analysis during the fall of 1981 by the Idaho Department of Water Resources (Mitchell and others, 1984). The analysis suggests that thermal waters might be Pleistocene age. Isotopic data indicate little evidence for mixing of thermal and nonthermal waters. A summary of the IDWR study follows.

A high-angle fault east of the hot springs area is a possible source for the thermal water. The high-angle faults associated with a graben structure believed to exist near the western margin of the study area may also provide conduits for the movement of thermal water.

Most thermal water occurrences in west-central Idaho are confined to arcuate zones defined by the general courses of the South Fork of the Salmon and the Weiser rivers. Springs that do not lie on this arcuate trend are generally found east of this zone and include Cove Creek Hot Springs (**87-1**) and Crane Creek Hot Springs (**87-7**) in Washington County, and White Licks Hot Springs (**3-6**) in adjacent Adams County.

Samples were taken along the length of two of the arcuate zones defined in the Weiser River and Little Salmon River drainage basins to determine isotopic compositions of thermal water along their lengths. Sites for isotopic sampling along the arcuate trends were chosen on the basis of surface temperature and geographic location. All springs were sampled during the fall of 1981 to insure sampling of perennial discharge. A total of 24 samples were collected.

Many of the thermal springs and wells are found on or near major mapped faults or near contacts of different rock units. Thermal wells generally have been drilled into Miocene stream or lake deposits or Quaternary alluvial deposits close to their contact with basalt rocks or with each other.

Only a few deep wells have been drilled in the Weiser Hot Springs-West Weiser Flat area. These include: a 244 m (800 ft) deep well **(87-22)**(11N-6W-10cca2) drilled near Weiser Hot Springs **(87-18)**, from which thermal water flows, that was formerly used for greenhouse space heat and for a natatorium; Weiser Strat No. 2 well (11N-6W-15aa1), drilled by Phillips and then plugged, was 209 m (658 ft) deep and encountered 64°C (147°F) water near the bottom; Weiser Strat No. 3 well, drilled to 437 m (1550 ft) again by Phillips, that bottomed in basalt and had no water reported in the well; and well 11N-5W-33bc1, drilled by the City of Weiser for municipal use [no temperature is given for this well and therefore it is not included in the data base]. An interesting aspect of the logs from these wells is the association of thermal water (< 100°C [< 212°F]) with a lithologic unit identified by a water well drillers' term "blue clay". "Blue clay" is associated with thermal water in the Crane Creek, Parma, Nampa-Caldwell, and Boise areas of the western SRP and has been noted in drillers' logs in thermal wells as far east as Bannock County. In the Nampa-Caldwell area a "blue clay" acts as an aquitard or cap rock, separating nonthermal water from thermal water found below the "blue clay" [(Anderson and Wood, 1981)](Mitchell and others, 1984).

In the Weiser Hot Springs area, based on geologic data, there is no obvious reason for the hot springs occurrence. Therefore, it is assumed that the hydrothermal water is generated elsewhere and brought to the surface through some minor structure.

The isotope data gathered indicate that recharge to the thermal systems is from ancient (Pleistocene) precipitation which fell in proximity to the thermal discharges on adjacent slopes or in adjacent mountain ranges. Thermal waters issuing from Weiser, Crane Creek, Cove Creek, and White Licks hot springs have been enriched in oxygen-18, indicating that these waters have been at higher temperatures than other thermal waters sampled from the study area. There is little or no evidence in the isotope data to indicate that sampled thermal waters are mixtures of thermal and nonthermal waters. Possible exceptions might be water issuing from Stinky (also spelled *Stinkey*) Warm Springs **(3-19)** in Adams County, and the Glen Hill well **(87-16)**(Mitchell and others. 1984).

Recommended Future Study Areas

Introduction

Site specific studies of the economic potential for geothermal development were conducted during the period from 1978 to 1982 for several Idaho communities. Most of these investigations show the need for further exploration of the geothermal resources for many areas in Idaho. Areas that should be further investigated are discussed below by county. The Twin Falls area is considered the highest priority for immediate study due to the heavy use of the resource that has caused a significant local water level decline, as well as underutilization of the resource that is withdrawn from the aquifer. Other areas of interest have not been prioritized.

Ada County (Boise area)

An extensive review of data and evaluation of the Boise Geothermal Aquifer was conducted by the Berkeley Group (1990) under contract to the Idaho Department of Water Resources. The Berkeley Group evaluated an area extending from approximately 2.4 km (1.5 mi) southeast of the State Capitol building to 0.8 km (0.5 mi) northwest along the Boise Front. Pressure and temperature response modeling was conducted. The report concluded that: 1) geothermal production wells along the Boise Front Fault communicate readily and 2) interference occurs between production wells and affects water levels along the fault in general. Further hydrologic, geophysical and geochemical investigations are needed to predict the effects of development on the geothermal aquifer and its longevity.

The report outlined needed monitoring and recommended methods for further investigation. Locations of slim hole observation wells were proposed, along with identification of existing wells for temperature and water level monitoring. Recommendation of a long-term flow test was also made, along with installation of accurate total flow devices on selected production wells. Regular geochemical sampling of major pumping wells and tracer testing of injection wells was also suggested. Details of the proposed follow-up studies are contained in the report (Berkeley Group, 1990).

Bannock County (Pocatello-Tyhee and Lava Hot Springs areas)

Corbett and others (1980) believed that warm water suitable for space heating may be available in the Tyhee area if structures controlling thermal water movement can be identified at depth. Highest estimate of subsurface temperature at drillable depth is 80°C (176°F); a low of 41°C (105.8°F) is represented by surface discharge in the area.

Additional data collection is necessary before a realistic assessment of the geothermal resource can be made. Corbett and others (1980) recommended the following additional studies:

1) Flow tests on the known warm water wells to determine sustainable yield and well interference potential.

2) Seismic and electrical prospecting to delineate locations of controlling geologic structures.

3) Monitoring holes drilled and aquifer tests conducted to determine aquifer characteristics and well interference potential. Monitoring holes would help better determine structural and stratigraphic controls on thermal and nonthermal water in the area.

4) Hydrogen-deuterium and oxygen 18-oxygen 16 isotope ratios should be determined for both thermal and nonthermal water in the Tyhee area to indicate origin of the thermal waters.

In the Lava Hot Springs area, McClain (1978) described investigations undertaken to determine the feasability of designing a district heating project. Flow potential, temperatures, and low likelihood for interference with existing wells appeared to favor the project. A follow-up investigation in the near future may be warranted.

Boise County (Garden Valley area)

Several greenhouses, resort facilities, and numerous homes use geothermal resources to provide hot water and space heating needs in Boise County, particularly in the Garden Valley-Crouch area, a major developing area for space heating. The combination of relatively high temperatures at shallow depth, moderately productive domestic wells, nearby developments, and a user base make this an attractive area for further investigation. The geothermal reservoir is a fracture-controlled granitic aquifer.

According to Blackwell (1988), the area with the most documented geothermal gradient and heat flow data is just west of Garden Valley along the South Fork of the Payette River. The nature of the geothermal system is still unknown and further studies are needed. There may be significant potential for development of some of these systems for space and/or process heating where nearby developments exist (Blackwell, 1989).

Further detailed study of the geothermal reservoir should be conducted. Well inventory, current water level measurement, and determination of historic water level decline patterns should be carried out. Aquifer tests and heat hole drilling should be conducted to determine potential size of geothermal aquifer and temperature expected. Other aquifer characteristics such as recharge and discharge areas, hydrologic boundaries, and structural controls should be investigated.

Camas County (Camas Prairie area)

The Camas Prairie, especially the Magic Reservoir area, has above average geothermal potential. Temperatures are certainly in the range of 30-40°C (86-104°F) at depths of 300± m (984±) and may be high enough for commercial electric power production in the most favorable case. High gradients are also indicated along the north and south edges of the Mount Bennett Hills (Blackwell, 1989).

The three areas around Fairfield discussed by McClain and others (1979) that appear to offer excellent geothermal exploration targets should be considered for future study. These include: the area around Barron's Hot Springs, on the downdip (east) side of the fault, which appears to be an excellent area for both shallow and deep exploration; the area south of Fairfield, also rated excellent for shallow exploration; and the area along the downdip (east) side of the N-S trending inferred fault passing just to the east of Fairfield, rated very good for deep exploration. Fairly deep geothermal exploration wells must be drilled into fault zones in order to encounter permeable zones that will result in maximum production and temperature. Geophysical (electromagnetic VLF radio and earth magnetic) surveys recommended by McClain and others (1979) should be conducted to pinpoint the existence and attitude of faults in the valley that extend down into the granitic basement. Based on funding available, some follow-up characterization of the geothermal resource in the area is likely warranted.

Canyon County (Nampa-Caldwell area)

Numerous warm water wells and favorable geologic conditions indicate that the Nampa area has good potential for using geothermal energy in direct applications. Many existing warm water wells are in the 24°C to 38°C (75°F to 100°F) temperature range.

Nampa is an agricultural service center 28.8 km (18 mi) west of Boise with a population of about 25,000 people. The combination of a thermal water resource matched with a community of considerable size makes this an attractive area for geothermal energy development in the future.

The rock units in the Nampa area are composed of basalt of Miocene to early Pliocene age. Several widespread sandstone aquifers overlie the basalt units. These sandstone aquifers are projected to yield good flows of 30°C (86°F) to 60°C (140°F) water from depths of 305 to 670 m (1,000 to 2,200 ft). The sandstone aquifers are better targets than the basalt because of greater anticipated permeability (Dellinger and others, 1982).

The Idaho Department of Water Resources (IDWR) conducted an integrated geological, hydrological, geochemical and geophysical survey for the purpose of evaluating the geothermal potential of the Nampa-Caldwell area (Mitchell, 1981). The area studied by the IDWR included approximately 925 km^2 (357 mi^2) of the Nampa-Caldwell portion of Canyon County. Geologic mapping, hydrologic, geochemical, and geophysical surveys were run. In addition, existing magnetotelluric and reflection seismic data were purchased and incorporated into the investigation. Their recommendations for resource definition and development are outlined below.

1) Investigations of effects of widespread artificial aquifer communication by well drilling on the thermal permeable zones and their use as a heat source should be conducted.

2) Should large scale development take place, it would be advisable to establish a geochemical sampling program whereby quarterly or even monthly samples are obtained from production zones. Such information has been utilized in high temperature fields for early detection of impending production changes (volume, temperature, fluid characteristics) in geothermal wells.

3) Thief sampling of water from permeable zones, isolated by packers to prevent mixing within the well bore of the Richardson No. 1 well should be made to determine deep water isotope and geochemical characteristics.

4) Investigations to delineate possible recharge of the thermal aquifers should be undertaken to determine if recharge is presently occurring. These could include further stable isotope work in suspected recharge areas in the mountains on both sides of the SRP, tritium age dating, dating using 12C, 13C, and 14C and inert gas methods to determine absolute age of thermal water from various thermal aquifers.

5) More work is needed to determine clay layer semi-permeable membrane effects on the stable isotope ratios in the Nampa-Caldwell area.

6) Monitoring of potentiometric surfaces to detect stress effects in the aquifers and permeable zones would provide early warning of water level declines should these take place due to increased pumpage from geothermal development.

7) Stable isotope data should be incorporated as standard water quality data in other areal investigations where deemed appropriate. Stable isotope studies should be integrated in any groundwater study of the Boise front geothermal system.

8) Seismic risks associated with possible large scale dewatering of the geothermal system should be assessed. A seismic net (3 stations) should be set up in the Nampa-Caldwell area and another along the Boise front area to obtain background data before large scale withdrawal of geothermal water begins, and should be continued after production begins.

9) Detailed petrographic and geochemical studies of well cuttings from deep wells with comparisons to outcrops in and around the western SRP should be made for correlation purposes.

10) More geophysical data within the western SRP should be purchased and interpreted to help determine the boundaries of the geothermal system(s).

11) More detailed geologic mapping, particularly on the northern margin of the western SRP is needed to unravel the stratigraphy and correlate units. A better understanding of the geology, hydrology and geochemistry of groundwaters in and near the plain will greatly expand geologists' ability to locate and evaluate areas of geothermal potential in this region.

Caribou County (Greys Lake and Blackfoot Reservoir area)

According to Blackwell and others (1992), there is a very large area of elevated geothermal gradient in the vicinity of Grey's Lake and Blackfoot Reservoir. The Gray's Lake/Soda Lake area heat flow in deep wells ranges from 50 to 120 mWm^{-2}. The area has been thought to have significant geothermal potential from the geologic setting alone (Leeman, 1985). Gradients in this area are distinctly anomalous with respect to those elsewhere in the southeastern Idaho Basin and Range province. This vicinity is sparsely populated, but temperatures reported in oil wells suggest this area may have temperatures sufficient for electricity generation at depth. Extremely young rhyolitic rocks and structures exist in the vicinity and the geologic framework favors the possibility of a high-temperature reservoir at depths greater than 2 km (1.25 mi); exploration for this resource will be expensive. However, Caribou County presents a unique opportunity for low temperature resource prospecting by drilling into fault zones associated with travertine deposits (Mitchell, 1976). Detailed delineation of these fault zones combined with limited shallow test drilling should be conducted to evaluate this resource.

Fremont County (Island Park area)

The Island Park geothermal reservoir is at present off-limits to drilling activities due to an unsubstantiated fear that development of the aquifer will endanger geothermal features at Yellowstone Park. However, deep drilling is necessary to substantiate the interpretation postulated by Hoover and others (1985) that the Island Park area is underlain by a solidified but still hot pluton that represents a significant hot dry rock resource. Deep drilling would also provide needed heat-flow data.

The Island Park-Yellowstone National Park region comprises a complex caldera system which has formed over the last 2 million years. The caldera system has been estimated to contain 50% of the total thermal energy remaining in all young igneous systems in the United States. The Island Park System contributes 32% of the total thermal energy remaining in the complex. The Island Park system, alone, contains twice as much energy as the next largest system, the Valles caldera in New Mexico. These considerations make the Island Park region an excellent site for geothermal exploration, yet there is essentially no activity in the region today. Although development is not permitted within Yellowstone National Park, neither exploration nor development is progressing in the caldera complex outside the park. Environmental concerns have in part caused this, but the lack of surface thermal manifestations and the lack of evidence for hydrothermal systems within the Island Park part of the caldera complex are also responsible.

Lemhi County (Big Creek Hot Springs)

An evaluation of Big Creek Hot Springs as a source of electrical power for the Blackbird Cobalt Mine was conducted (Struhsacker, 1981). Big Creek Hot Springs is one of the hottest known geothermal systems in Idaho, with a surface temperature of 93°C (199°F). Geothermometer estimates of reservoir temperature range from 137°C to 179°C (279°F to 354°F). It was concluded that Big Creek Hot Springs is an excellent geothermal prospect. A suggested exploration program, engineering and economic analyses, and appraisal of institutional factors was outlined.

Big Creek Hot Springs is located approximately 20.8 km (13 mi) north of the Blackbird Mine. Reservoir rocks are likely competent Precambrian metamorphic and metasedimentary rocks, with fractures serving as hot water conduits. The system consists of a linear set of spring vents trending N40-45W that intersect Hot Springs fault. The heat source is probably deep circulation of meteoric water. There may be potential for buried thermal anomalies along the entire length of Hot Springs fault.

Several institutional factors complicate the development potential of Big Creek Hot Springs; it lies on Forest Service land and is near the River of No Return Wilderness Area. The distance from population centers precludes development at present of electrical generation potential.

The engineering feasibility study modeled an 11 MWe binary power plant, utilizing propane (95%) and hexane (5%) as the mixed working fluid. It was determined a power plant could be located along Panther Creek; power would be transmitted 20.8 km (13 mi) to where it would tie into the Idaho power grid that services the town of Cobalt (Struhsacker, 1981).

Follow-up studies suggested by Struhsacker (1981) include:

1) Thermal gradient measurements in existing accessible water or exploration wells and mineral exploration holes; local gradient is unknown.

2) Mapping to define the nature of the Hot Springs Fault and to determine the role the fault plays in controlling the geothermal system.

3) Shallow (49 to 160 m [160 to 525 ft]) temperature gradient hole drilling.

4) Resistivity survey to identify buried structures and low resistivity zones that may correspond with the presence of warm water and hydrothermal alteration.

