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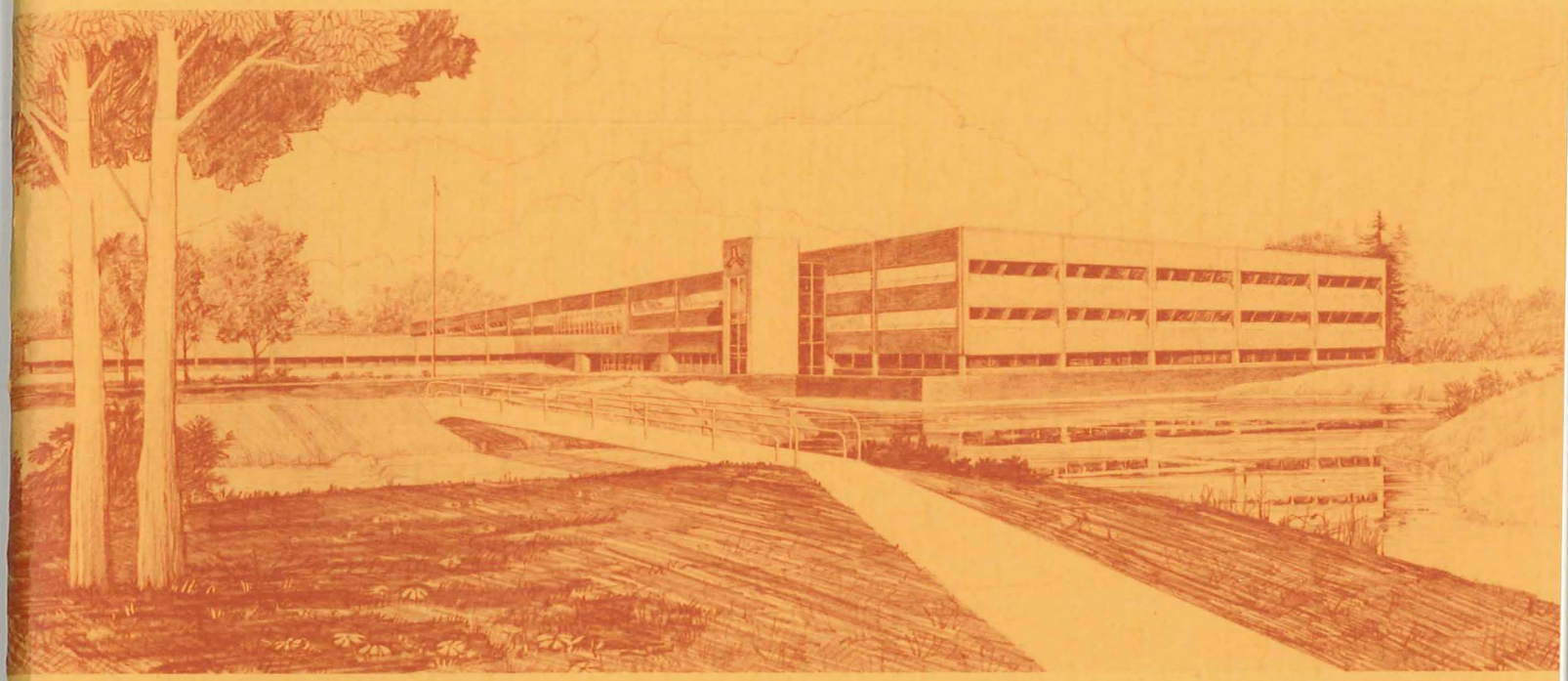

U.S. Department of Energy
Idaho Operations Office • Idaho National Engineering Laboratory

Potential Use Of Geothermal Resources In The Snake River Basin: An Environmental Overview

VOLUME I

Susan G. Spencer
Brent F. Russell
Jacquelyn F. Sullivan
Editors

September 1979

Prepared Under DOE Contract No. DE-AC07-76-IDO 1570

EG&G Idaho

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B. Moore	J. Gladwell
N. Savage	C. Warnick

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Geotechniques, Inc.

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C. Miller	Hydrology and Water Quality
C. Warnick	Hydrology and Water Quality

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K. McCarthy	Aquatic Ecology

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T. Anstett	Bureau of Land Management
E. Chew	Department of Energy, Idaho Operations Office
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CONTENTS

POTENTIAL USE OF GEOTHERMAL RESOURCES IN THE SNAKE RIVER BASIN: AN ENVIRONMENTAL OVERVIEW VOLUME I

ABSTRACT

Environmental baseline data for the Snake River Plain known geothermal resource areas (KGRAs) are evaluated for geothermal development. The objective is to achieve a sound data base prior to geothermal development. These KGRAs are: Vulcan Hot Springs, Crane Creek, Castle Creek, Bruneau, Mountain Home, Raft River, Island Park, and Yellowstone. Air quality, meteorology, hydrology, water quality, soils, land use, geology, subsidence, seismicity, terrestrial and aquatic ecology, demography, socioeconomics, and heritage resouces are analyzed. This program includes a summary of environmental concerns related to geothermal development in each of the KGRAs, an annotated bibliography of reference materials (Volume II), detailed reports on the various program elements for each of the KGRAs, a program plan identifying future research needs, and a comprehensive data file.

INTRODUCTION

EG&G Idaho, Inc., has completed an environmental analysis for the known geothermal resource areas (KGRA) in the Snake River Basin. EG&G Idaho, Inc., has performed this preplanning environmental program under the auspices of the Office of Health and Environmental research of the U.S. Department of Energy (DOE). KGRAs included under this program (see Figure 1) are Vulcan Hot Springs, Crane Creek, Castle Creek, Bruneau, Mountain Home, Raft River, Island Park, and Yellowstone.

The ultimate goal of this environmental program is to reduce the delays in geothermal development while minimizing environmental impacts by (a) assessing the existing environmental baseline data for the KGRAs, (b) evaluating those data for adequacy and applicability, and (c) developing a plan for supplementing the existing data to achieve a sound environmental data base prior to geothermal development.

Regional universities and consulting agencies were contracted to evaluate the environmental data and concerns. A steering committee was established to serve as program consultants which included representatives from State and Federal agencies, public interest groups, and national laboratories.

Results from the environmental program thus far include a summary of the environmental concerns related to geothermal development in each of the KGRAs, an annotated bibliography of reference materials, detailed reports on the various program elements for each of the KGRAs, a program plan identifying future research needs, and a comprehensive data file. These will serve: (a) as planning tools for state and federal energy, environmental, and land management agencies, (b) as reference documents for developers to shorten and simplify project environmental evaluations, and (c) to identify the significant environmental concerns for each KGRA so that mitigation measures can be incorporated early in the development process.

This report summarizes the environmental concerns identified in the technical reports and those brought out in two public workshops. Current commitments that might affect further geothermal development are outlined. The objective of the report is to address the following questions:

1. Could an environmental impact be determined after development, based on the information that is now available?

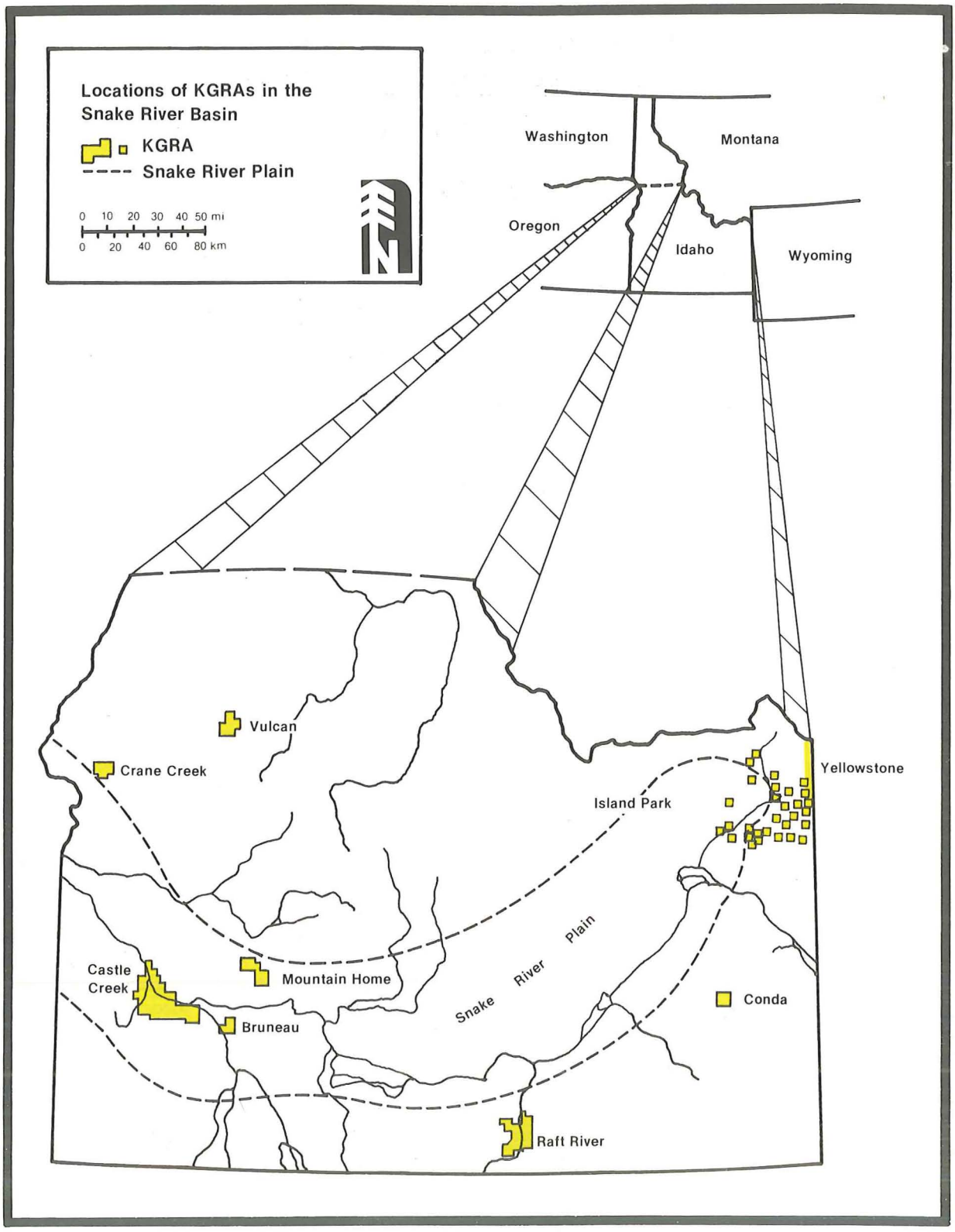

Figure 1. Map of regional setting.

2. Are there existing or potential commitments that would restrict geothermal development, (historic areas, trails, closed ground water basins, etc.)?

3. Are there land use restrictions that would affect geothermal development?

This report presents the information in three ways:

1. A summary of the environmental and geothermal characteristics of each KGRA

2. A presentation of the concerns by program element

3. Tables detailing the key findings of each program element.

As a matter of interest, a summary of Federal and State environmental regulations for geothermal exploration, development, and use is presented in Appendix B.