5) After completion of work listed above, target modeling would indicate if further, more detailed work was merited. Work would include detailed prospect mapping, deeper drilling, and flow testing.

Twin Falls County (Twin Falls area)

The Twin Falls area should be given the highest priority for additional geothermal assessment, exploration and development because of the potential size and temperature of the geothermal reservoir, the close proximity to the population center of Twin Falls, and the recent decline of water levels in several wells being used for space heating, including the geothermal space heating system of the College of Southern Idaho. Recently the college had to install pumps in their wells to maintain adequate flow for their system. Other users have also expressed concern about pressure decline in the thermal system.

Although several investigations have focused on the Twin Falls area, the source of the heat component of the Twin Falls system is not clear and the relationship of the Twin Falls and Banbury systems is poorly understood. Lewis and Young (1989) estimated that the reservoir is approximately 1000 km^3 (240 mi^3) with temperatures of 70-80°C (158-176°F). Additional studies should be conducted to assess the Twin Falls geothermal system. These studies should be conducted to: 1) compile existing geologic, hydrologic and geothermal information from local, state and federal sources; 2) develop a conceptual model of the reservoir which could be used as the basis for future numerical modeling; and 3) provide information for resource management decisions.

Summary

This report summarizes investigations of geothermal resources of Idaho that have been conducted since the compilation by the Idaho Department of Water Resources in 1980 (Mitchell and others, 1980). The DBase file accompanying this report contains data for all geothermal wells and springs we have been able to identify in Idaho with temperatures above 20°C (68°F). Data sources include past compilations along with more recently published reports and unpublished documents.

With over 1500 individual thermal wells and springs, Idaho has a significant potential for further geothermal resource development. Because most thermal sites are relatively low temperature, development of the resource for additional space heating and other low-temperature uses appears promising. Several areas are recommended for further study, including the Boise, Nampa-Caldwell, Twin Falls, Pocatello, Garden Valley and Camas Prairie areas. Of these, the Twin Falls area should be given the highest priority.

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Appendix A

List of Thermal Wells and Springs

Record#	NAME	CO	ID	TWN	RNG	SEC	SUB	TEMP_C
1	Lillie Collias Well	01	1	01N	01E	01	ADC1	26
2	E. L. Hennis well	01	2	01N	01E	01	DAD	25
3	Agri-Con of Idaho well #1	01	3	01N	01E	23	CDA1	24
4	Agri-Con of Idaho well #2	01	4	01N	01E	25	BDC1	24
5	Nicholson well #1	01	5	01N	01E	25	CAA1	23
6		01	6	01N	01E	25	DBA1	25
7	Agri-Con well #3	01	7	01N	01E	26	ADD1	25
8	Betty Deshazo well	01	8	01N	01E	33	AAD1	24
9	Agri-Con of Idaho well #4	01	9	01N	01E	35	BAA1	23
10	Floyd Edwards well	01	10	01N	01E	35	BBB1	22
11	Agri-Con of Idaho well #5	01	11	01N	01E	36	AAD1	24
12	Jerry Davis Well #1 ?	01	12	01N	01W	07	ACC1	21
13	Clayton Forsgren well	01	13	01N	01W	07	BCC1	21
14	Jerry Davis well #2	01	14	01N	01W	07	CBA1	21
15		01	15	01N	01W	08	BBB1	20
16	Irvin Boehlke well #1	01	16	01N	01W	08	DBA1	22
17	Herb Montierth well	01	17	01N	01W	15	BDC1	21
18	Herb Montierth well	01	18	01N	01W	15	BDD1	21
19	Shane Bues well	01	19	01N	01W	15	DAA1	21
20	Irvin Boehlke well #2	01	20	01N	01W	17	ACA1	22
21	Irvin Boehlke well #3	01	21	01N	01W	17	CAB1	22
22	Lloyd Noe well	01	22	01N	01W	19	DDB1	21
23	Terry Tlucek well #1	01	23	01N	01W	22	CAC1	21
24	Terry Tlucek well #2	01	24	01N	01W	22	DDD1	27
25	Herb Montierth well	01	25	01N	01W	24	AAD1	24
26	Terry Tlucek well #3	01	26	01N	01W	27	BBB1	23
27	Lloyd Noe well #2	01	27	01N	01W	30	ADA1	22
28	Lloyd Noe well #3	01	28	01N	01W	31	CAD1	24
29	C. J. Stewart well	01	29	01N	02E	06	AAA1	32
30	IDU Land and Beef well	01	30	01N	02E	06	ABA1	24
31		01	31	01N	02E	06	ABA2	25.5
32	Mike Vandenberg Well ?	01	32	01N	04E	32	AAB1	24
33	Nicholson well #2	01	33	01N	01E	25	DBA	25
34	Harry Charters Well ?	01	34	01S	01W	05	BAC1	23.5
35		01	35	01S	01W	30	AAB1	23.5
36	Initial Butte Farm well	01	36	01S	01W	36	BBC1	23
37	John Cooknell well	01	37	02N	01E	21	DDA1	23
38	Tom Bevans well	01	38	02N	01E	22	DDB1	24
39	Niles Clark well	01	39	02N	01E	23	BAC1	24
40	David Neal well	01	40	02N	01E	23	CAB1	25
41		01	41	02N	01E	23	DDA	24
42	Kuna East Water Corp.	01	42	02N	01E	24	CBA1	24
43	George Whitmore well	01	43	02N	01E	24	DAD1	27
44	Charles Bair well	01	44	02N	01E	26	ABA1	27
45	Desert View Estates	01	45	02N	01E	27	ADA1	24
46	Ed Johnson well	01	46	02N	01E	35	BCD1	23
47		01	47	02N	01W	27	BCC1	20
48	Kenneth Forrey Well #1 ?	01	48	02N	01W	34	CCD1	25
49	Kenneth Forrey well #2	01	49	02N	01W	34	DAD1	20
50	Sam Gabiola well #1	01	50	02N	01W	35	CAA1	25
51	Sam Gabiola well #2	01	51	02N	01W	35	DDA1	22
52	Ronald Yanke well	01	52	02N	02E	19	AAD1	27
53	State Prison well #2	01	53	02N	02E	27	CCC1	24
54	State Prison well #1	01	54	02N	02E	27	DBD1	23
55	LDS Stake Farm well #1	01	55	02N	02E	29	AAD1	25
56	LDS Stake Farm well #2	01	56	02N	02E	29	AAD2	25
57	IDU Land and Beef well #1	01	57	02N	02E	31	CDC1	26
58	IDU Land and Beef well #2	01	58	02N	02E	31	DCA1	30

59	David Weiss well	01	59	02N	02E	33	CDC1	25
60		01	60	02N	02E	34	CCD1	22.5
61		01	61	02N	03E	07	BBD	26
62	Warren Tozer well	01	62	02N	03E	10	BCB1	20
63		01	63	02N	03E	28	CAC1	22
64	State Transport Dept. Well ?	01	64	02N	03E	28	CAD1	22.5
65	Mel Brown well	01	65	02S	01E	20	ABA1	27
66		01	66	02S	02W	18	BBB	27
67		01	67	03N	01E	03	ADC1	20.5
68	Bischof Realty	01	68	03N	01W	25	ADD1	21
69		01	69	03N	02E	02	BBAA1	26
70		01	70	03N	02E	02	CBC	60
71	Ferd Koch well	01	71	03N	02E	02	CBD1	50
72		01	72	03N	02E	02	CBDB1	39
73		01	73	03N	02E	02	CDCD	71
74	BSU well #1	01	74	03N	02E	02	DBD1	28
75	Garden City well	01	75	03N	02E	05	DCA1	20
76	Capitol Mall-2 (production)	01	76	03N	02E	10	AABB1	67.5
77	Idaho State Capitol well	01	77	03N	02E	10	ABA1	40
78	Old Boise Hotel well	01	78	03N	02E	10	ABB1	44
79	Clark Magstadt well	01	79	03N	02E	10	BDC1	24
80	Boise Geothermal-2	01	80	03N	02E	11	ABBC1	76
81	Beard well	01	81	03N	02E	11	ABC1	74
82	Boise Geothermal-4	01	82	03N	02E	11	ABCB2	79.5
83	Boise Geothermal-3	01	83	03N	02E	11	BAAA1	71.5
84	BSU Well #2	01	84	03N	02E	11	BAB1	78
85	BSU well #3	01	85	03N	02E	11	BAC1	74
86	Boise City Park well	01	86	03N	02E	11	BBD1	90
87	Boise City Well?	01	87	03N	02E	11	BBDD1	25
88	Ann Sparks well	01	88	03N	02E	12	BDD1	21
89	BSU well #4	01	89	03N	02E	12	CBB1	35
90	Warm Springs Water District	01	90	03N	02E	12	CDDD1	79
91	Warm Springs Water District 2	01	91	03N	02E	12	CDDD2	78
92	Old Penitentiary well #1	01	92	03N	02E	13	AAC1	28
93	Old Penitentiary well #2	01	93	03N	02E	13	ACD1	59
94		01	94	03N	02E	13	BABA1	51
95		01	95	03N	02E	21	AAB1	20.5
96	Warm Springs Mesa Subdivision	01	96	03N	02E	24	ACAD1	28.5
97	Boise Water Corp. well	01	97	03N	02E	36	ABC1	22
98		01	98	03N	03E	20	BDD	82
99	Dallas Harris well	01	99	03N	03E	20	CAB1	56
100		01	100	03N	03E	31	BDD1	21.5
101		01	101	03N	03E	32	CDD	23
102	Mores Creek H.S.	01	102	03N	04E	21	BAB1s	
103	Thomas Flat W.S.	01	103	03S	01E	15	CAA1s	24
104		01	104	03S	02W	13	ACC	77
105		01	105	04N	01E	10	AAA1	61
106		01	106	04N	01E	10	AAB	26
107	Dennis Flake well	01	107	04N	01E	24	DCC1	28
108		01	108	04N	01E	25	BCC1	27.5
109	Idaho Dept. of Trans.	01	109	04N	01E	25	CDA1	24
110		01	110	04N	01E	34	CAC	24
111	J.N. James #1	01	111	04N	01W	27	CCC	174.4
112	Carl Rush well	01	112	04N	02E	04	BDC1	30
113	Lillian Barnes well #1	01	113	04N	02E	08	DCC1	41
114		01	114	04N	02E	09	CD	24
115		01	115	04N	02E	17	ADC	23
116	Lillian Barnes well #2	01	116	04N	02E	17	CBA1	32
117		01	117	04N	02E	17	CBB1	24.5
118	E. Van Hendricks well	01	118	04N	02E	17	CDA1	20

119	William Galloway well	01	119	04N	02E	19	AAB1	25
120	Ethel Ficks well	01	120	04N	02E	19	AAC1	21
121	Ed Genther well	01	121	04N	02E	19	AAC2	26
122	Jess Donaho well	01	122	04N	02E	21	CCA1	36
123	Terteling H.S.	01	123	04N	02E	22	BBA1s	41
124	Joe Terteling well #1	01	124	04N	02E	22	BCB1	24
125	Joe Terteling Well #2	01	125	04N	02E	22	BCDA1	43.5
126	Joe Terteling well #3	01	126	04N	02E	22	CBB1	43
127	Crane Creek Golf Course	01	127	04N	02E	26	CCC1	20
128		01	128	04N	02E	27	ABC	26
129	Cartwright Water Dist. #1	01	129	04N	02E	27	DBA1	32
130	Cartwright Water Dist. #2	01	130	04N	02E	27	DBA2	32
131	Cartwright Water Dist. #3	01	131	04N	02E	27	DBA3	32
132	Vic Nibbler Well?	01	132	04N	02E	28	ABAD1	44.5
133	Vic Nibbler Well	01	133	04N	02E	28	ABBD1	35.5
134	Hunt Brothers Floral #1	01	134	04N	02E	28	CBBB1	41.5
135	Ryan well	01	135	04N	02E	29	ACB1	46
136	Wayne Church well #1	01	136	04N	02E	29	ACD2	39
137	Wayne Church well #2	01	137	04N	02E	29	ACD3	21
138	Edwards Greenhouse Well	01	138	04N	02E	29	ACDB1	47.5
139		01	139	04N	02E	29	ADCC1	45.5
140		01	140	04N	02E	29	BADD1	46.5
141	Hunt Brothers Floral #2	01	141	04N	02E	29	DAA1	45
142	Hunt Brothers Floral #3	01	142	04N	02E	29	DAA2	43
143	Idaho Dept. of Trans. well	01	143	04N	02E	33	CCC1	20
144	Richard Smith well	01	144	04N	02E	34	CAA1	21
145		01	145	04N	02E	35	CB	30
146	John Boehm well	01	146	05N	01E	25	ACB1	20
147	Shadow Valley well	01	147	05N	01E	25	BCC1	28
148	Don Swanson well	01	148	05N	01E	25	CBC1	21
149	John Ferguson well	01	149	05N	01E	25	CCB1	25
150	D. McArthur well	01	150	05N	01E	26	CDC1	20
151	Ben Stadler well	01	151	05N	01E	26	DCD1	30
152	John Burgess well	01	152	05N	01E	29	DAA1	22
153	Julius Jeker Well #1	01	153	05N	01E	35	ACA1	41.5
154	Julius Jeker well #2 ,	01	154	05N	01E	36	BDB1	24
155	Clifford Smith well	01	155	05N	01W	08	ADC1	28
156	Dee Rachilla well	01	156	05N	01W	08	ADD1	21
157	David Traylor well	01	157	05N	01W	09	CAD1	20
158	Bill Leach well	01	158	05N	01W	09	CDD1	29
159	Letha Fisher Well	01	159	05N	01W	16	CAB1	21
160	D.J. Gancheff Well	03	1	14N	01W	33	ACA	31
161	Coyote Spring	03	2	14N	01W	33	BCCs	43.5
162	Council Mountain H.S.	03	3	15N	01E	02	BDD1s	68
163	Crab and Thompson well	03	4	16N	01W	11	ACD1	22
164	Bill Kampeter well	03	5	16N	01W	15	BAC1	22
165	White Licks H.S.	03	6	16N	02E	33	BCC1s	70.5
166	Starkey H.S.	03	7	18N	01W	34	DBB1s	55
167	Krigbaum H.S.	03	8	19N	02E	22	CCA1S	43
168	Dixon H.S.	03	9	20N	01E	25	CCA1s	63
169	Del Geddes well	03	10	20N	01E	25	CCC1	70
170	Geddes H.S.	03	11	20N	01E	25	CCC1s	68
171		03	12	20N	01E	25	CCD	68
172		03	13	20N	01E	26	ACD	44
173	Evans H.S.	03	14	20N	01E	26	DAD1s	60
174		03	15	20N	01E	26	DDA	71
175	Zims H.S.	03	16	20N	01E	26	DDB1s	64
176		03	17	20N	01E	26	DDD	43
177		03	18	20N	01E	36	BBC	21
178	Stinky W.S.	03	19	21N	01E	23	ABA1s	30