Two public workshops were held in Boise, Idaho, during the initial phases of the program. The objectives of these workshops were to identify and discuss public concerns, issues, and potential environmental impacts related to geothermal development. The results of these workshops are summarized in Appendix C.

A bibliography of materials pertinent to the KGRAs is presented by subject in Volume II. Cross-referencing is available for those references which are applicable to specific KGRAs.

Detailed information for the KGRAs is contained in the following reports:[a]

EGG-GTH-5001 — Vulcan Hot Springs KGRA: An Environmental Analysis

EGG-GTH-5002 — Crane Creek KGRA: An Environmental Analysis

EGG-GTH-5003 — Castle Creek KGRA: An Environmental Analysis

EGG-GTH-5004 — Bruneau KGRA: An Environmental Analysis

EGG-GTH-5005 — Mountain Home KGRA: An Environmental Analysis

EGG-GTH-5006 — Raft River KGRA: An Environmental Analysis

EGG-GTH-5007 — Geothermal Development in Southwest Idaho: The Socioeconomic Data Base

Reports EGG-GTH-5001 through EGG-GTH-5007 are available from the editors at:

EG&G Idaho, Inc.
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KGRA OVERVIEW

The summary for each KGRA and its environment includes information on geothermal resources, geology, topography, soils, climate, air quality, water resources, ecology, socioeconomics, demography, land use, and heritage resources. The primary environmental concerns relating to geothermal development in each KGRA are analyzed. Additional information can be obtained from the environmental reports for each KGRA or from the references presented in the bibliography (Volume II).

a. An environmental analysis of potential geothermal development in the Island Park and Yellowstone KGRAs is presented in the "Environmental Statement of the Island Park Geothermal Area," U.S. Department of Agriculture, Forest Service, and U.S. Department of Interior, Bureau of Land Management (01-15-79-02). A separate volume for these KGRAs will not be presented as part of this series.

1.0 Vulcan Hot Springs KGRA

1.0 Vulcan Hot Springs KGRA

The 1552-hectare (ha) Vulcan Hot Springs KGRA is located in Valley County near the headwaters of the South Fork of the Salmon River (Figures 2 through 5). Land within and surrounding the KGRA is part of the Boise National Forest and is under multiple-use management. The topography is rugged with elevations ranging from 1630 m to over 2190 m. Primary land uses in the region include timber production, watershed maintenance, and recreation. Significant mining occurred in the area in the late 1800s, and several lead and silver mines near the KGRA remain active. Access to the hot springs is from Cascade, 48 km by road to the west of the KGRA.

Vulcan Hot Springs, located above the South Fork, are composed of 13 vents with a combined discharge of 32 l/second and a surface temperature of 84°C. Estimates of the subsurface temperature based on water chemistry are 135°C (quartz) and 147°C (Na-K-Ca).[1] These estimates indicate the resource may be a candidate for power generation. A chemical analysis of the effluent from the hot springs is shown in Table 1. With the exception of the fluoride content, the quality of the fluids is excellent.

Physical Environment

The topography of the region consists of uplands to elevations of 2200 m, dissected mountain slope lands, and valleys at elevations of 1650 m. The dark colored, subhumid forest soils which were formed over fractured granite bedrock on steep slopes have a high erosion hazard.

The KGRA is located within the Idaho Batholith, a plutonic igneous body of quartz monzonite and granodiorite emplaced during the late Cretaceous period over much of Idaho. Surficial deposits of recent alluvium occur in the valley of the South Fork which is aligned along a possible fault. Unconsolidated morainal deposits dating from the Late Pleistocene-period alpine glaciation occur on some slopes. North-south trending faults forming the western margin of the batholith occur west of the KGRA and appear to be a structural control on the Vulcan and on other hot springs in the area.

Historic earthquake records show a significant amount of seismic activity in the vicinity of the KGRA. A swarm of activity occurred to the east in Bear Valley with the closest event 15 km from the KGRA. The available data appear to indicate a relatively high likelihood of an occasional earthquake of magnitude 7 or greater within 25 km of the KGRA. However, the data are not sufficient to indicate any recurrence interval.

Fluctuations in water levels in highly fractured and/or altered granodiorite, or in valley fill, may result in subsidence. An analysis of regional geology suggests that subsidence would not be widespread.

Because of the diverse regional topography, the climate is influenced by local orographic effects. The annual temperatures at Cascade, the nearest weather station, range from extremes of -30 to 40°C. The site receives an average annual precipitation of 914 mm, much of it falling as snow. Strong valley winds and hail up to 1.5 cm are associated with summer thunderstorms. The frequency of inversions in the valley ranges from 3.5% in the summer to 53% in the autumn. The nearest source of air pollutants to the KGRA is the lumber mill at Cascade. Due to the topography and local meteorology, effluents from this mill are not expected to affect the air quality in the KGRA.

The South Fork of the Salmon River flows to the north through the KGRA and drains a watershed of 490 km^2. The principal tributaries to the South Fork include Trail Creek, Lodgepole Creek, and Warm Lake Creek. Characteristic monthly runoff at the Knox gaging station, 10 km downstream of the KGRA, ranges from 2.2% in February to 31.7% of the total annual flow in May. Ground water data are not available for the KGRA. There are no water rights filed within the KGRA; however, one water right 6 km downstream involves a series of seven hot springs. A 570-l/second water right on the South Fork is held by the Idaho Department of Fish and Game for a salmon egg gathering facility just downstream of the KGRA.

Ecology

The Vulcan Hot Springs KGRA is located primarily in Douglas fir habitat which is extensive in Valley County. An important elk calving

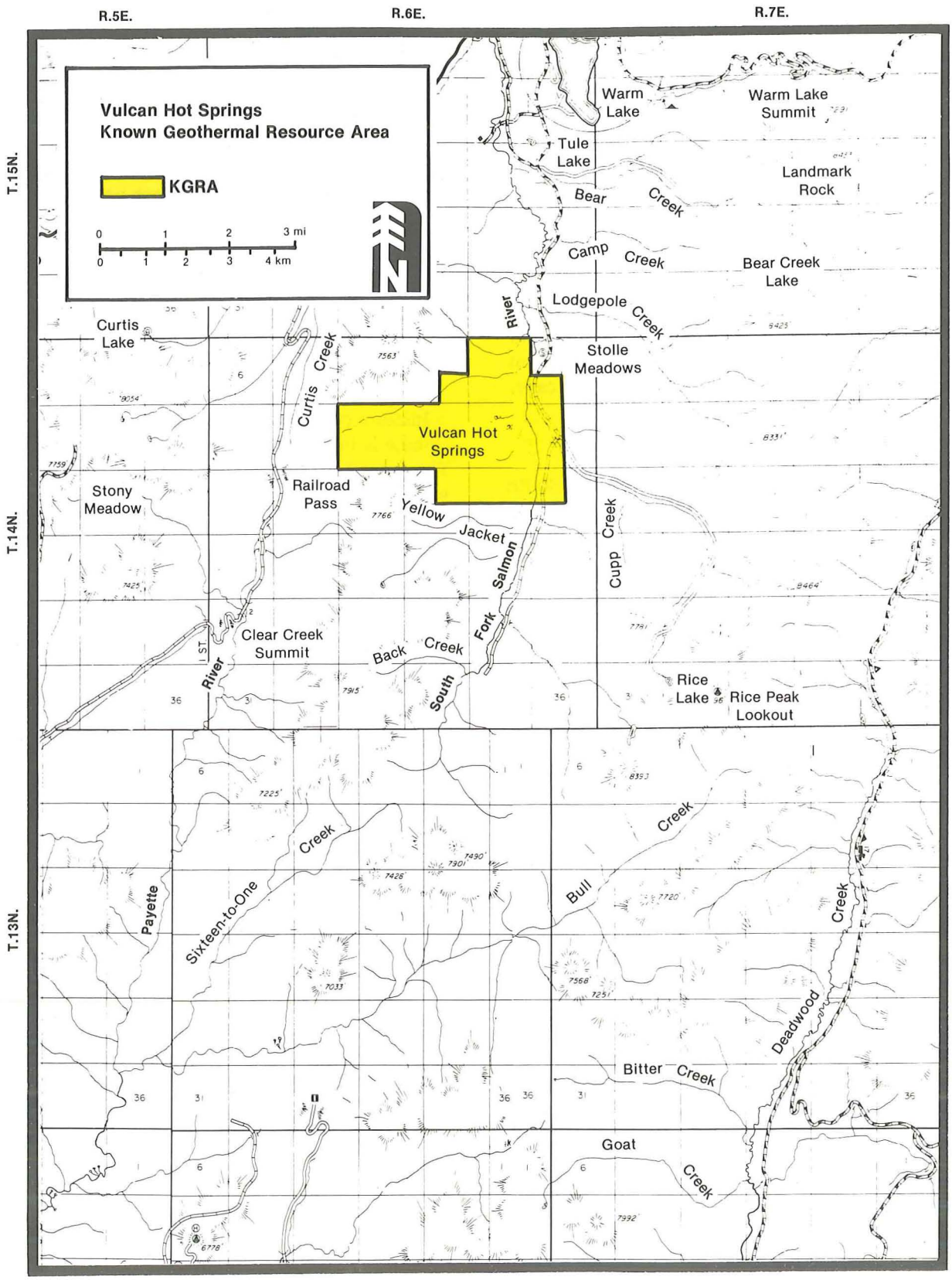


Figure 2. Map of Vulcan KGRA.

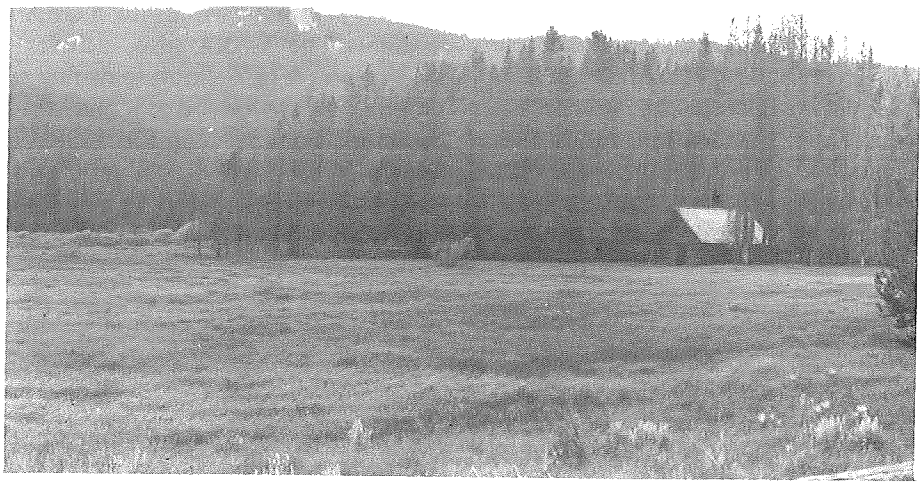


Figure 3. Stolle Meadows near Vulcan KGRA.

Figure 4. Vulcan Hot Springs.

Figure 5. Vulcan Hot Springs KGRA.