179		03	20	21N	01E	23	ABD1s	30
180		03	21	22N	01E	34	DAC1s	26
181	Boulder Creek Resort	03	22	22N	01E	34	DAD1s	27
182	Gerald Johnson well	05	1	05S	34E	25	CBB1	27
183	Robert Brown Well	05	2	05S	34E	26	DAB	41
184	Shoal Subdivision Well	05	3	05S	34E	26	DBA1	26
185		05	4	05S	34E	26	DBA2	40.5
186	Bert Huth Well	05	5	05S	34E	26	DBA3	28
187	Robert Brown well #2	05	6	05S	34E	26	DBD1	41
188	Shoal Subdivision Well	05	7	05S	34E	26	DBD2	25
189	Gwinn Sigmain well	05	8	05S	34E	26	DCC1	29
190	Tadpole W.S.	05	9	05S	34E	27	ADD1s	20
191	Floyd Peterson well	05	10	05S	34E	35	BAA1	20
192	Harry Hardt Well	05	11	06S	34E	01	CDA1	23
193		05	12	07S	38E	34	BDD1s	34
194	Dean Morris well	05	13	09S	36E	03	CDB1	22
195	Lava Hot Spring	05	14	09S	38E	21	DDAs	43
196	Lava H.S.	05	15	09S	38E	22	CCB1s	45
197	Downata Hot Spring	05	16	12S	37E	12	CCDs	43
198	Big Canyon Federal No. 1-13	07	1	10S	43E	13	DCD	161
199	Gentile Valley Spring #1	07	2	11S	40E	05	AAAs	22
200	Gentile Valley Spring #3	07	3	11S	40E	08	DDDs	30
201	Pescadero Warm Spring	07	4	11S	43E	36	BDAs	23
202		07	5	11S	44E	07	CCB1	48
203		07	6	12S	43E	25	DAA1	47
204		07	7	12S	44E	33	DCC1	48.5
205		07	8	13S	43E	16	DCC1	51
206	Jensen No. 21-1	07	9	13S	44E	22	CCD	74
207		07	10	14S	43E	35	BBA1	48
208		07	11	14S	44E	12	CCC1	56
209	Bear Lake Hot Spring #3	07	12	15S	44E	12	CCDs	33
210	Bear Lake Hot Spring #2	07	13	15S	44E	13	CBAs	39
211	Bear Lake Hot Spring #1	07	14	15S	44E	13	CCAs	40
212	N.Eden Federal 8214'-8469'Int	07	15	16S	45E	21	AA?	92
213	North Eden Federal No. 22-11	07	15	16S	45E	21	BBC	92
214	North Rabbit Creek Federal6-21	07	16	16S	46E	06	BBA	80
215	Grace Federal No. 10-1	07	17	16S	46E	10	BC	83
216	King No. 2-1	11	1	02S	41E	02	ACA	210
217	2-1 King, 11375'-11519'Int.	11	1	02S	41E	02	BC	160
218	2-1 King, 12830'-12884' Int.	11	1	02S	41E	02	BC	249
219	2-1 King, 8550'-8660' Interval	11	1	02S	41E	02	BC	116
220		11	2	03S	35E	13	AAA1	20
221	Yandell Springs	11	3	03S	37E	31	DBBs	32
222		11	4	04S	35E	12	BDD1	20
223	Alkali Flats W.S.	11	5	04S	38E	28	DDDs	34
224	Queedup Springs	11	6	04S	38E	32	DDBs	20
225	Shoal Subdivision Well	11	7	05S	34E	26	DBA	26
226	Dean Morris Well	11	8	09S	36E	03	CDB	22
227	near Magic Hot Springs	13	1	01S	17E	23	AAA	37
228	Magic Hot Springs Well	13	2	01S	17E	23	AAB1	74.5
229	Magic Reservoir H.S.	13	3	01S	17E	23	AAB1s	20
230	Magic Reservoir (H.S.?)	13	3	01S	17E	23	AABs	72 ?
231	UMR-13	13	4	01S	17E	24	ACA	24.5
232	Charles Larkin Well	13	5	01S	20E	16	DCA1	37.5
233	Condie H.S.	13	6	01S	21E	14	DDD1s	52
234	Milford Sweat H.S.	13	7	01S	22E	01	DAD1s	42
235	Rush W.S.	13	8	01S	22E	06	DBA1s	22
236	Hailey Well 1	13	9	02N	18E	18	DBB1	73
237	Hailey H.S.	13	10	02N	18E	18	DBB1s	60
238	Hailey Well 2	13	11	02N	18E	18	DBB2	55

239	UMR-8	13	12	02S	18E	08	ACC	20
240	Clarendon H.S.	13	13	03N	17E	27	DCB1s	50
241		13	14	04N	16E	31	BBD	21
242	USGS OR Warfield H.S.?	13	15	04N	16E	36	ACC1s	58.5
243	Grayhawk Hot Spring	13	16	04N	17E	14	BBCs	55
244	Guyer H.S.	13	17	04N	17E	15	AAC1s	70.5
245		13	18	04N	17E	15	ABC	42
246	Warfield H.S.	13	19	04N	17E	31	BBC1s	52
247		13	20	04N	18E	32	CCA	21
248		13	21	04N	18E	32	CCC	21
249	Easley H.S.	13	22	05N	16E	10	DBC1s	37.5
250	Russian John H.S.	13	23	06N	16E	33	CCA1s	34
251	Twin Springs	15	1	04N	06E	24	BCB1s	67
252	Stope W.S.	15	2	06N	05E	33	ABC1s	40.5
253	Idaho City W.S.	15	3	06N	05E	33	ADC1s	42
254	Danskin Creek H.S.	15	4	08N	05E	01	BCC1s	41
255	Hot Springs Campground	15	5	08N	05E	06	DCB1s	45
256	Goller H.S.	15	6	08N	05E	06	DCC1s	51
257	Corder H.S.	15	7	08N	05E	10	ADD1s	55
258	Donlay Ranch H.S.	15	8	08N	05E	10	BDD1s	55
259	Grimes Pass H.S.	15	9	08N	05E	10	DAA1s	48
260	Dan Hodges H.S.	15	10	08N	05E	11	ABB1s	60
261		15	11	08N	05E	11	BAA1s	60
262		15	12	08N	05E	11	BAC1s	56.5
263	Pine Flat W.S.	15	13	08N	06E	01	ADA1s	35
264	Pine Flat H.S.	15	14	08N	06E	01	ADB1s	59
265	Deer H.S.	15	15	09N	03E	25	BAC1s	81
266		15	16	09N	03E	28	CBD1	22.5
267		15	17	09N	04E	15	BDB	26
268		15	18	09N	07E	35	AAA1s	37
269	Haven Lodge H.S.	15	19	09N	08E	31	AAC1s	64
270		15	20	09N	08E	31	ACA1s	63.5
271		15	21	09N	08E	32	ACC	35
272	Kirkham H.S.	15	22	09N	08E	32	CAB1s	65
273		15	23	09N	08E	32	CBB1	27
274		15	24	09N	08E	32	CBB2	31
275		15	25	09N	09E	22	DCB1s	54
276		15	26	10N	04E	32	ADD	60
277		15	27	10N	04E	32	DAC	82
278		15	28	10N	04E	32	DCA	79
279		15	29	10N	04E	32	DCB1	83
280		15	30	10N	04E	32	DCB2	84
281		15	31	10N	04E	32	DDD	82
282		15	32	10N	04E	33	BCC	63
283		15	33	10N	04E	33	CAA	67
284		15	34	10N	04E	33	CAB1	46
285		15	35	10N	04E	33	CAB2	66
286		15	36	10N	04E	33	CAB3	64
287		15	37	10N	04E	33	CAC1	54
288		15	38	10N	04E	33	CAC2	66
289		15	39	10N	04E	33	CAD1	66
290		15	40	10N	04E	33	CAD2	82
291		15	41	10N	04E	33	CAD3	71
292		15	42	10N	04E	33	CBB1	82
293		15	43	10N	04E	33	CBB2	77
294		15	44	10N	04E	33	CBD	64
295	Warm Springs Crk. H.S.	15	45	10N	04E	33	CBD1s	75
296		15	46	10N	04E	33	CCA	72
297		15	47	10N	04E	33	CCD1	71
298		15	48	10N	04E	33	CCD2	73

299		15	49	10N	04E	33	CCD3	77
300		15	50	10N	04E	33	CDD	35
301		15	51	10N	04E	33	DBB	46
302		15	52	10N	04E	33	DBC	59
303		15	53	10N	04E	33	DCD	54
304	Bonneville H.S.	15	54	10N	10E	31	BCC1s	85
305	Sacajawea H.S.	15	55	10N	11E	31	AAD1s	67
306	Grandjean H.S.	15	56	10N	11E	32	BAD1s	
307	Fall Creek Mineral Spring (3)	19	1	01N	43E	08	DCD1s	25
308	Fall Creek Mineral Spring (1)	19	2	01N	43E	09	CBB1s	24
309	Fall Creek Mineral Spring (2)	19	3	01N	43E	09	CBB2s	23
310	Unnamed Spring	19	4	01S	40E	04	ABCs	21
311	Dyer Well	19	5	02N	39E	21	BCCs	21
312	Anderson Well	19	6	02N	39E	29	BAC	20
313	Richard Piggot well	19	7	02N	39E	30	ADC1	20
314	MSPNRCNY	19	8	02N	44E	04	DC	112
315	GRNDVLLY	19	9	02N	44E	20	BC	140
316	Brockman Hot Spring	19	10	02S	42E	26	DCD1s	35
317	Brockman Creek W.S.	19	11	02S	42E	26	DCD2s	35
318	Big Elk Mountain No. 1	19	12	02S	44E	23	DB	103
319	Alpine Hot Springs	19	13	02S	46E	19	CADs	37
320	Stinking Spring	19	14	03N	41E	10	BBBs	20
321	Unnamed Hot Springs	19	15	03N	41E	32	BBDs	23
322	Taylor Warm Spring	19	16	03N	44E	07	AAs	21
323	Black Mountain Federal No. 1	19	17	03S	44E	36	CC	100
324	13550'-13703' Int. Blk Mtn Fed	19	17	03S	45E	36	CC	65
325	GENVA1-9	19	18	04S	42E	09	AAC	185
326		19	19	04S	43E	25	BBB1	21
327	Bald Mtn 2	19	20	04S	45E	06		148
328		23	1	02N	30E	35	DAD1	30
329	Champaign	23	2	03N	24E	11	CDD	36
330	Lewis Rothwell well	23	3	03N	25E	32	CDC1	43
331		23	4	03N	25E	32	CDD1	41
332		23	5	03N	27E	09	AAA1	20
333	Harvey Walker well	23	6	03N	27E	09	AAB1	40
334	Butte City well	23	7	03N	27E	09	ABB1	35
335	Butte City Well	23	8	03N	27E	09	ABB2	33
336	Richardson	23	9	03N	27E	09	BAA	49
337		23	10	03N	27E	09	DAB1	37.5
338	INEL WO-2	23	11	03N	30E	16	DDD	72
339	Wardrop H.S.	25	1	01N	13E	32	ABB1s	65
340	Hot Springs Ranch (Wardrop HS)	25	2	01N	13E	32	ABC1s	60
341	Hot Springs Ranch (Wardrop HS)	25	3	01N	13E	32	ABC2s	66.7
342	Hot Springs Ranch (Wardrop HS)	25	4	01N	13E	32	ABC3s	63.9
343	Elk Creek H.S.	25	5	01N	15E	14	ADA1s	54
344	Elk Creek Hot Springs	25	6	01N	15E	14	ADA2s	55
345	Elk Creek Hot Springs	25	7	01N	15E	14	ADA3s	45
346	Sheep Hot Springs	25	8	01S	12E	16	CAB1s	48.9
347	Wolf Hot Springs	25	9	01S	12E	16	CBA1s	45
348	Kieth Strom well	25	10	01S	12E	31	CBC1	25
349	Lee Barron Well #1	25	11	01S	13E	22	CCC1	26.1
350	Sun Valley Ranches well	25	12	01S	13E	22	DCC1	25
351	Lee Barron Well #2	25	13	01S	13E	27	CCB1	35
352	Lee Barron Well #3	25	14	01S	13E	27	CCB2	45
353		25	15	01S	13E	27	DAA1	20
354	Barron's Hot Springs	25	16	01S	13E	34	BCB1s	72.8
355	Lee Barron well #4	25	17	01S	13E	34	BCC1	72
356	Barron Hot Spring	25	18	01S	13E	34	BCC1s	69
357		25	19	01S	14E	09	DAA1	21
358	Fairfield City well	25	20	01S	14E	09	DBA1	21

359		25	21	01S	14E	19	DAA1	21.5
360	UMR-12	25	22	01S	17E	23	BDC	44
361	UMR-10	25	23	01S	17E	26	DBC	24
362	Mormon Reservoir W.S.	25	24	02S	14E	17	BBB1s	
363	UMR-7	25	25	02S	17E	13	CDC	20
364	Baumgartner H.S.	25	26	03N	12E	07	DCD1s	50
365		25	27	03N	13E	07	DCA1s	56.5
366	Houseman H.S.	25	28	03N	13E	07	DCC1s	67
367	Lightfoot H.S.	25	29	03N	13E	07	DCD1s	62
368	Preis H.S.	25	30	03N	14E	19	DDB1s	41
369	Worswick H.S.	25	31	03N	14E	28	CAD1s	86.5
370		25	32	03N	14E	30	AAA1s	61
371	Big Smokey W.S.	25	33	04N	14E	12	BAA1s	
372	Skillern H.S.	25	34	04N	14E	29	DCC1s	64.5
373		27	1	01N	02W	03	CBB1	20
374		27	2	01N	02W	03	DBB1	20
375		27	3	01N	02W	04	DA1	22
376		27	4	01N	02W	05	ADD1	21.5
377		27	5	01N	02W	05	BBC1	23
378		27	6	01N	02W	05	CAB1	23
379	Leonard Tiegs Well #2 ?	27	7	01N	02W	05	CB1	22
380		27	8	01N	02W	06	ADD1	
381		27	9	01N	02W	06	CAA1	24
382		27	10	01N	02W	07	ADC1	26
383		27	11	01N	02W	08	AB1	23
384		27	12	01N	02W	08	ACB1	21
385	Don Tiegs well #2	27	13	01N	02W	08	ACC1	22
386	Ron Cassidy Well	27	14	01N	02W	09	AAA1	22
387		27	15	01N	02W	09	BBA1	22
388		27	16	01N	02W	09	CCB1	24
389		27	17	01N	02W	10	BA1	21
390	Mark Harker well	27	18	01N	02W	12	ADD1	22
391		27	19	01N	02W	16	CB1	26
392		27	20	01N	02W	17	DA1	22
393		27	21	01N	02W	17	DCC1	21
394	J. Sheral Johnston well	27	22	01N	02W	22	DAD1	21
395	Melba City well	27	23	01N	02W	36	CAA1	24
396		27	24	01N	03W	01	BBC1	21
397		27	25	01N	03W	08	BBA	27
398		27	26	01N	03W	08	DBA	27
399		27	27	01N	03W	08	DDD	26
400		27	28	01N	03W	12	BA1	32
401		27	29	01N	03W	12	BAB1	29
402		27	30	01N	03W	13	AAA1	20
403	M. O. Clements well #1	27	31	01N	03W	13	DAB1	20
404		27	32	01S	02W	17	ABB1	25.5
405	Cleo Swawne well	27	33	01S	02W	17	ACA1	22
406		27	34	02N	02W	04	DCA1	23
407	John Tucker well	27	35	02N	02W	09	BCA1	27
408		27	36	02N	02W	11	DAD	27
409		27	37	02N	02W	16	DAA1	26
410		27	38	02N	02W	21	CBC1	20
411		27	39	02N	02W	27	AAA1	22
412		27	40	02N	02W	27	ABB1	23
413		27	41	02N	02W	27	DAB1	22
414	Dale Getter well	27	42	02N	02W	28	DBB1	20
415		27	43	02N	02W	31	CDD1	24
416		27	44	02N	02W	31	DAD1	22
417		27	45	02N	02W	34	AAC1	29
418		27	46	02N	02W	34	ABC1	51