TABLE 1. CHEMICAL ANALYSIS – VULCAN HOT SPRINGS[1]

Surface Temperature (°C)	87
Discharge (l/second)	32
B (mg/l)	0.0
Ca (mg/l)	1.8
K (mg/l)	3.0
Mg (mg/l)	0.1
Na (mg/l)	94
NH_3 (mg/l)	0
SiO_2 (mg/l)	120
Cl^- (mg/l)	17
$CO_3^=$ (mg/l)	0
F^- (mg/l)	24
HCO_3^- (mg/l)	120
$NO_3^=$ (mg/l)	0.05
$SO_4^=$ (mg/l)	43
Specific Conductance (µmhos)	451
pH	8.5
Total Dissolved Solids (TDS)	361

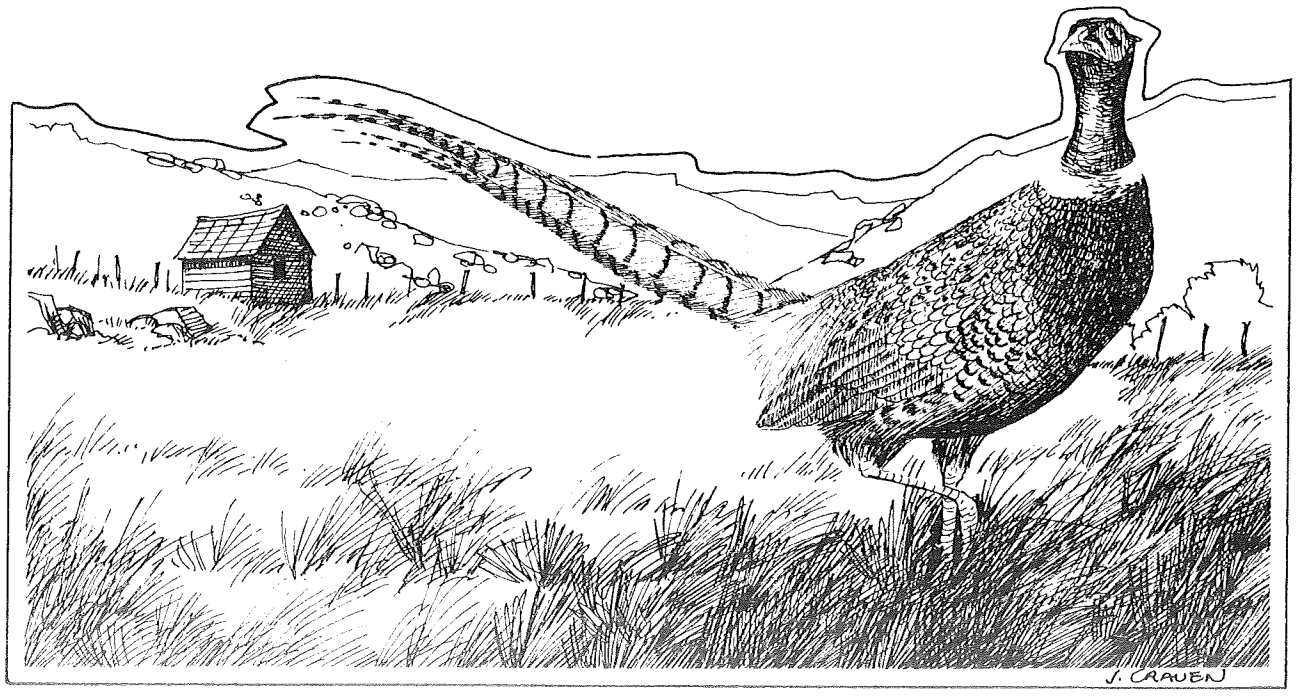
ground is located within the KGRA in a meadow habitat. The KGRA also includes a mule deer migration route. Salmon spawning grounds in the South Fork are located at Stolle Meadows near the northern boundary of the KGRA. Any disturbance of the highly erodible granitic soil in this area has the potential to destroy spawning habitat and impact the endangered salmon runs.

Socioeconomic and Heritage Resources

The cities of McCall (population 2147; 1975 census), Donnelly (population 143; 1975 census), and Cascade (population 1004; 1975 census) are located along Highway 55 west of Vulcan Hot Springs. These cities represent most of the population of Valley County. A population increase of 22% took place in these cities between 1970 and 1976, 60% of which was due to migration into the area. Similar population increases are forecast through the year 2000. Unemployment has averaged 12% over the past few years. A large portion of the labor force is employed in Federal civilian employment, logging related jobs, and seasonal employment. Per capita annual income is $5482.

Known heritage resources in the KGRA include two prehistoric lithic scatters found in creek bottoms. The area provided hunting and fishing grounds for both northern and southern Indian tribes throughout prehistoric times, and the potential for additional cultural sites is significant.

2.0 Crane Creek KGRA



2.0 Crane Creek KGRA

This KGRA is located in Washington County along Crane Creek, which flows west through a steep, narrow canyon and enters the broad Weiser River Valley (Figures 6 through 9). Of the 1757 ha included in the KGRA, 1311 are controlled by the Bureau of Land Management (BLM). The remaining lands are privately owned. Ninety-two percent of the KGRA is utilized as rangeland, while 8% is irrigated cropland.

Estimated resource temperatures from the Crane Creek Hot Springs are 166°C (Na-K-Ca) and 176°C (quartz). Sinter deposits indicate reservoir temperatures exceeding 180°C. Based on the estimated reservoir temperatures, the Crane Creek resource is one of the two hottest resources in Idaho. The Idaho Department of Water Resources has classified the area as a Designated Geothermal Resource Area. Any drilling in excess of 900 m requires a geothermal permit. The hot springs are located on the east side of a fault zone and may be controlled by a deep-seated basement fault. The springs surface along the margin of a siliceous sinter terrace or in adjacent sediments. A chemical analysis of the geothermal fluids is shown in Table 2.