419		27	47	02N	02W	34	BDA1	48
420	Jay Neider well #1	27	48	02N	02W	34	CAD1	29
421	Jay Neider well #2	27	49	02N	02W	34	CCB1	20
422		27	50	02N	02W	34	CDA1	
423		27	51	02N	02W	34	DAA1	31
424		27	52	02N	02W	34	DAA2	31
425		27	53	02N	03W	08	CDD1	22
426		27	54	02N	03W	11	CBA1	21
427		27	55	02N	03W	15	CDC1	26
428		27	56	02N	03W	22	ACD1	27
429	Canon Farms well #2	27	57	02N	03W	22	BCD1	31
430		27	58	02N	03W	22	BDC1	28
431		27	59	02N	03W	22	CB1	27
432	Cannon Farms well #3	27	60	02N	03W	22	CCD1	28
433	Cannon Farms well #4	27	61	02N	03W	22	DCC1	30
434		27	62	02N	03W	22	DDC1	28
435		27	63	02N	03W	22	DDC2	35
436		27	64	02N	03W	23	ACD1	28
437		27	65	02N	03W	23	CC1	23
438	Cannon Farms well #7	27	66	02N	03W	23	CDC1	20
439		27	67	02N	03W	25	BDA1	26
440		27	68	02N	03W	26	AAC1	25
441		27	69	02N	03W	26	CDC	27
442		27	70	02N	03W	27	BAB1	30
443	Cannon Farms well #9	27	71	02N	03W	27	BBA1	30
444		27	72	02N	03W	34	BDA1	48
445		27	73	02N	03W	34	DB1	27
446		27	74	02N	03W	35	CAA1	28
447	Charles Pentlers well	27	75	02N	03W	35	CBA1	29
448		27	76	03N	02W	10	ABA1	38
449	Idaho State School-Hospital	27	77	03N	02W	14	ADA1	22
450		27	78	03N	02W	17	BCB1	24
451		27	79	03N	02W	22	BCB1	26
452	Nampa City well #2	27	80	03N	02W	23	BCA1	31
453		27	81	03N	02W	23	BCD1	31
454		27	82	03N	02W	27	ADC1	23.5
455		27	83	03N	03W	19	DCB	23
456	Richardson #1 - 650′	27	84	04N	03W	19	ADC1	63.2
457	Simplot Feedlot (Richardson#1)	27	84	04N	03W	19	ADC1	40
458		27	85	04N	03W	21	CDD1	21.5
459	Caldwell Munc. Park	27	86	04N	03W	28	AAB1	29
460		27	87	04N	03W	35	ABC1	20
461	Caldwell City well	27	88	04N	03W	35	ABD1	20
462	George Wright Well	27	89	04N	04W	04	DCC1	21
463	Russel Fivecolt well	27	90	04N	04W	05	DBD1	25
464		27	91	04N	05W	04	DAC1	27
465	Webber State #1	27	92	05N	03W	16	CD	66.7
466	Parma City well #1	27	93	05N	05W	04	DCD1	27
467		27	94	05N	05W	06	CDC	27
468	Parma City well #2	27	95	05N	05W	09	ADB1	20
469		27	96	05N	05W	09	BDB1	21
470	Parma Ice well	27	97	05N	05W	09	CAB1	20
471		27	98	05N	05W	09	CCA1	20
472		27	99	05N	05W	09	CCA2	20
473	Blackfoot River W.S.	29	1	05S	40E	14	BCD1s	26
474	Wilson Lake W.S.	29	2	05S	41E	06	ABB1s	22
475		29	3	05S	43E	24	CBB1	20.5
476	Tincup Mtn	29	4	05S	45E	06	DC	160
477	Blackfoot Reservoir	29	5	06S	41E	01	ADC1s	22
478	Corral Creek Well #3 ?	29	6	06S	41E	19		42

479	Corral Creek well #1	29	7	06S	41E	19	BAA1	42
480		29	8	06S	41E	19	BAA1s	42
481	Corral Creek well #2	29	9	06S	41E	19	BAB1	41
482	Corral Creek well #4	29	10	06S	41E	19	BAD1	36
483	Corral Creek Well #?	29	11	06S	41E	19	BBD	40
484	Lone Tree	29	12	06S	42E	06	ABs	26
485	Warm Spring (Henry W.S. ?)	29	13	06S	42E	08	DBs	23
486	Henry Warm Spring #2	29	14	06S	42E	09	BCs	20
487	IDST-A1	29	15	06S	44E	16	AB	180
488	Portneuf River Warm Spring	29	16	07S	38E	26	CBDs	41
489		29	17	07S	39E	30	AAB1	49
490	SUNHUB-25 (Hubbard #25-1)	29	18	07S	41E	25		70
491		29	19	08S	39E	01	DAD1	54
492		29	20	08S	42E	07	BDA1	48
493		29	21	09S	40E	04	CDD1	53
494		29	22	09S	41E	10	ACA1	51
495		29	23	09S	41E	10	DAC	22
496	Steamboat Spgs, in Soda Pt.Res	29	24	09S	41E	10	DDAs	31
497		29	25	09S	41E	12	AAA1s	26.5
498	Soda Spring Geyser	29	26	09S	41E	12	ADAs	29
499		29	27	09S	41E	12	ADD1s	30
500		29	28	09S	42E	07	BBD	26
501		29	29	10S	40E	14	BBA1	51
502		29	30	10S	40E	36	DCC1	54
503	Federal No. 1-8	29	31	10S	46E	08	BDA	188
504	Federal Elk Valley No. 1	29	32	10S	46E	20	DD	40
505	Amerada T1-W1	29	33	10S	46E	28	BDD	49
506		29	34	11S	41E	30	BDD1	50
507	J. T. Robinson well	31	1	09S	28E	33	DAC1	25
508	Rainbow Ranch well #1	31	2	10S	26E	02	BCB1	37
509	Rainbow Ranch well #2	31	3	10S	26E	02	CBA1	24
510	6-S Ranch Well#1	31	4	11S	25E	11	CCA	60
511	Marsh Creek H.S.	31	5	11S	25E	22	CDC1s	40
512	Marsh Gully H.S.	31	6	11S	25E	22	DAD1s	41
513		31	7	11S	26E	20	DCC1	32
514	Six S Ranch well #2	31	8	11S	26E	20	DDD1	33
515	Crutchfield Land and Cat.	31	9	11S	26E	28	BCB1	37
516	C and Y Ranch well #1	31	10	11S	27E	05	ABA1	28
517	C & Y Ranch Well#2	31	11	11S	27E	05	BAB	29
518	Ruby Farms well	31	12	11S	27E	34	DDB1	23
519	Stoker well	31	13	11S	27E	36	ADA1	24
520		31	14	11S	28E	31	DDD1	24
521	O. M. Johnson well	31	15	11S	28E	34	CDD1	20
522	Galen Meyers well #1	31	16	12S	19E	02	AAD1	35
523	Galen Meyers well #2	31	17	12S	19E	02	ADD1	37
524	Robert Peterson well #1	31	18	12S	19E	02	BBC1	27
525		31	19	12S	19E	02	DAA1	36
526	Robert Peterson well #2	31	20	12S	19E	03	BCC1	27
527	Robert Peterson well #3	31	21	12S	19E	03	BDB1	27
528	Robert Peterson well #4	31	22	12S	19E	03	DBB1	27
529	Creed Concern Inc. #1	31	23	12S	19E	05	CBD1	36
530	Creed Concern Inc. #2	31	24	12S	19E	06	ADD1	37
531	Creed Concern Inc. #3	31	25	12S	19E	06	CAD1	27
532	Clarence Daggner well	31	26	12S	19E	06	CDC1	34
533		31	27	12S	19E	06	CDD1	27
534	Creed Concern Inc. #4	31	28	12S	19E	06	DDD1	38
535	Thurman Willis well	31	29	12S	19E	07	ACA1	34
536		31	30	12S	19E	24	BBA1	43.5
537	K. C. Barlow well	31	31	12S	20E	02	DDD1	24
538	Mountain View Ranch Inc.	31	32	12S	20E	03	CAC1	32

539		31	33	12S	20E	03	CDD1	32
540		31	34	12S	20E	04	BCB1	
541	Joe Savage well	31	35	12S	20E	05	CCB1	23
542		31	36	12S	20E	06	BAC1	40
543	Coiner Brothers well #2	31	37	12S	20E	06	BCC1	37
544	Harold Savage well	31	38	12S	20E	06	DAC1	32
545	Merle Wolverton well	31	39	12S	20E	11	ADC1	28
546		31	40	12S	20E	12	DCC1	27.5
547		31	41	12S	20E	25	BCA1	20.5
548	Gerald Conard well	31	42	12S	21E	01	AAA1	27
549		31	43	12S	21E	10	DCC1	21
550		31	44	12S	21E	11	ADD1	29
551		31	45	12S	21E	14	CCB1	48
552		31	46	12S	21E	19	DCC2	39.5
553		31	47	12S	21E	25	CCC1	25
554		31	48	12S	21E	27	BCC1	23.5
555	Golden Valley well	31	49	12S	21E	27	CCB1	39
556		31	50	12S	21E	28	CCB1	22
557	Simon Baker well #1	31	51	12S	21E	32	CCB1	21
558	Susan Baker well	31	52	12S	21E	34	AAD1	26
559		31	53	12S	22E	03	CCC1	20
560		31	54	12S	22E	06	BBB1	32
561	Anderson Brothers well	31	55	12S	22E	34	ACC1	24
562	Wilford Wrigley well	31	56	12S	23E	12	AAA1	22
563	Vard Chatburn well	31	57	12S	25E	04	BDD1	21
564	K. C. Barlow well	31	58	13S	21E	05	BCC1	23
565		31	59	13S	21E	05	CBC1	24
566	Simon Baker well #2	31	60	13S	21E	06	AAD1	22
567		31	61	13S	21E	08	BDA1	24
568	Lyle Durfee well	31	62	13S	25E	22	BCB1	32
569	Ward Warm Spring	31	63	13S	26E	17	CCDs	21
570	Rice Spring	31	64	13S	26E	17	CDB1s	22
571	Lester Thompson well	31	65	13S	27E	02	ADC1	26
572		31	66	13S	27E	16	ADD1	20
573	Nelson well	31	67	14S	21E	34	AAC1	43
574		31	68	14S	21E	34	ABD1	44.5
575		31	69	14S	21E	34	BDC1	45.5
576	Oakley H.S.	31	70	14S	22E	27	DCB1s	48
577	Sears Spring	31	71	14S	25E	06	BBB1s	29
578	Griffeth-Wight well	31	72	14S	26E	01	BDD1	77
579	Harold Wight well	31	73	14S	26E	01	CDA1	63
580	Harold Ward well #1	31	74	14S	27E	18	CCC1	24
581	Hepworth well	31	75	14S	27E	18	CCD1	27
582	Jack Pierce well	31	76	14S	28E	18	AAA1	21
583	Old Oakley Canal well #1	31	77	15S	21E	04	ACB1	31
584	Old Oakley well #2	31	78	15S	21E	04	ACB2	32
585	Oakley Canal well #1	31	79	15S	21E	13	DAB1	37
586	Oakley Canal well #2	31	80	15S	21E	24	BAA1	27
587	Morris Mitchell well #1	31	81	15S	21E	25	CDA1	41
588		31	82	15S	21E	25	CDC1	46
589		31	83	15S	21E	25	DCB1	42
590		31	84	15S	21E	25	DCC1	44.5
591	Durfee Spring	31	85	15S	24E	22	DAC1s	39
592	Harold Ward well #2	31	86	15S	24E	22	DDB1	32
593	Grape Creek W.S.	31	87	15S	25E	29	CCA1s	22
594	BLM	31	88	15S	25E	29	CDC1	60
595		31	89	15S	25E	29	CDD1	60
596	BLM	31	90	15S	26E	12	ACC1	26
597	RRGP-5B (EG&G Thermal #5 ?)	31	91	15S	26E	22	DDA1	125
598	BLM	31	92	15S	26E	22	DDD1	28

599	Ivan Darrington well #1	31	93	15S	26E	23	AAA1	85
600	RRGE-2	31	94	15S	26E	23	AAA2	
601	Ivan Darrington well #2	31	95	15S	26E	23	ABD1	28
602		31	96	15S	26E	23	BBC1	92.5
603	RRGE-1	31	97	15S	26E	23	CAA	146
604	EG&G Thermal well #4 (RRGP-4?)	31	98	15S	26E	23	CDA1	82
605	Ivan Darrington well #3	31	99	15S	26E	23	DDB1	40
606	Gary Crook well	31	100	15S	26E	23	DDC1	90
607	Ivan Darrington well #4	31	101	15S	26E	23	DDD1	33
608	Lance Udy well	31	102	15S	26E	24	BAD1	32
609	Reid Stuart	31	103	15S	26E	24	BCB1	24
610	Ivan Darrington well	31	104	15S	26E	24	DCC1	31
611	BLM well	31	105	15S	26E	25	ACA1	30
612	RRGI-6	31	106	15S	26E	25	ADA	121
613	EG&G Thermal well (RRGE-3 ?)	31	107	15S	26E	25	BDA1	144
614	RRGE-3	31	108	15S	26E	25	BDC	
615	Thououghbred W.S.	31	109	16S	19E	28	BBA1s	21
616	BLM well	31	110	16S	26E	05	BBA1	40
617		31	111	16S	26E	05	BBA2	40
618	Lidy H.S. (1)	33	1	09N	33E	02	BBC1s	51
619	Wilson Bros. well	33	2	09N	33E	02	CDC1	50
620	Lidy H.S. well	33	3	10N	33E	35	CCC1	58
621	Lidy H.S. (2)	33	4	10N	33E	35	CCC1s	51
622	Warm Springs	33	5	11N	32E	25	AAC1s	29
623	Big Springs	33	6	13N	32E	15	BCB1s	23
624	Targhee	33	7	13N	34E	24	A	160
625	Meyer Fed #1	33	8	14N	35E	14	AC	110
626	Bowery H.S.	37	1	07N	17E	06	ABA1s	43
627		37	2	08N	14E	27	DBA1s	29
628	Pierson H.S.	37	3	08N	14E	27	DBD1s	43
629		37	4	08N	17E	31	DCB1s	52.5
630	East Fork H.S.(West Pass H.S.)	37	5	08N	17E	32	BCA1s	52.5
631	Rozalys Smith well #1	37	6	09N	14E	18	CAD1	37
632	Rozalys Smith well #2	37	7	09N	14E	19	ABA1	50
633	Rozalys(Id Rocky Mtn Rnch)H.S.	37	8	09N	14E	19	BAA1s	41
634	Stanley H.S.	37	9	10N	13E	03	CAB1s	41
635	Slate Creek H.S.	37	10	10N	16E	30	B1s	50
636		37	11	11N	13E	25	DCC1s	55
637	Elkhorn H.S.	37	12	11N	13E	36	BAA1s	58
638		37	13	11N	13E	36	BBC1s	57
639	Basin Creek H.S.	37	14	11N	14E	21	DDB1s	35
640	USFS H.S. (Campground H.S. ?)	37	15	11N	14E	22	CCA1s	56.5
641	Mormon Bend H.S.	37	16	11N	14E	29	AAB1s	38
642	Sunbeam H.S.	37	17	11N	15E	19	C1s	76.5
643	East Robinson Bar H.S.	37	18	11N	15E	26	CCC1s	42
644	Robinson Bar H.S.	37	19	11N	15E	27	DDC1s	55
645	Warm Springs Creek H.S.	37	20	11N	15E	34	ADC1s	52
646	Sullivan H.S.	37	21	11N	17E	27	BDD1s	40
647	Barney H.S. nr Goldburg	37	22	11N	25E	23	CAB1s	26
648	Cape Horn W.S.	37	23	12N	11E	02	CDB1s	37
649	Little Antelope Flat W.S.	37	24	12N	20E	10	CBD1s	33
650	Shama 86-1	37	25	13N	18E	03	BCCA	30
651	Sulphur Creek H.S.	37	26	14N	11E	01	B1s	
652	Beardsley (Challis) H.S.	37	27	14N	19E	23	DDD1s	50
653	Bill Johnston Well	37	28	14N	19E	34	DAA1	41
654	Owen Cabin H.S.	37	29	15N	14E	10	ADC1s	56
655	Upper Loon Creek H.S.	37	30	15N	14E	10	DCC1s	63
656	Shower Bath H.S.	37	31	15N	16E	17	Ds	53
657	Sunflower Flats H.S.	37	32	16N	12E	08	DDC1s	47
658		37	33	16N	12E	16	BBB1s	59

659		37	34	16N	12E	17	CDC1s	43
660	Thomas Ck H.S.	37	35	16N	12E	17	DAD1s	62
661	Whitey Cox Camp H.S.	37	36	17N	13E	27	ADB1s	39
662	Lower Loon Ck H.S.	37	37	17N	14E	19	BDB1s	49.5
663	Bridge H.S.	39	1	02N	10E	05	ACA1s	59
664		39	2	02N	10E	05	ADA1s	60
665	Towne Creek W.S.	39	3	02N	10E	19	ABA1s	24
666		39	4	02S	04E	02	BBD1	22.5
667	Big D Ranch well	39	5	02S	04E	28	BDD1	27
668		39	6	02S	04E	34	AAC1	20
669	Fred Hickey well	39	7	02S	05E	11	ADD1	22
670		39	8	02S	05E	15	ABA1	20
671	Charles Coe well	39	9	02S	05E	22	AAD1	21
672	John Malota well	39	10	02S	05E	23	BBC1	21
673	Rattlesnake H.S.	39	11	03N	07E	07	DCA1s	56
674	Charles Baker well	39	12	03N	10E	10	ABA1	43
675		39	13	03N	10E	10	ABB1s	40.5
676	Paradise H.S. (1)	39	14	03N	10E	33	ACD1s	53
677	Paradise H.S. (2)	39	15	03N	10E	33	BDA1s	56
678	Paradise H.S. well	39	16	03N	10E	33	BDB1	38
679	Michael Jackson well	39	17	03S	06E	24	DCB1	21
680		39	18	03S	06E	26	ADA1	21
681		39	19	03S	06E	26	ADA2	21
682	Mountain Home City well	39	20	03S	06E	26	ADC1	23
683		39	21	03S	06E	27	DDD1	20.5
684	Richard Chandler well	39	22	03S	06E	35	BCC1	20
685	Long Tom Ranch well #1	39	23	03S	07E	01	ACA1	20
686	Robert Ford well #1	39	24	03S	07E	02	ACA1	31
687	Robert Ford well #2	39	25	03S	07E	02	ACC1	21
688	Del Foster well	39	26	03S	07E	03	ADD1	31
689	Long Tom Ranch well #2	39	27	03S	08E	06	CBC1	21
690	S70 Hot Springs	39	28	03S	08E	16	CCCs	70
691		39	29	03S	08E	17	DDD1s	70
692	Leslie Beam Well #1	39	30	03S	08E	36	CAD1	67
693	Leslie Beam Well #1 ?	39	30	03S	08E	36	CDA?	67
694	Leslie Beam Well #2	39	31	03S	08E	36	CDA1	36
695	Coyote H.S.	39	32	03S	09E	25	DDB1s	57
696	Latty H.S.	39	33	03S	10E	31	DDB1s	62
697	Basset H.S.	39	34	04N	07E	01	AAB1s	
698	Reed H.S.	39	35	04N	07E	07	ADC1s	41
699	Sheep Creek Bridge H.S.	39	36	04N	07E	08	CBB1s	61
700	Willow Creek H.S.	39	37	04N	11E	34	DBB1s	53
701		39	38	04S	03E	29	DDC1	22
702	John Dobaron well	39	39	04S	04E	32	ACC1	21
703		39	40	04S	04E	36	DAB1	20
704		39	41	04S	05E	15	BBB1	20
705		39	42	04S	05E	15	BBC1	20
706	Pete Nielson well	39	43	04S	05E	19	ABC1	20
707		39	44	04S	05E	19	CBA1	21
708		39	45	04S	05E	21	CAA1	20.5
709		39	46	04S	05E	22	CDC1	20
710		39	47	04S	05E	22	DAC1	22
711		39	48	04S	05E	25	BBC1	24
712	Robert Bruce well #2	39	49	04S	05E	26	AAD1	24
713	Terry Peterman well	39	50	04S	05E	26	CAB1	21
714		39	51	04S	05E	26	DAD1	22.5
715	Mt. Home Air Force Base Test	39	52	04S	05E	27	AAB1	45
716		39	53	04S	05E	27	DBC1	20
717		39	54	04S	05E	33	CDB1	19
718	Terry Peterman well	39	55	04S	05E	36	CAD1	24

719	Hugh Harden well	39	56	04S	06E	07	CAA1	22
720		39	57	04S	06E	19	BAC1	23
721		39	58	04S	06E	19	CDB1	23
722		39	59	04S	06E	24	CCB1	21.5
723	Dave Spencer well	39	60	04S	06E	25	BCA1	24
724		39	61	04S	06E	31	DDD1	21.5
725	Frank Lutz well #2	39	62	04S	06E	32	CCC1	21
726	Ralph Moore well	39	63	04S	06E	35	BCD1	24
727		39	64	04S	06E	35	DCA1	23
728	Ralph Yrazabal well	39	65	04S	07E	09	BBA1	24
729		39	66	04S	07E	16	BBB1	23
730		39	67	04S	07E	17	CAB1	21
731	Beverly Olson well	39	68	04S	07E	19	BDB1	23
732		39	69	04S	07E	28	BBA1	24
733	Tom Gill well	39	70	04S	08E	01	DBA1	52
734	Tom Gill well	39	70	04S	08E	01	DBA1	58
735	Al Griffith Bostic No. 1A	39	71	04S	08E	25	CC	174
736		39	72	04S	08E	36	BBA1	26.5
737	Bill Davis Well	39	73	04S	09E	08	ACA1	60
738	Pool Creek H.S.	39	74	05N	07E	24	AAD1s	42
739	Neinmeyer H.S.	39	75	05N	07E	24	BDD1s	76
740	Vaughn Spring	39	76	05N	07E	26	DAB1s	68
741	Smith Cabin H.S.	39	77	05N	07E	34	CCB1s	60
742	Loftus H.S.	39	78	05N	07E	34	DBA1s	55
743	Browns Creek H.S.	39	79	05N	08E	10	DCA1s	51
744	Straight Creek H.S.	39	80	05N	08E	12	ABD1s	62
745	Granite Creek H.S.	39	81	05N	09E	05	AAD1s	56
746	Dutch Frank's H.S.	39	82	05N	09E	07	BAB1s	65
747	Gary Lawson well	39	83	05S	03E	14	CBB1	59
748	Gary Lawson well	39	84	05S	03E	14	CBB2	57
749		39	85	05S	04E	05	CAA1	21
750		39	86	05S	04E	28	ABB1	22.5
751		39	87	05S	06E	01	AAD1	21
752		39	88	05S	06E	03	AAB1	20.5
753		39	89	05S	06E	06	BBB1	22.5
754		39	90	05S	06E	06	DBA1	21
755		39	91	05S	06E	08	ADD1	21
756		39	92	05S	06E	15	BCD1	22
757	Mike Wissel well #1	39	93	05S	06E	24	AAD1	20
758	Mike Wissel well #2	39	94	05S	07E	16	ABD1	20
759		39	95	05S	07E	24	DDD1	22.5
760		39	96	05S	08E	22	ACD1	29.5
761		39	97	05S	08E	25	BBD1	20.5
762		39	98	05S	08E	27	CCD1	22
763	Charles Boyd well	39	99	05S	08E	34	BDC1	34
764		39	100	05S	10E	19	DDD1	21.5
765	Ray Thompson well	39	101	05S	10E	25	ACA1	21
766	Daniel Hatcher well	39	102	05S	10E	28	BDC1	32
767	Lloyd Knight well	39	103	05S	10E	28	CAB1	30
768		39	104	05S	10E	29	DCC1	36
769		39	105	05S	10E	30	CAC1	21.5
770	Magic West Co. well	39	106	05S	10E	32	BDB1	38
771	Charles Anderson well	39	107	05S	11E	07	ACC1	30
772		39	108	05S	11E	07	ACD1	29.5
773	Union Pacific RR well	39	109	05S	11E	07	CBB1	23
774	Rodney Ruberry well	39	110	05S	11E	18	BAD1	23
775	Darrell Drake well	39	111	05S	11E	18	BCB1	27
776	Robert Graham well	39	112	05S	11E	19	CCA1	24
777	Weatherby Mill well	39	113	06N	09E	35	ACA1	30
778		39	114	06N	10E	30	CCA1s	50

779	Unnamed on Hot Creek	39	115	06N	10E	30	CDA1s	64
780	Queens River H.S.	39	116	06N	11E	30	ADB1s	20.5
781	Atlanta H.S.	39	117	06N	11E	35	DAD1s	60
782	Chattanooga H.S.	39	118	06N	11E	35	DBB1s	53
783	Atlanta H.S.	39	119	06N	11E	35	DDB1s	53.5
784	Leggit Creek H.S.	39	120	06N	12E	33	BCB1s	
785	Black Mesa Farm well	39	121	06S	10E	12	CAA1	30
786		39	122	06S	10E	31	CCC1	22
787		39	123	07S	10E	22	DDD1	25
788	Mound Valley Warm Spring	41	1	12S	40E	13	DCDs	34
789	Treasureton Warm Spring	41	2	12S	40E	36	ACDs	40
790	Unnamed Warm Spring	41	3	12S	41E	31	BADs	21
791	Cleveland Hot Springs	41	4	12S	41E	31	CACs	55
792	West Banks W.S.	41	5	12S	41E	31	CBD1s	35
793	Maple Grove Hot Spring	41	6	13S	41E	07	ACAs	75
794	Unnamed Hot Spring	41	7	13S	41E	07	DABs	62
795	Ben Meek Well	41	8	14S	39E	36	ADA	40
796	Ray Barrington well	41	9	14S	40E	31	BCB1	40
797		41	10	14S	40E	31	CBC	40
798	Sun-1001	41	11	15S	39E	06	CA	110
799	M. Fonnesbeck Well	41	12	15S	39E	07	DBC	63
800	Battle Creek (Wayland) H.S.	41	13	15S	39E	08	BDCs	77
801	Squaw Hot Spring Well	41	14	15S	39E	17	BCD1	82
802	Squaw H.S.	41	15	15S	39E	17	BDC1s	73
803	E. Bingham Well	41	16	16S	38E	24	ABC	23
804		41	17	16S	38E	24	ACB1	24
805	P. L. Koller well	41	18	16S	38E	24	BDD1	21
806	Kieth Jergenson well #1	43	1	07N	41E	13	CAB1	23
807	Kieth Jergenson well #2	43	2	07N	41E	13	CAD1	23
808	Donald Trupp well	43	3	07N	41E	25	CBD1	36
809	Wayne Larson well	43	4	07N	41E	26	ACC1	22
810	Gorden Clark well	43	5	07N	41E	33	DDD1	22
811	Henry Harris well	43	6	07N	41E	34	ADD1	34
812	Newdale City well	43	7	07N	41E	34	DCD1	32
813		43	8	07N	41E	35	CDD1	36
814	Steter and Swindleman	43	9	07N	41E	35	DCD1	37
815	Claude Haws well	43	10	07N	41E	36	DDA1	34
816		43	11	07N	41E	36	DDA2	32
817	UN-ST-07	43	12	07N	42E	07	DCB	87
818	UN-ST-08	43	13	07N	42E	08	AA	83
819	Dean Swindelman Well	43	14	07N	42E	08	CAA1	36.5
820	Kieth Jergenson well #3	43	15	07N	42E	17	BAC1	27
821	Kieth Jergenson well #4	43	16	07N	42E	17	BBC1	39
822	Kieth Jergenson well #5	43	17	07N	42E	18	BAA1	51
823	Naomi Jergensen well	43	18	07N	42E	18	CAA1	33
824		43	19	07N	42E	19	BBB1	43.5
825	Remington Produce well	43	20	07N	42E	19	CCA1	26
826	Ashton W.S.	43	21	09N	42E	23	DAC1s	26
827		43	22	09N	43E	15	DDC1s	24.5
828		43	23	09N	43E	19	BCB1	37
829	Sturm-1	43	24	09N	43E	19	BDC	45
830	HFT-19; OXY-19	43	25	12N	42E	36	CCB	23
831	Big Springs	43	26	14N	44E	34	BBC1s	21
832	Highland Land Co. W.S.	45	1	06N	01W	25	ADB1s	23
833	Donald Jensen well #1	45	2	06N	01W	26	ADA1	20
834	Donald Jensen well #2	45	3	06N	01W	26	ADC1	20
835	Paul Crank well	45	4	06N	02W	14	DBC1	24
836	Fred Scott well	45	5	06N	02W	17	DBA1	24
837	Berglund #1	45	6	06N	03W	03	DA	29.4
838	Rawla Izatt well	45	7	06N	03W	12	AAB1	21

839	Sweet W.S.	45	8	07N	01E	03	CAA1s	20
840	Roystone H.S.	45	9	07N	01E	08	DDA1s	66
841	East Roystone H.S.	45	10	07N	01E	09	CDC1s	45
842	Tschanne H.S.	47	1	04S	12E	35	AAA1s	43
843	Dave Archer well #1	47	2	04S	12E	35	CAD1	45
844		47	3	04S	13E	01	BDC1s	21
845	J. Shannon well	47	4	04S	13E	28	ABB1	53
846		47	5	04S	13E	28	ABC1	52
847	Hot Sulfur Lake	47	6	04S	13E	29	ADD1s	27
848	White Arrow H.S.	47	7	04S	13E	30	ADB1s	54.5
849	Dave Archer well #2	47	8	05S	12E	03	AAA1	57
850	Barron's Hot Springs	47	9	05S	13E	34	BCC1	48.9
851	BLM	47	10	06S	12E	05	BDD1	28
852		47	11	08S	14E	04	BBD	43
853		47	12	08S	14E	09	ABB	31
854		47	13	08S	14E	33	ADC	54
855		49	1	22N	02E	23	CCB1s	49
856	Burgdorf H.S.	49	2	22N	04E	01	BDC1s	45
857	Riggins H.S.	49	3	24N	02E	14	DAC1s	41
858	Cow Flats H.S.	49	4	24N	04E	07	CDA1s	59
859	Barth H.S.	49	5	25N	11E			59.5
860	Unnamed H.S.	49	6	25N	12E	18	DD1s	45.5
861	Red River H.S.	49	7	28N	10E	03	DDD1s	55
862	Running Creek H.S.	49	8	29N	12E	14	ABB1s	43
863	Marten H.S.	49	9	31N	11E	24	DCD1s	
864	Stuart H.S.	49	10	32N	11E	04	CAA1s	
865	Prospector H.S.	49	11	33N	14E	04	A1s	
866	Stanley H.S.	49	12	34N	10E	06	CAA1s	49
867	Weir Creek H.S.	49	13	36N	11E	13	BCC1s	47
868	Colgate Licks H.S.	49	14	36N	12E	15	ADB1	45
869	Little Jerry Johnson H.S.	49	15	36N	13E	18	ADB1s	41
870	Jerry Johnson H.S.	49	16	36N	13E	18	ADD1s	48.5
871	Heise Hot Springs-1	51	1	04N	40E	25	DDA1s	48
872	Heise Hot Springs-2	51	2	04N	40E	25	DDA2s	49
873		53	1	09S	17E	28	BDA1	27
874		53	2	09S	17E	28	BDC	30
875		53	3	09S	17E	29	ACD1	41.5
876		53	4	09S	17E	29	DBA	43
877		53	5	09S	18E	03	DDB1	27
878		53	6	10S	18E	01	DDA	31
879		53	7	10S	18E	01	DDD1	42
880	Richard Abbot well	57	1	38N	02W	17	CD?	20
881	Foster Ranch H.S.	59	1	15N	15E	01	BDC1s	57
882	Shower Bath Springs	59	2	15N	16E	15	DAD1s	50
883	Big Eightmile Creek W.S.	59	3	15N	25E	08	DDB1s	33
884	Whittaker W.S.	59	4	15N	26E	21	DBC1s	24
885	Milford	59	5	15N	27E	19	CBD	78 ?
886	Cronks Canyon H.S.	59	6	16N	21E	18	ADC1s	45.5
887	Forge Creek H.S.	59	7	18N	16E	14	BBB1s	
888		59	8	18N	17E	31	DCB1s	52.5
889	Goldbug H.S.	59	9	18N	21E	12	BCD1s	45
890	Mormon Ranch H.S.	59	10	19N	14E	26	DDD1s	47
891	Snowshoe Johnson's H.S.	59	11	20N	16E	20	DCC1s	42
892	Salmon River H.S.	59	12	20N	22E	03	ABD1s	45
893	Sharkey H.S.	59	13	20N	24E	34	CCC1s	63.5
894	Owl Creek H.S.	59	14	23N	17E	10	BBA1s	51
895	Big Creek H.S.	59	15	23N	18E	22	CAD1s	94
896	Horse Creek H.S.	59	16	25N	17E	15	BBA1s	39
897	UMR-5	63	1	03S	17E	02	DBB	21
898	Elkhorn Warm Spring	65	1	04N	40E	23	CADs	20