Physical Environment

The Crane Creek KGRA is located along the Western Idaho Fault Zone, which marks the northern boundary of the Snake River Plain. The basement complex is believed to be composed of Paleozoic and Mesozoic metamorphosed rocks and granitic rocks of the Idaho Batholith. Most of the exposed rocks within the KGRA are lava flows, volcaniclastic sediments, and silica cemented arkosic sandstones of Miocene age. Erosion is a problem in alluvial deposits on the steep canyon slopes.

Geologic evidence suggests the faults which transect the KGRA were active in the Late Cenozoic, possibly Pliocene. Recent data show significant seismic activity slightly to the east and north of the area (within approximatley 20 km). Evidence suggests that earthquake activity could produce accelerations in the Crane Creek area in excess of 0.25 g. Although no subsidence has been documented in the KGRA, the shallow Idaho Group rocks appear to be susceptible to subsidence.

Average annual precipitation is 360 mm. Annual temperatures average 10°C, with extremes of -26 and 40°C. The maximum potential for inversions in the canyon occurs in the fall and winter. The Crane Creek KGRA is isolated from pollution sources at Weiser and does not suffer from air pollution.

Crane Creek, which drains 75 000 ha, has an average annual discharge of 7.5×10^7 m^3. Coliform bacteria counts in Crane Creek exceed drinking water standards. Typical ground water quality is shown in Table 3. Water rights consist of two surface diversions (45 l/second) and a well (0.8 l/second).

Ecology

The KGRA is located in a Tall Sagebrush habitat with some riparian vegetation. Animal species of concern in the area include mule deer, pronghorn antelope, quail, chukar, and wintering waterfowl.

Socioeconomic and Heritage Resources

The population centers of Weiser (population 4538; 1975 census), Midvale (population 409; 1975 census), and Cambridge (population 442; 1975 census) are located near the Crane Creek KGRA. County growth between 1970 and 1976 was 11.5%, over half of which was migration into the area. Population forecasts predict a steady increase in population, but a declining net migration rate through the year 2000. Per capita income in 1976 was $4870.

No archaeological survey has been conducted within the bounds of the Crane Creek area. Findings elsewhere in the county suggest that a high probability exists for prehistoric sites within the KGRA.

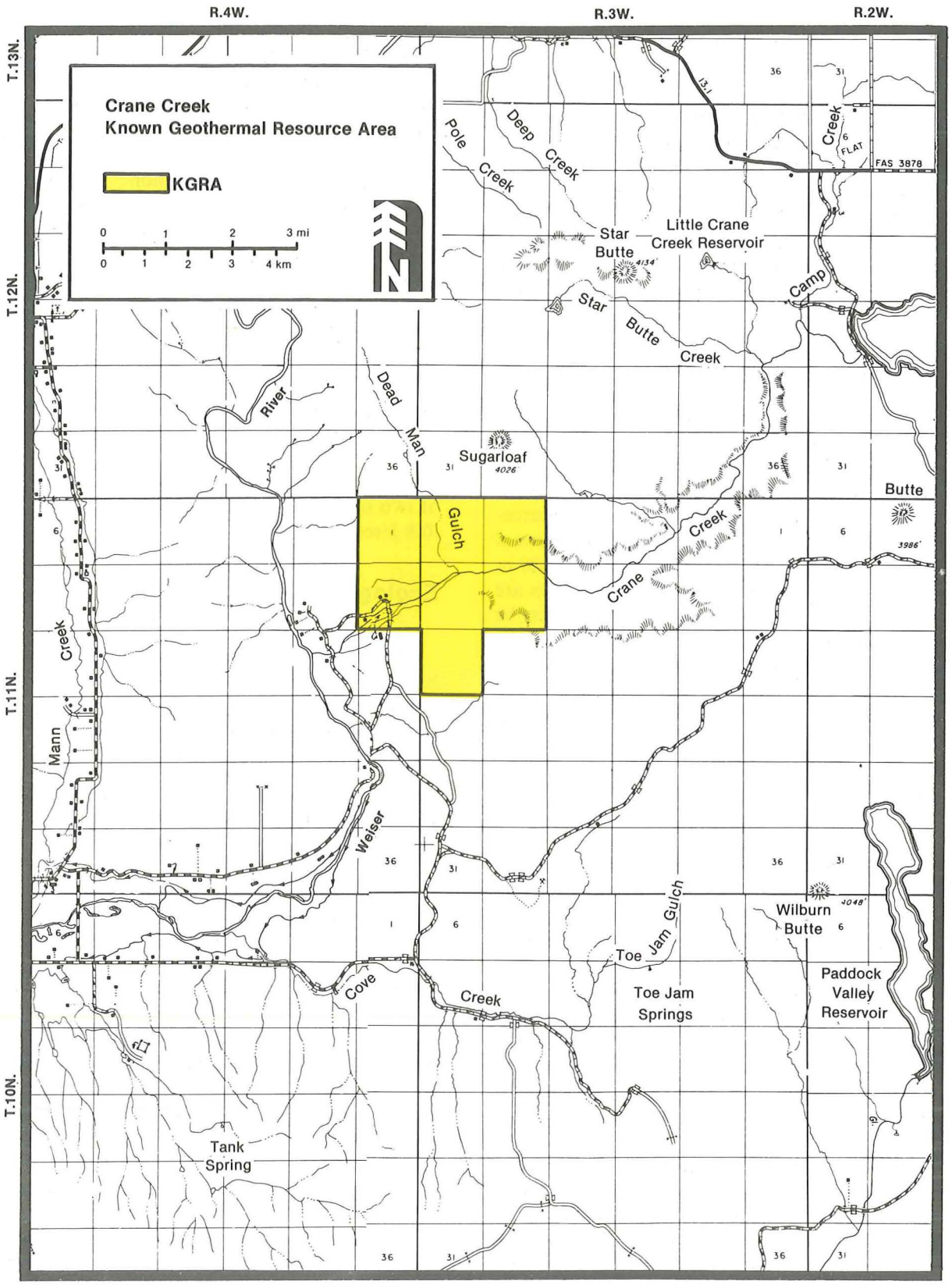


Figure 6. Map of Crane Creek KGRA.