899	Lavere Ricks well	65	2	05N	40E	05	CBA1	21
900	Mark Ricks well	65	3	05N	40E	08	BCC1	26
901	Pauline Smith well	65	4	05N	40E	09	CCC1	21
902		65	5	05N	40E	12	CAA1	20.5
903	Bill Webster well	65	6	05N	40E	36	BDB1	22
904		65	7	05N	41E	07	ACC1	33
905	Walz Warm Spring	65	8	05N	41E	07	ACs	35
906	Green Canyon H.S.	65	9	05N	43E	06	BCA1s	44
907	Madison Co. Geotherm test well	65	10	06N	40E	31	BBA1	22
908	Val Schwendiman well	65	11	06N	41E	01	ADD1	29
909	Walz Ent. Inc. well	65	12	06N	41E	10	ACC1	26
910	Wanda Wood well #1	65	13	06N	41E	10	BBB1	24
911	Wanda Wood well #2	65	14	06N	41E	10	DBB1	27
912		65	15	06N	41E	11	CDB1	21.5
913	BLM	65	16	07N	42E	30	DBD1	34
914	O.J. Neeley Well	65	17	07N	43E	30	CCC	22
915	Paul City well	67	1	09S	23E	28	CCA1	22
916	Lewiston City well	69	1	35N	05W	06	CBC1	20
917	Kent Warm Spring	71	1	12S	34E	36	BCBs	24
918		71	2	14S	35E	09	AD1s	22
919		71	3	14S	36E	18	DDB1	22
920	Malad Warm Spring	71	4	14S	36E	27	CDAs	24
921	Pleasantview Warm Spring	71	5	15S	35E	03	AABs	25
922	East Bingham Well	71	6	16S	36E	10	BBC	63
923	Woodruff Warm Spring	71	7	16S	36E	10	BBCs	27
924	Prices W.S.	71	8	16S	36E	23	BBD1s	25
925		73	1	01N	03W	06	BBC	27
926		73	2	01N	03W	06	DDC1	40
927	Ferring well	73	3	01N	03W	07	AAC1	41
928		73	4	01N	03W	07	CAA	26
929		73	5	01N	03W	08	CCA	47
930		73	6	01N	03W	08	CCC	33
931		73	7	01N	03W	08	CD1	36
932		73	8	01N	03W	08	CD2	37
933		73	9	01N	03W	08	CD3	37
934	M. Goff well	73	10	01N	03W	08	CDA1	36
935	Norris White well	73	11	01N	03W	08	CDB1	36
936		73	12	01N	03W	16	CCA1	39
937		73	13	01N	03W	16	CCA2	38
938		73	14	01N	03W	16	CCB1	41
939		73	15	01N	03W	16	CCB2	38
940		73	16	01N	03W	16	CCC	30
941		73	17	01N	03W	16	CDB1	36
942		73	18	01N	03W	17	AAC	30
943		73	19	01N	03W	17	ABB	32
944		73	20	01N	03W	17	ADB	28
945	Jim Avahauser well	73	21	01N	03W	17	ADD1	34
946	Charles Elumbaugh well	73	22	01N	03W	20	DAC1	37
947		73	23	01N	03W	21	A?	45
948		73	24	01N	03W	21	AB	57
949		73	25	01N	03W	21	ACD	36
950	Givins H.S.	73	26	01N	03W	21	BAB1s	47
951	Eldon Marsh well	73	27	01N	03W	21	BBA1	41
952		73	28	01N	03W	21	BBB	59
953		73	29	01N	03W	28	BCD1	47
954	Marie Brunell well	73	30	01N	04W	12	ABC1	40
955		73	31	01N	04W	12	BAD	27
956	Robert Coffelt well	73	32	01N	04W	12	BDA1	27
957	Wesley Higgins well	73	33	01N	04W	12	DBB1	36
958	Guy Freeman well #1	73	34	01N	04W	13	BAC1	39

959	Guy Freeman well #2	73	35	01N	04W	13	BAD1	29
960	Earl Foote well	73	36	01S	02W	07	CCB1	46
961	Cotner Farm well	73	37	01S	02W	18	CDD1	30
962	Jim Taylor well	73	38	01S	02W	27	CCC1	21
963	Jack Morgan well	73	39	01S	02W	33	DDD1	28
964	Roger Quinney well	73	40	01S	02W	34	CAB1	20
965	Cereda Ranches well #1	73	41	01S	03W	01	DCB1	40
966	Cereda Ranches well #2	73	42	01S	03W	01	DCC1	36
967	Jacobson's Feed Lot #1	73	43	01S	03W	09	ACC1	27
968	Jacobson's Feed Lot #2	73	44	01S	03W	09	BDA1	37
969	Paul Warrick well	73	45	02S	01W	23	CBC1	30
970	Lannis Givins well	73	46	02S	02W	02	CBD1	38
971	Guy Givins well #1	73	47	02S	02W	03	BDA1	38
972	Guy Givins well #2	73	48	02S	02W	03	BDD1	43
973	W. Ohm well	73	49	02S	02W	03	CBB1	36
974	Skyles and Neeley well #1	73	50	02S	02W	35	ABA1	25
975		73	51	02S	02W	35	ACB1	40
976	Skyles and Neeley well #2	73	52	02S	02W	35	ACD1	41
977	Skyles and Neeley well #3	73	53	02S	02W	35	BAA1	32
978	Skyles and Neeley well #4	73	54	02S	02W	36	CDD1	23
979		73	55	02S	05W	24	CBC1s	26.5
980	Homedale City well #1	73	56	03N	05W	04	DAC1	20
981	Homedale City well #2	73	57	03N	05W	09	AAB1	23
982	George Johnstone well	73	58	03N	05W	28	CBC1	21
983	Justamere Farms well #1	73	59	03N	05W	30	AAA1	20
984	Justamere Farms well #2	73	60	03N	05W	30	ADA1	21
985	Alfred Heywood Well?	73	61	03S	01E	35	DAC1	22.5
986	Omalley well	73	62	03S	02W	01	BCB1	24
987		73	63	03S	02W	08	ACC1s	22
988	Wayne Smith well	73	64	04S	01E	06	ABB1	22
989		73	65	04S	01E	11	ADC	29
990	William Cox well #1	73	66	04S	01E	25	CCD1	32
991	William Cox #2	73	67	04S	01E	26	ABC1	27
992	T. Adcock well	73	68	04S	01E	29	CCD1	68
993	George King well	73	69	04S	01E	34	BAD1	75
994		73	70	04S	02E	06	CDA1	21
995		73	71	04S	02E	17	BBA	54
996		73	72	04S	02E	17	BCD1	58
997		73	73	04S	02E	19	ACB1	75.5
998	Wes-Con Inc. well	73	74	04S	02E	19	ACC1	42
999		73	75	04S	02E	20	CAC1	20
1000	G. Christensen well	73	76	04S	02E	29	DBC1	28
1001	R. Ketterling well	73	77	04S	02E	32	BCC1	39
1002	Charles Steiner well	73	78	05S	01E	03	AAB1	32
1003		73	79	05S	01E	10	BDD1	59
1004	Elmer Johnston well #1	73	80	05S	01E	21	BCA1	48
1005		73	81	05S	01E	21	CBD1	72
1006	E. Lawrence well #2	73	82	05S	01E	24	ACD1	67
1007	E. Lawrence well #3	73	83	05S	01E	24	ADB1	66
1008		73	84	05S	02E	01	BBC1	44.5
1009	Clarence Hopkins well	73	85	05S	02E	02	CDA1	37
1010		73	86	05S	02E	05	BCD1	40
1011	Henry Driskell well #1	73	87	05S	02E	13	ADA1	20
1012	Henry Driskell well #2	73	88	05S	02E	25	ADA1	21
1013		73	89	05S	03E	15	CBA	59
1014	Norris McKeeth well	73	90	05S	03E	20	ADA1	59
1015		73	91	05S	03E	20	BBB1	26.5
1016	Harald Simper well #1	73	92	05S	03E	21	BBC1	22
1017	Harald Simper well #2	73	93	05S	03E	21	BCB1	27
1018	Leroy Beaman well	73	94	05S	03E	22	AAD1	25

1019		73	95	05S	03E	26	BCB1	84
1020	Cooke's Greenhouse #2	73	96	05S	03E	26	BCB2	67
1021	D. Bybee well #1	73	97	05S	03E	27	BDD1	60
1022		73	98	05S	03E	28	BCC1	63
1023	D. Layton well	73	99	05S	03E	34	DAA1	32
1024		73	100	05S	03E	34	DDA1	20
1025		73	101	05S	03E	35	CCC1	73
1026		73	102	05S	03E	36	CBB1	23.5
1027	Idaho Power Co. well	73	103	05S	04E	34	CCB1	27
1028		73	104	05S	04W	08	ADA1	20
1029		73	105	05S	05E	33	BBD1	19
1030	Clay Atkins well	73	106	05S	05E	34	ADD1	25
1031		73	107	05S	05E	34	DDD1	25
1032	Streeter-Bradberry well	73	108	05S	06E	31	DCD1	21
1033	Lower Birch Spring	73	109	06S	01E	32	BBA1s	25
1034	Leslie Post well #1	73	110	06S	03E	02	CBB1	59
1035		73	111	06S	03E	02	CBC1	62
1036	Leslie Post well #2	73	112	06S	03E	02	CCC1	54
1037	W. Bunt well	73	113	06S	03E	04	BCC1	48
1038	J. Agenbroad well	73	114	06S	03E	05	CAC1	60
1039		73	115	06S	03E	09	AAB1	39.5
1040	Nielson and Carothers	73	116	06S	03E	09	ACC1	41
1041	Bob Dirks well	73	117	06S	03E	10	CAA1	30
1042		73	118	06S	03E	11	CCC1	34.5
1043	Triangle Dairy well #1	73	119	06S	03E	11	DAD1	34
1044	Triangle Dairy well #2	73	120	06S	03E	14	BCB1	29
1045	Robert Davis well #1	73	121	06S	03E	23	CDA1	30
1046	Robert Davis well #2	73	122	06S	03E	26	CBC1	30
1047	B. Burghardt well #1	73	123	06S	03E	34	DCC1	29
1048		73	124	06S	04E	02	BAC1	26.5
1049		73	125	06S	04E	14	ABC1	55.5
1050	Jim Morrison well #1	73	126	06S	04E	14	BDD1	55
1051	Jim Morrison well #2	73	127	06S	04E	14	BDD2	27
1052	Kent Kohring well #1	73	128	06S	04E	25	BCC1	27
1053	Antonio Deleon well #1	73	129	06S	04E	32	DAB1	33
1054	Antonio Deleon well #2	73	130	06S	04E	33	DBA1	31
1055	Dick Ward well	73	131	06S	04E	35	CDA1	33
1056	Merrill Tallman well #1	73	132	06S	04E	35	DAA1	22
1057	Merrill Tallman well #2	73	133	06S	04E	35	DBB1	30
1058	Kent Kohring well #2	73	134	06S	04E	36	CCC1	40
1059	Kent Kohring well #3	73	135	06S	04E	36	CCC2	20
1060	Colyer Cattle Co. well	73	136	06S	05E	10	DDD1	39
1061	J. R. Simplot well #1	73	137	06S	05E	18	CCB1	27
1062	J. R. Simplot well #2	73	138	06S	05E	20	AAB1	43
1063	George Hutchinson well	73	139	06S	05E	24	BCA1	34
1064		73	140	06S	05E	24	DBD1	33.5
1065	Bruneau City well	73	141	06S	05E	24	DDB1	32
1066		73	142	06S	05E	24	DDD1	21.5
1067		73	143	06S	05E	26	BBB1	20
1068		73	144	06S	05E	26	BBD	27
1069		73	145	06S	05E	26	BCD1	20
1070	Don Davis well #1	73	146	06S	05E	29	DCC1	33
1071		73	147	06S	05E	35	CBD1	22.5
1072		73	148	06S	05E	36	DDA1	21.5
1073		73	149	06S	06E	12	CCB1	37
1074		73	150	06S	06E	19	CCD1	36
1075		73	151	06S	06E	19	DBD1	40.5
1076		73	152	06S	06E	30	DBA	27
1077		73	153	06S	06E	30	DBB1	22.5
1078	Ace Black well	73	154	06S	06E	32	BDB1	35

1079		73	155	06S	06E	32	BDD1	34.5
1080	Wilbur Wilson well #1	73	156	06S	07E	01	ACB1	42
1081	Wilbur Wilson well #2	73	157	06S	07E	01	DBD1	33
1082		73	158	06S	07E	01	DCA1	33
1083		73	159	06S	07E	02	CDD1	34
1084		73	160	06S	07E	03	DDC1	20.5
1085		73	161	06S	07E	08	BBA1	24
1086	Bill Burghardt well #2	73	162	07S	03E	04	ACD1	29
1087		73	163	07S	03E	10	ADC	40
1088		73	164	07S	03E	10	DDC	39
1089	Wilber Mastre well	73	165	07S	03E	12	ACC1	39
1090		73	166	07S	04E	01	ACC1	39
1091		73	167	07S	04E	02	ABB1	20.5
1092		73	168	07S	04E	02	BDC	39
1093		73	169	07S	04E	02	CAB1	29
1094		73	170	07S	04E	02	DBA1	39.5
1095	Pete Merrick well #1	73	171	07S	04E	03	ABD1	42
1096	Clarence Merrick well #1	73	172	07S	04E	03	BBC1	33
1097	Bob Mastre well	73	173	07S	04E	04	ADB1	34
1098		73	174	07S	04E	04	BDD	38
1099	Delbert Wright well	73	175	07S	04E	05	CCA1	30
1100	Les Isaac well	73	176	07S	04E	05	DDC1	30
1101		73	177	07S	04E	10	BDB1	41
1102	Clarence Merrick well #2	73	178	07S	04E	10	DBC1	35
1103	Paul Glerum well	73	179	07S	04E	11	ACC1	43
1104	Frank Millett well #1	73	180	07S	04E	11	CBC1	36
1105		73	181	07S	04E	12	ABB1	40
1106		73	182	07S	04E	12	ABD	40
1107	Faria Brothers well	73	183	07S	04E	12	BDD1	43
1108		73	184	07S	04E	12	CCC1	42
1109		73	185	07S	04E	12	DDC1	40.5
1110	Clarence Cook well	73	186	07S	04E	13	BCC1	39
1111		73	187	07S	04E	13	DCD1	38.5
1112		73	188	07S	04E	14	ABC1	38.5
1113	Elmo Griffits well	73	189	07S	04E	14	CDC1	29
1114	Robert Black well	73	190	07S	04E	15	ACD1	33
1115	Blaine Rawlins well	73	191	07S	04E	22	ACB1	38
1116	C. Russel well	73	192	07S	04E	22	BAD1	41
1117		73	193	07S	04E	22	BBD1	38.5
1118	Blaine Rawlins well #2	73	194	07S	04E	23	CBB1	35
1119	Blaine Rawlins well #3	73	195	07S	04E	23	CBB2	39
1120	John McGuire well	73	196	07S	04E	24	BDC1	32
1121	Conner H.S.	73	197	07S	04E	24	D1s	37.5
1122		73	198	07S	04E	24	DCC1	37
1123	Bell Brand Ranches	73	199	07S	04E	25	ADC1	36
1124		73	200	07S	04E	26	BCB1	30.5
1125		73	201	07S	04E	27	BCC1	26
1126		73	202	07S	05E	01	DCA1	21
1127	Don Davis well #2	73	203	07S	05E	05	BAA1	23
1128	Don Davis well #3	73	204	07S	05E	05	BAC1	20
1129		73	205	07S	05E	05	DBC1	32
1130		73	206	07S	05E	07	ABB1	39
1131		73	207	07S	05E	07	DDA1	26.5
1132	Merle Bachman well #1	73	208	07S	05E	08	BCC1	40
1133	Merle Bachman well #2	73	209	07S	05E	08	BCC2	26
1134		73	210	07S	05E	08	CCC1	38.5
1135		73	211	07S	05E	09	DDA1	33.5
1136		73	212	07S	05E	09	DDD1	39
1137	Roy Davis well #1	73	213	07S	05E	13	AAA1	23
1138	Roy Davis well #2	73	214	07S	05E	13	AAC1	25

1139	Carl Steiner well	73	215	07S	05E	13	CBB1	36
1140	Robert Tindall well	73	216	07S	05E	16	ACD1	39
1141	Chester Sellman well #1	73	217	07S	05E	18	ABC1	30
1142	Chester Sellman well #2	73	218	07S	05E	18	ABC2	34
1143		73	219	07S	05E	18	BCD1	25.5
1144	Clarence Miller well #2	73	220	07S	05E	18	DBA1	41
1145		73	221	07S	05E	19	CCC1	35.5
1146		73	222	07S	05E	21	CCA1	40
1147		73	223	07S	05E	28	BCBB1	27
1148		73	224	07S	05E	28	BDA1	33.5
1149		73	225	07S	05E	28	CBB1	27
1150		73	226	07S	06E	03	CCA	49
1151		73	227	07S	06E	03	CDB	49
1152		73	228	07S	06E	03	DCB1	49
1153	Colyer Cattle Co. well #1	73	229	07S	06E	04	CAD1	32
1154	Colyer Cattle Co. well #2	73	230	07S	06E	04	DCC1	44
1155		73	231	07S	06E	05	AAD1	21
1156	Ron Prow well	73	232	07S	06E	06	BAA1	22
1157		73	233	07S	06E	07	AAC1	27.5
1158	Roy Davis well #3	73	234	07S	06E	07	CDD1	23
1159	Colyer Cattle Co. well #3	73	235	07S	06E	09	BAD1	50
1160		73	236	07S	06E	09	BAD2	49.5
1161	R. L. Owen well #1	73	237	07S	06E	15	DAA1	27
1162		73	238	07S	06E	16	ABB2	20.5
1163		73	239	07S	06E	16	CDC1	41
1164		73	240	07S	06E	16	CDC2	27
1165	Roy Davis well #4	73	241	07S	06E	18	BBB1	23
1166		73	242	07S	06E	21	DABCs	39.5
1167	Hot Springs Ranch Well	73	243	07S	06E	21	DBC1	43
1168		73	243	07S	06E	21	DBC1	44.5
1169		73	244	07S	06E	21	DBC2	41
1170		73	245	07S	06E	22	AAD1	45
1171		73	246	07S	06E	22	AADA2	44
1172	R. L. Owen well #3	73	247	07S	06E	22	CAA1	47
1173		73	248	07S	06E	22	CCDA1	41.5
1174	Pence Hot Springs	73	249	07S	06E	22	DADBs	46
1175	Bat H.S.	73	250	07S	06E	22	DBB1s	47
1176		73	251	07S	06E	23	BBB1	47
1177	R. L. Owen well #5	73	252	07S	06E	23	BBB2	41
1178	William Rose Well	73	253	07S	06E	23	CAD1	44
1179		73	254	07S	06E	23	CCA1	37.5
1180		73	255	07S	06E	23	DCB1	42
1181		73	256	07S	06E	26	ADA1	37
1182	R.L. Owen Well #7	73	256	07S	06E	26	ADA1	38
1183	R. L. Owen well #8	73	257	07S	06E	26	BAA1	38
1184	R. L. Owen well #9	73	258	07S	06E	26	BAA2	36
1185		73	259	07S	06E	26	BDA1	34
1186	R. L. Owen well #11	73	260	07S	06E	26	BDB1	34
1187	Buckaroo H.S.	73	261	07S	06E	26	CCD1s	43
1188	Jean Longhurst well	73	262	07S	06E	27	AAC1	45
1189		73	263	07S	06E	27	AAD1	47
1190		73	264	07S	06E	27	ADB1	40.5
1191		73	265	07S	06E	29	BBA1	39
1192		73	266	07S	06E	34	BCA1	39
1193		73	267	07S	06E	34	DAD1	35.5
1194		73	268	07S	06E	34	DCB1s	40
1195	R. L. Owen well #12	73	269	07S	06E	34	DDA1	33
1196		73	270	07S	06E	35	BBB1s	41.5
1197		73	271	08S	05E	16	AAA1	42.5
1198	Lower Indian Bathtub	73	272	08S	06E	03	ADB1s	42

1199		73	273	08S	06E	03	BDC1	35.5
1200		73	274	08S	06E	03	BDC2	34
1201		73	275	08S	06E	03	BDC3	34.5
1202	Indian Bathtub Hot Springs	73	276	08S	06E	03	BDD1s	33
1203		73	277	08S	06E	04	DCD1	31
1204	U. S. Corps of Engineers	73	278	09S	05E	04	BDA1	52
1205		73	279	09S	05E	04	DAD1	60
1206		73	280	09S	12E	17	BDC1	20
1207		73	281	09S	12E	28	CBB1	28
1208	Tom Wheeler well #2	73	282	09S	12E	28	CDC1	27
1209	J. Wheeler well #1	73	283	09S	12E	28	DBC1	35
1210	J. Wheeler well #2	73	284	09S	12E	29	AAA1	22
1211	J. Wheeler well #3	73	285	09S	12E	29	ADC1	30
1212	J. Wheeler well #4	73	286	09S	12E	29	BBB1	28
1213	J. Wheeler well #5	73	287	09S	12E	29	DBA1	30
1214	J. Wheeler well #6	73	288	09S	12E	29	DBD1	31
1215		73	289	11S	07E	25	ACA1	34.5
1216	Indian H.S.	73	290	12S	07E	33	CBC1s	71
1217		73	291	12S	08E	06	ADA1	38.5
1218	A. Kramer well	73	292	12S	10E	12	CDC1	24
1219		73	293	13S	09E	35	CDC1	25.5
1220	Murphy H.S.	73	294	16S	09E	24	BBB1s	52
1221	Clarance Nye well	73	295	16S	09E	24	BBD1	25
1222	Janacek well	73	296	16S	09E	24	CAA1	23
1223	A. L. Cristenson well	75	1	06N	05W	12	BBD1	23
1224	Nelson-Deppe well	75	2	06N	05W	13	CBB1	22
1225		75	3	06N	05W	24	BBD1	24
1226	Highland L & L #1	75	4	06N	05W	24	BD	122.2
1227	James Libby well	75	5	07N	05W	25	DBB1	20
1228	Mike McKague well	75	6	07N	05W	33	AAB1	20
1229	James Mosier well	75	7	08N	04W	07	CCD1	20
1230	V. Johnson #2	75	8	08N	04W	27	DC	48.9
1231	T. Daws #1	75	9	08N	04W	34	AD	37.8
1232	B. Charpenter #1	75	10	08N	05W	04	AD	57.2
1233	Assmussen #1	75	11	09N	03W	08	DB	131.2
1234	Walter Smity well	75	12	09N	03W	19	DDA1	29
1235	Albert Coates well	75	13	09N	03W	21	BDC1	25
1236		75	14	09N	05W	33	BAA	22
1237		75	15	09N	05W	34	DDD	24
1238	Lee Reed well	75	16	09N	05W	35	CCB1	20
1239	Falls Irrigation Dist.	77	1	07S	31E	11	ACA1	26
1240		77	2	07S	31E	11	BDD2	22
1241	Idaho Power Co. well	77	3	07S	31E	31	ADA1	24
1242	Emil Mayer well	77	4	08S	30E	24	ACA1	22
1243	Max Mayer well	77	5	08S	31E	17	ABA1	25
1244		77	6	08S	31E	17	BAB1	29.5
1245	Fred Mayer well	77	7	08S	31E	17	BDB1	26
1246	Indian Springs	77	8	08S	31E	18	DABs	32
1247	D. M. Thornhill well	77	9	08S	31E	18	DAC1	33
1248	Indian W.S.	77	10	08S	31E	18	DAC1s	34
1249	Lake Walcott W.S.	77	11	09S	29E	19	ACD1s	21
1250		77	12	10S	30E	12	ACB1	20
1251	Rockland Warm Spring	77	13	10S	30E	13	CDCs	38
1252	Upper Rockland W.S.	77	14	10S	30E	24	BBA1s	38
1253	Rosco Weston well	77	15	10S	30E	24	DCC1	38
1254		77	16	10S	31E	33	CDA1	20
1255		81	1	03N	45E	07	ABB1s	20
1256	Taylor Springs	81	2	03N	45E	07	BAA1s	20
1257		81	3	04N	45E	30	BAB1s	23
1258	Cook 26-1 2962′-2997′ Interval	81	4	05N	44E	26	BA	49

1259	Cook 26-1 4210'-4230' Interval	81	4	05N	44E	26	BA	70
1260	Cook 26-1 2497'-2584' Interval	81	4	05N	44E	26	BA	46
1261	Cook 26-1	81	4	05N	44E	26	BAB	70
1262	O. Neely well	81	5	07N	43E	36	AAC1	49
1263		83	1	06S	13E	18	ABC1	32
1264		83	2	07S	12E	23	BAB1	24
1265		83	3	07S	13E	17	CCB1	26.5
1266		83	4	08S	12E	24	CCC1	24
1267		83	5	08S	14E	29	BBB	32
1268		83	6	08S	14E	29	BCC	57
1269		83	7	08S	14E	30	AA	29
1270	Bill Sliger well	83	8	08S	14E	30	ABA1	63
1271		83	9	08S	14E	30	ACA1	65.8
1272		83	9	08S	14E	30	ACA1	34
1273		83	10	08S	14E	30	ACD1	72
1274	Salmon Falls H.S.	83	11	08S	14E	30	ACD1s	67
1275		83	12	08S	14E	30	ACD2	71.5
1276		83	13	08S	14E	30	ACD3	65.8
1277		83	14	08S	14E	30	DAA	66
1278		83	15	08S	14E	30	DAD1	62
1279		83	16	08S	14E	30	DBA1	69
1280		83	17	08S	14E	30	DBB	71
1281		83	18	08S	14E	30	DCC	71
1282		83	19	08S	14E	30	DDD	69
1283		83	20	08S	14E	31	ABB	59
1284	Miracle H.S.	83	21	08S	14E	31	ACB1s	55
1285		83	22	08S	14E	31	CBB	39
1286		83	23	08S	14E	32	AAC	40
1287		83	24	08S	14E	32	CAC	60
1288		83	25	08S	14E	32	DAA	49
1289		83	26	08S	14E	32	DAC	47
1290		83	27	08S	14E	32	DBB	49
1291		83	28	08S	14E	32	DDC1	42.5
1292		83	29	08S	14E	33	BC1s	56.5
1293		83	30	08S	14E	33	BCC	54
1294	Harry Huttanus well #1	83	31	08S	14E	33	BCD1	49
1295	Harry Huttanus well #2	83	32	08S	14E	33	CBA1	57
1296	Banbury H.S.	83	33	08S	14E	33	CBA1s	59
1297	Harry Huttanus well #3	83	34	08S	14E	33	CBA2	57
1298	Darwin Collier well	83	35	08S	14E	33	CBD1	44
1299		83	36	08S	14E	33	CBD2	45
1300		83	37	08S	14E	33	CCA1	44.3
1301		83	38	08S	14E	33	CCC1	45
1302		83	39	08S	14E	33	CCC2	47
1303		83	40	08S	14E	33	CCC3	47
1304	George Anthony well	83	41	09S	12E	34	DDA1	25
1305	Poison Spring	83	42	09S	13E	14	DDD1s	
1306	Phil Ranick well	83	43	09S	13E	18	AAC1	29
1307		83	44	09S	13E	22	DDD1	22
1308	Jack Kinyon well	83	45	09S	13E	31	DCD1	26
1309	Ed Jaramelnik well #1	83	46	09S	13E	33	BCD1	31
1310	Ed Jaramelnik well #2	83	47	09S	13E	33	CAB1	31
1311	Rose Jaramelnik well	83	48	09S	13E	33	CBA1	31
1312		83	49	09S	13E	33	CBD1	30
1313		83	50	09S	14E	04	BBD1	40.7
1314	Dick Kaster well	83	51	09S	14E	04	BDC1	46
1315		83	52	09S	14E	04	CDB1	34
1316	Leo Ray well #1	83	53	09S	14E	04	CDC1	34
1317	Leo Ray well #2	83	54	09S	14E	04	CDD1	37
1318		83	55	09S	14E	04	DCC1	35

1319		83	56	09S	14E	05	AAA	24
1320		83	57	09S	14E	06	CDA1	20
1321		83	58	09S	14E	09	AAA	31
1322		83	59	09S	14E	09	ADA	
1323		83	60	09S	14E	09	ADB1	32
1324		83	61	09S	14E	09	ADC1	31.8
1325	Ed Kerpa well	83	62	09S	14E	09	ADD1	33
1326	Kenneth Harbast well	83	63	09S	14E	09	ADD2	33
1327	Robert Luntey well	83	64	09S	14E	09	ADD3	32
1328		83	65	09S	14E	09	BAA	32
1329		83	66	09S	14E	10	ADA1	37
1330	Wesley Reynolds well	83	67	09S	14E	10	BCC1	33
1331		83	68	09S	14E	10	CBB1	32.5
1332		83	69	09S	14E	10	DAA	28
1333		83	70	09S	14E	10	DDB1	28.5
1334		83	71	09S	14E	13	DDD1	26
1335		83	72	09S	14E	14	BAB	34
1336		83	73	09S	14E	14	BCD	36
1337		83	74	09S	14E	14	BDB1	32.5
1338		83	74	09S	14E	14	BDB1	33.3
1339		83	75	09S	14E	14	BDD1	32
1340		83	76	09S	14E	14	BDD2	35
1341		83	77	09S	14E	14	CBB	33
1342		83	78	09S	14E	14	CBC	27
1343		83	79	09S	14E	21	ABA1	
1344		83	80	09S	14E	21	ABB1	24.5
1345		83	81	09S	14E	21	ACA	30
1346		83	82	09S	14E	23	ABD1	25
1347	Wright Fuel Co. well	83	83	09S	14E	24	BCA1	24
1348	Buhl City well #1	83	84	09S	14E	36	DAC1	30
1349		83	85	09S	15E	12	CCA1	44.3
1350		83	86	09S	15E	12	CCC	49
1351		83	87	09S	15E	13	BBD1	23
1352		83	87	09S	15E	13	BBD1	46
1353	Green Giant Canning	83	88	09S	15E	31	CBB1	20
1354		83	89	09S	15E	31	CCB1	31
1355		83	90	09S	16E	20	ADD1	30.5
1356		83	91	09S	17E	32	DDA1	39.5
1357		83	92	09S	17E	33	BBB	39
1358		83	93	09S	17E	33	BBC1	39
1359	Chester McClain well #1	83	94	10S	12E	01	AAD1	26
1360	Chester McClain well #2	83	95	10S	12E	01	ACB1	26
1361	Chester McClain well #3	83	96	10S	12E	01	DCB1	25
1362	Chester McClain well #4	83	97	10S	12E	01	DCC1	25
1363		83	98	10S	12E	01	DDC1	26
1364	Dick Kirbs well #1	83	99	10S	12E	02	CCA1	25
1365	Dick Kirbs well #2	83	100	10S	12E	02	CCA2	25
1366	Chester McClain well #5	83	101	10S	12E	02	CDB1	26
1367		83	102	10S	12E	11	DCA1	24
1368	Dick Kirbs well #3	83	103	10S	12E	11	DCB1	23
1369		83	104	10S	13E	20	ADA1	41.5
1370		83	105	10S	13E	20	ADC	42
1371		83	106	10S	13E	20	ADD	40
1372		83	107	10S	14E	01	AAC	27
1373		83	108	10S	14E	01	ABB	25
1374		83	109	10S	15E	07	ABD1	25
1375		83	110	10S	16E	08	CAB1	27
1376		83	111	10S	16E	08	CDA1	31.5
1377		83	112	10S	17E	04	CAC1	37.5
1378		83	113	10S	17E	04	CCA	38