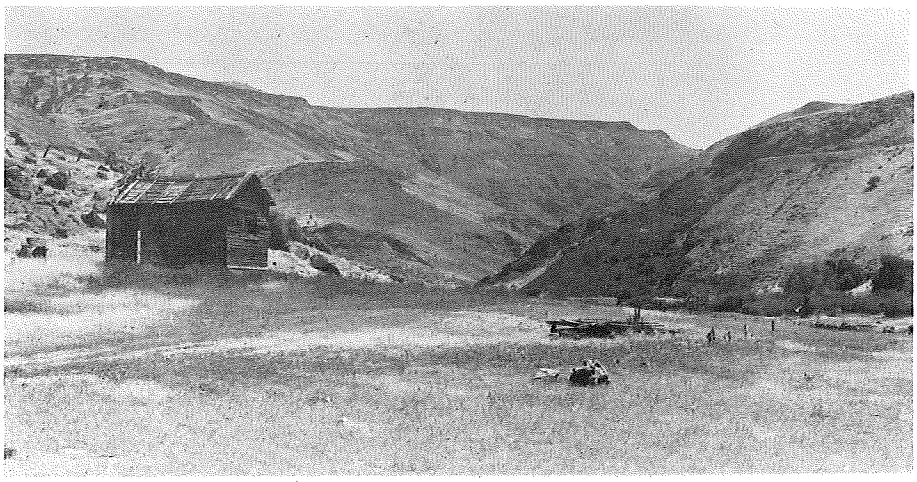


Figure 7. Crane Creek KGRA.

Figure 8. Hot spring at Crane Creek KGRA.

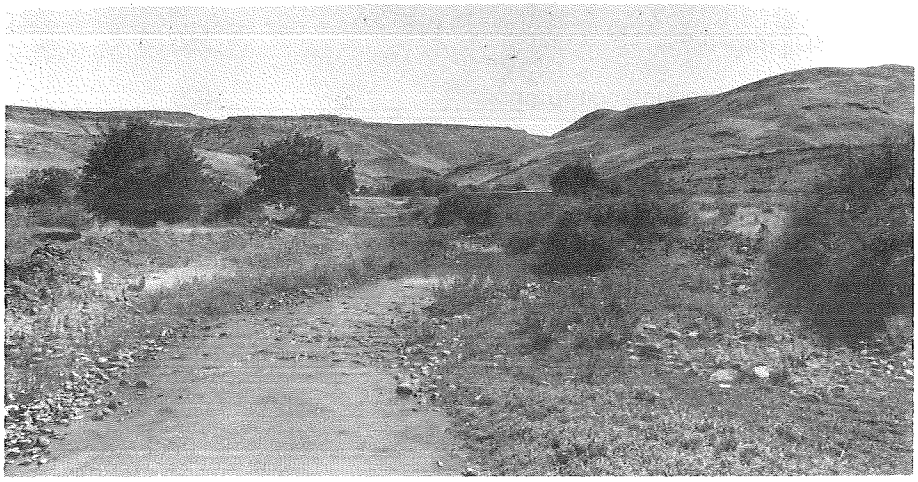


Figure 9. Crane Creek.