1379		83	114	10S	17E	04	CDA1	36.5
1380		83	115	10S	17E	05	ADD	33
1381		83	116	10S	17E	05	DAA1	30.5
1382		83	117	10S	17E	10	BDC	36
1383		83	118	10S	17E	14	CCD1	30.5
1384		83	119	10S	18E	06	BBB1	41.5
1385		83	120	10S	18E	06	BBB2	42
1386	U. S. Steel-Hansen Plant	83	121	10S	18E	26	BBA1	20
1387		83	122	11S	16E	06	DBA1	20
1388		83	123	11S	16E	24	AAA1	20.5
1389		83	124	11S	16E	34	CCB1	21
1390		83	125	11S	17E	16	BBA1	21
1391		83	126	11S	17E	26	ABC1	20.5
1392		83	127	11S	17E	29	BBB1	30
1393		83	128	11S	19E	14	ABB2	20
1394		83	129	11S	19E	14	DAD1	20.5
1395		83	130	11S	19E	21	DAA1	26.5
1396	Stanger Brothers well	83	131	11S	19E	24	ACB1	23
1397		83	132	11S	19E	26	ACC1	27
1398		83	133	11S	19E	27	BCD1	24
1399	Dean Kidd well #1	83	134	11S	19E	31	BDA1	27
1400	Therman Willis well	83	135	11S	19E	31	CDC1	28
1401	Dean Kidd well #2	83	136	11S	19E	31	DDD1	29
1402	Frank Barrows well	83	137	11S	19E	32	CDD1	28
1403		83	138	11S	19E	33	CDD1	32
1404	Sam High and Sons well	83	139	11S	19E	33	DDD1	33
1405		83	140	11S	19E	34	DBA1	25.5
1406		83	141	11S	19E	35	BDD1	25
1407	Ray Stanger and Sons well	83	142	11S	19E	35	CCD1	28
1408		83	143	11S	19E	36	DAC1	23
1409		83	144	11S	19E	36	DCC1	24.5
1410		83	145	11S	20E	33	AAD1	22.5
1411	Theodore Sturgill well	83	146	11S	20E	34	CCC1	32
1412	Pete Salizer well	83	147	12S	16E	36	CAD1	34
1413		83	148	12S	16E	36	DBC2	33
1414		83	149	12S	17E	06	CBB1	37
1415		83	150	12S	17E	16	BAB	23
1416		83	151	12S	17E	31	BAA	37
1417		83	152	12S	17E	31	BAB1	37
1418	Nat-Soo-Pah W.S.	83	153	12S	17E	31	BAB1s	36
1419		83	154	12S	17E	31	BAB2	35.5
1420		83	155	12S	17E	31	BAB2s	35.5
1421		83	156	12S	18E	01	BBA1	38
1422		83	157	12S	18E	01	BBD1	41
1423		83	158	12S	18E	04	ABD1	34
1424		83	159	12S	18E	06	ADC1	33.5
1425		83	160	12S	18E	24	BBD1	25.5
1426		83	161	12S	18E	24	CBA	29
1427		83	162	12S	18E	36	BBA1	25
1428		83	163	12S	19E	01	DBB	26
1429		83	164	13S	15E	01	DAD1	35.5
1430		83	165	13S	16E	01	DCC1	32
1431	Roger Jones well	83	166	13S	16E	12	ABB1	35
1432		83	167	13S	16E	12	ABB2	36.5
1433		83	168	13S	16E	12	DDA1	36.5
1434		83	169	13S	16E	18	DAA1	30.5
1435		83	170	13S	17E	06	BCD4	35.5
1436	Jones Corp. well #1	83	171	13S	17E	06	CAB1	39
1437	Jones Corp. well #2	83	172	13S	17E	06	CBA1	39
1438		83	173	13S	17E	06	CBB	24

1439	Jones Corp. well #3	83	174	13S	17E	06	CBD1	39
1440	Hollister Village well	83	175	13S	17E	07	BAB1	34
1441		83	176	14S	15E	14	CBD1	32
1442		83	177	14S	15E	16	DDC1	26
1443		83	178	14S	15E	23	DCC1	20.5
1444		83	179	14S	15E	35	CDD1	32
1445	H-Bar-H Ranch well	83	180	16S	17E	30	ACA1	45
1446	Magic Hot Springs (1)	83	181	16S	17E	30	ACA1s	43
1447	Magic Hot Springs (2)	83	182	16S	17E	30	ACA2s	45.5
1448	Rocky Canyon H.S.	85	1	11N	05E	29	CDB1s	49
1449		85	2	11N	07E	16	AAB1s	65
1450		85	3	12N	05E	02	CCC1s	46.5
1451	Goat W.S.	85	4	12N	05E	02	DAC1s	
1452	Dash Creek W.S.	85	5	12N	05E	10	DDC1s	59
1453	Ground Hog W.S.	85	6	12N	05E	11	BBD1s	38
1454	Boiling Springs H.S.	85	7	12N	05E	22	BBC1s	85
1455	Silver Creek Plunge	85	8	12N	05E	36	DBA1s	39
1456		85	9	13N	03E	13	AAB	27
1457		85	10	13N	03E	13	ADA1s	45.5
1458	Cabarton Hot Springs	85	11	13N	04E	31	CAB1s	63
1459	Bull Creek H.S.	85	12	13N	06E	29	DAB1s	
1460	Bear Valley H.S.	85	13	13N	10E	22	DAB1s	
1461	Cascade Reservoir H.S.	85	14	14N	03E	05	A1s	
1462		85	15	14N	03E	31	BDD1	30
1463		85	16	14N	03E	31	BDD2	38
1464		85	17	14N	03E	35	AB	27
1465		85	18	14N	03E	36	AAC1	37
1466		85	19	14N	03E	36	ABD1	42.5
1467		85	20	14N	03E	36	ADA1	20
1468	Vulcan Hot Springs	85	21	14N	06E	11	BDA1s	88.5
1469	Sulphur Creek H.S.	85	22	14N	09E	13	A1s	
1470	Dagger Creek Hot Springs	85	23	14N	10E	30	ADA1s	42
1471		85	24	15N	03E	05	AA	27
1472		85	25	15N	03E	13	BBC	33
1473	Arling W.S.	85	26	15N	03E	13	BBC1s	33.5
1474		85	27	15N	03E	13	BBD1	28
1475		85	28	15N	03E	13	BBD2	31
1476	Badley W.S.	85	29	15N	04E	21	CBB1s	38
1477		85	30	15N	04E	21	DCC1s	36
1478	Warm Lake Springs	85	31	15N	06E	13	ACA1s	
1479	Molly's H.S.	85	32	15N	06E	14	ABB1s	59
1480		85	33	15N	06E	14	CAC1s	57
1481	Trail Creek Hot Springs ?	85	34	15N	06E	17	DCC1s	51
1482	Trail Creek H.S.	85	35	15N	06E	20	AAC1s	50
1483	Sheepeater Hot Springs	85	36	15N	10E	24	BBB1s	49
1484	Trail Flat Hot Springs	85	37	15N	10E	29	BDA1s	50
1485		85	38	16N	04E	06	BAC	27
1486	Gold Fork H.S.	85	39	16N	04E	35	CCB1s	50
1487		85	40	16N	06E	14	CCC1s	20.5
1488	Upper Pistol Creek H.S.	85	41	16N	10E	14	CDA1s	
1489	Little Pistol Creek H.S.	85	42	16N	10E	14	DBA1s	
1490	Pistol CreeK H.S.	85	43	16N	10E	14	DBC1s	46
1491		85	44	16N	12E	15	AAA1s	65
1492	Sunflower Hot Springs	85	45	16N	12E	15	BBA1s	66
1493	Riverside H.S.	85	46	16N	12E	16	CBB1s	59
1494		85	47	17N	06E	02	BAA1s	47
1495		85	48	17N	07E	31	BCB1s	35
1496	Kwiskwis H.S.	85	49	17N	10E	11	BBA1s	69
1497	Middle Fork Indian Creek	85	50	17N	11E	16	ACB1s	72
1498	Indian Creek H.S.	85	51	17N	11E	21	B2s	88

1499		85	52	17N	13E	27	ACC1s	56
1500		85	53	17N	13E	27	DDB1s	54
1501		85	54	17N	13E	27	DDB2s	
1502		85	55	17N	13E	27	DDB3s	
1503	Hospital Hot Springs	85	56	17N	14E	05	BAB1s	46
1504		85	57	18N	06E	09	AB1s	60
1505		85	58	18N	06E	09	ADC1s	62
1506	Hot Creek W.S.	85	59	18N	08E	17	BDA1s	36
1507		85	60	20N	05E	13	BCC1s	31.5
1508	Lick Creek W.S.	85	61	20N	05E	15	DAB1s	33
1509	Sheep Creek H.S.	85	62	20N	07E	35	A1s	58
1510	Secesh H.S.	85	63	21N	05E	11	D1s	
1511	Cove Creek Hot Springs	87	1	10N	03W	09	CCC1s	
1512	Boulder Creek Resort	87	2	11N	01E	34	DAD1s	28
1513	Elvin Craig well	87	3	11N	02W	16	AAB1	21
1514		87	4	11N	02W	16	AAC1	20.5
1515	Phil Soulen well	87	5	11N	02W	27	ADB1	25
1516	Crystal Hot Springs	87	6	11N	02W	29	DADs	56
1517	Crane Creek Hot Springs	87	7	11N	03W	07	BDB1s	85
1518		87	8	11N	03W	07	BDB2s	57
1519		87	9	11N	03W	07	CCB1s	77
1520	Chrestensen A-1	87	10	11N	03W	29	BBB	162.8
1521	William Brummett well	87	11	11N	04W	33	DBA1	38
1522	Douglas McGinnis well	87	12	11N	05W	20	BDD1	21
1523		87	13	11N	05W	26	CDC	22
1524		87	14	11N	05W	32	AAA	21
1525		87	15	11N	06W	03	DBB1	24
1526	Hill Stock Well (Glen Hill)	87	16	11N	06W	03	DCB1	28
1527		87	17	11N	06W	09	ADD	26
1528	Weiser H.S.	87	18	11N	06W	10	ACB1s	22
1529	Weiser Hot Springs, Well #2	87	19	11N	06W	10	ACC2?	77
1530		87	20	11N	06W	10	CBD	43
1531		87	21	11N	06W	10	CCA1	73
1532	Geosolar Growers well #1	87	22	11N	06W	10	CCA2	77
1533	Geosolar Growers well #3	87	23	11N	06W	10	CCA3	76
1534		87	24	11N	06W	10	CCC1	32
1535		87	25	11N	06W	10	CCC2	71
1536		87	26	11N	06W	10	CCC3	71
1537		87	27	11N	06W	10	CCC4	54
1538		87	28	11N	06W	10	CCD	71
1539	Nakamura Brothers well	87	29	11N	06W	15	DDA1	30
1540	Chas Taylor Well	87	30	12N	01E	16	DDD	22
1541	Frank Chandler well	87	31	12N	05W	33	DBC1	24
1542	Old Homestead W.S.	87	32	12N	06W	28	BBB1s	
1543	Cache Valley Well	87	33	13N	01E	33	ACA	21
1544	Cutler Warm Spring	87	34	13N	02W	27	DBD	23
1545		87	35	13N	03W	05	BCB1	22.5
1546	Midvale City well	87	36	13N	03W	08	CCC1	29
1547	Morning Glory Pool	87	37	13N	03W	23	ACB	51
1548	Morning Glory Pool	87	38	13N	03W	35	DDAs	51
1549	Fairchild Lumber Co.	87	39	13N	04W	13	BAC1	25
1550	Blue Springs	87	40	13N	05W	29		28
1551	Lakey H.S.	87	41	14N	02W	06	BBA1s	70
1552	Salubria Cemetery well	87	42	14N	02W	06	DCB1	23
1553	Cambridge City well	87	43	14N	03W	03	DDC1	26
1554	Fairchild Hot Springs	87	44	14N	03W	19	CBD1s	52
1555	Kermit Wiggins well	87	45	15N	03W	10	DBC1	21
1556	R.W. Tolman Well	87	46	15N	06W	34	CCC	20.5

UNIVERSITY OF UTAH RESEARCH INSTITUTE
UURI
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108-1295
TELEPHONE 801-524-3422

July 8, 1994

Mr. John Kauffman
Idaho Water Resources Research Institute
Morrill Hall, 106
University of Idaho
Moscow, Idaho 83843

Dear John:

Thanks for the opportunity to review your draft final report "Overview of Geothermal Investigations in Idaho, 1980 to 1992", and the other materials which you sent last month. I apologize for the long delay in responding with comments; an out of state field job and a case of pneumonia combined with other work has left me way behind in my work. Although I have not taken time to complete a very detailed reading of the entire report it may be useful to forward some general thoughts now.

OVERVIEW OF GEOTHERMAL INVESTIGATIONS OF IDAHO, 1980 TO 1992

This is an excellent report with good background information and a very detailed geologic and utilization discussion for all the main resource areas. It reads well and seems to be quite free from typos and mechanical problems, but I admit to a cursory review. I did note a few areas on the early pages where some wording changes may help the reader, and a few pages are enclosed. The report format is somewhat different than that being used by most of the state teams, so I am enclosing copy of the general outline the state teams are using. Your discussion of individual resource areas is more complete, but the report lacks short, general (statewide) Summary, Discussion, and Recommendations sections that may be useful to the reader. The most important addition at this late date, may be a summary discussion about critical study areas, the collocation of resources with potential users, and priority areas for future study. This would be useful to IWRRI, OIT, and UURI in evaluating future (Phase 2?) detailed work. The report should have a DOE standard DISCLAIMER and an acknowledgement of funding as a separate item.

DATABASE TABLES

Most of the state teams integrated older (pre 1980) and new well and spring information in a single database, which may have included two or three different tabulations. Only metric units were used in accord with DOE's adoption of the SI system. The chemistry tables generally contain fewer chemical species than the IWRRI database, but try to include all the main geothermal indicators. The teams all completed a charge balance (cation/anion) to evaluate the quality of the chemistry, and used this to eliminate poor quality chemical analyses. Most teams have decided to omit geothermometry, feeling that it might be misleading without additional analysis and comment. An example of the Utah database is enclosed for your information. The IWRRI database seems to include almost all the important data (except charge balance), with some duplication due to units. The English units may well be of use to many Idaho users.

BIBLIOGRAPHY

This is a great compilation which seems to bring together all the previously reported literature. It should save future workers much time. Too bad it couldn't be easily cross-referenced with areas. Good job!

GEOGRAPHICAL VARIABILITY OF GROUND WATER GEOTHERMAL HEAT PUMPS..

This is a good paper with new information since the GRC paper. It makes a good arguement for ground water source heat pumps. A few comments are noted in the text.

MAPS

The maps look good and offer a nice breakdown of temperature ranges. Many (but not all) of the state teams have been able to label wells and springs with identification numbers which cross reference the detailed information in the tables. See copies of the Utah map enclosed.

I hope these comments may be of some use, but I realize the project is drawing to a close and it may be difficult to incorporate any substantial changes. IWRRI has done a nice job with the deliverables. Please call me at (801) 584-4444 if you wish to discuss any of my comments.

Sincerely,

Howard

Howard Ross
Section Head/Applied Geophysics

encl.

WATER
for
IDAHO

Idaho Water Resources
Research Institute

Leland L. Mink
Director
Morrill Hall 106
University of Idaho
Moscow, Idaho
83843

Phone: (208) 885-6429
FAX: (208) 885-6431

Al E. Murrey
Associate Director
2110 Ironwood Parkway
Coeur d'Alene, Idaho
83814

Phone: (208) 765-0590
FAX: (208) 667-4869

June 6, 1994

Dr. Howard Ross
University of Utah Research Institute
391 Chipeta Way, Suite C
Salt Lake City, UT 84108-1295

Dear Howard:

I am sending under separate cover several items for review and comment. These include: 1) a draft report entitled *Overview of Geothermal Investigations in Idaho, 1980 to 1992*; 2) *Bibliography of Idaho Geothermal Resources*; 3) a diskette with the geothermal database files (in DBase III Plus); 4) the draft report on geothermal heat pumps entitled *Geographical Viability of Ground Water Geothermal Heat Pumps in the United States*; and 5) two maps of Idaho geothermal resources at a scale of 1:1,000,000. Map 1 depicts only those wells and springs included in the geothermal database developed for this project; map 2 includes all reported wells and springs in Idaho.

Any comments or suggestions you have would be appreciated.

Sincerely,

John Kauffman

Enclosures

xc: Roy Mink

BIBLIOGRAPHY OF IDAHO GEOTHERMAL RESOURCES

by

William J. Dansart
John D. Kauffman
Leland L. Mink

Idaho Water Resources Research Institute
University of Idaho
Moscow, Idaho

April, 1994

ABSTRACT

This report is a listing of over 700 references to investigations and information sources of Idaho geothermal resources. The earliest work noted is *A report on fluorite equilibria in thermal springs in the Snake River Basin* by Roberson and Schoen (1873). The most recent reference is *Compilation of selected data for thermal-water wells and springs in Idaho, 1921 through 1991* by Parliman and Young (1992). The purpose of this report is to provide a guide to available sources of information that can be utilized by parties interested in Idaho warm water resources. Funding for this report was provided by the U. S. Department of Energy as part of a more comprehensive assessment of Idaho geothermal resource data.

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