TABLE 2. ANALYSIS OF WATER CHEMISTRY — CRANE CREEK HOT SPRINGS[1] 11N-3W-7BDB1S

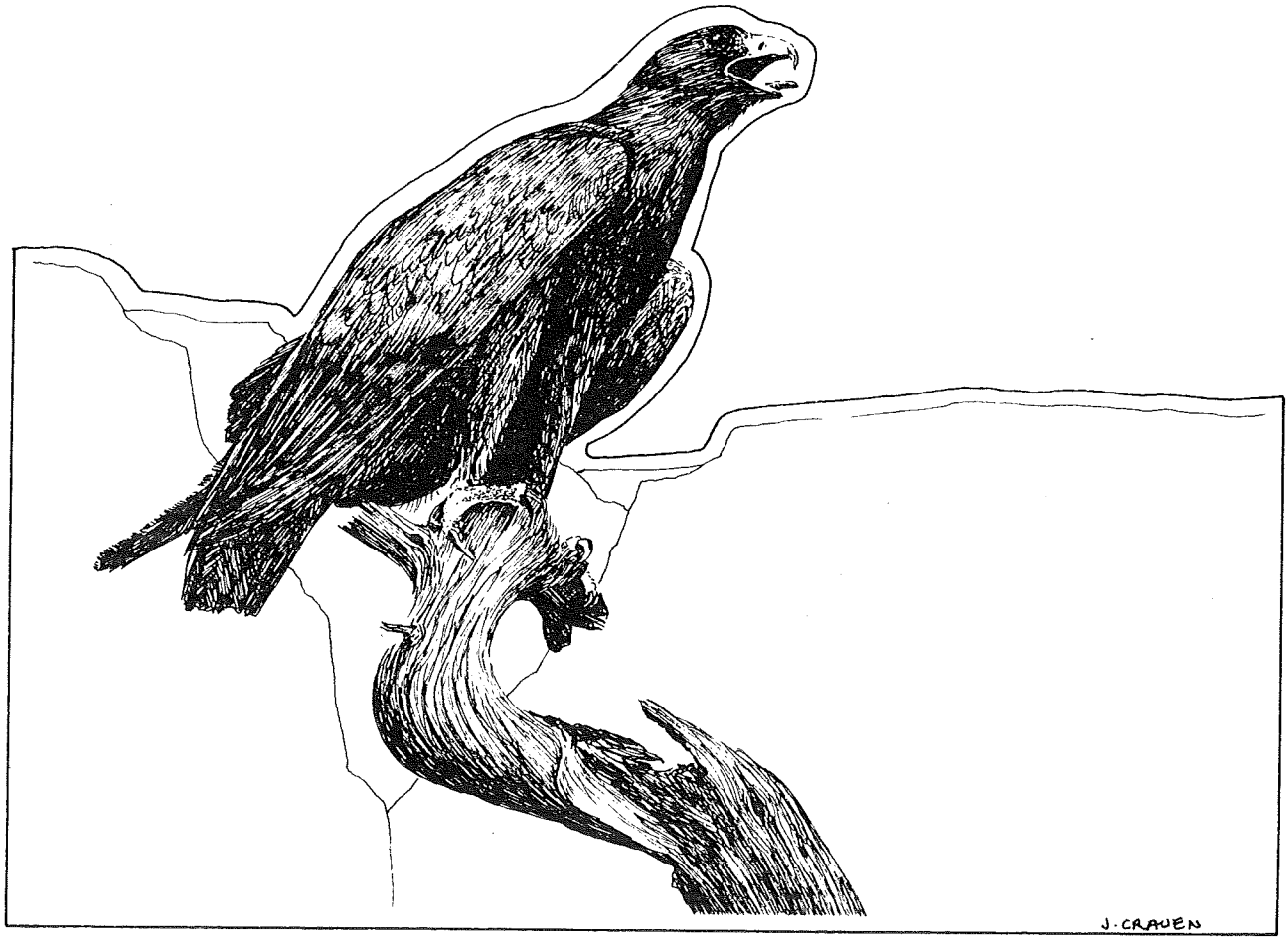
Surface Temperature (°C)	92
Discharge (l/second)	0.3
B (mg/l)	0.0
Ca (mg/l)	29
K (mg/l)	18
Mg (mg/l)	0.5
Na (mg/l)	280
NH_3 (mg/l)	10
$Si0_2$ (mg/l)	180
Cl^- (mg/l)	200
$CO_3^{=}$ (mg/l)	0.0
F^- (mg/l)	3.2
HCO_3^- (mg/l)	201
$NO_3^{=}$ (mg/l)	0.01
$SO_4^{=}$ (mg/l)	250
Specific Conductance (µmhos)	1629
pH	7.8
TDS	1059

TABLE 3. WATER QUALITY — CRANE CREEK KGRA GROUND WATER[a]

	Well 11N-4W-12CCB1	Well 11N-4W-12CDC1
Depth (m)	24	9
Ca (mg/l)	13	20
K (mg/l)	8.7	8.4
Mg (mg/l)	2.3	8.2
Na (mg/l)	89	13
SiO_2 (mg/l)	25	22
Cl^- (mg/l)	17	2.1
F^- (mg/l)	0.1	0.2
HCO_3^- (mg/l)	232	119
$SO_4^=$ (mg/l)	13	8.4
Conductivity (µmhos)	447	200
pH	8.3	7.0
TDS	294	181

a. H. W. Young and W. A. Harenberg, *Water Resources of the Weiser River Basin, West-Central Idaho,* Idaho Department of Water Resources Water Information Bulletin No. 44, 1977.

3.0 Castle Creek KGRA



3.0 Castle Creek KGRA

Castle Creek KGRA, the largest in Idaho, is located along the Snake River in Owyhee County (Figures 10 through 13). The river has dissected basalt plateaus, resulting in numerous buttes and steep canyon walls. The majority of the 32 263 ha within the KGRA is controlled by the Bureau of Land Management and is utilized for rangeland. Geothermal leases granted on nine units total 8470 ha. Nearly 2400 ha of the KGRA overlaps the Snake River Birds of Prey Natural Area (BPNA), established in 1971 to protect a large population of raptors (birds of prey).

The Castle Creek KGRA is part of the Bruneau-Grandview thermal anomaly, the largest geothermal area in the western United States (excluding Yellowstone Park). The U.S. Geological Survey estimates that 450×10^{18} J of heat are contained in a reservoir underlying 14 800 ha of land.[2] The area represents a complex geothermal system consisting of several aquifers. Thermal water is extracted from over 100 wells, which produce from volcanic and sedimentary aquifers. The most accurate temperature at depth is from a Phillips Petroleum exploratory well which reported a bottomhole temperature of 108°C at 2670 m.[1] The area may have a potential for greenhouse operations and other low-temperature, direct-heat applications, utilizing warm water from shallow depths. Chemical analyses from thermal wells in the KGRA are shown in Table 4. 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.

Physical Environment

The Castle Creek KGRA lies on the downthrown side of the southern margin of the western Snake River Plain graben. The KGRA is associated with the Western Idaho Fault Zone which is suspected to have been recurrently active since Middle Miocene. Historic records for the period 1880 through 1975 show no epicenters of "felt reports" within 80 km of the KGRA. 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. Soils range from deep and poorly drained in the valleys, to shallow and highly erodible on steep badlands topography.

The unconsolidated and semiconsolidated rocks found in the Castle Creek area have proved to be susceptible to subsidence. A decline in shallow ground water levels could be initiated or accelerated by production of deeper thermal water.

Castle Creek, the driest area of Idaho, is located in a semiarid desert with 200 mm average annual precipitation. The KGRA is characterized by clear skies and marked fluctuations in diurnal and annual temperatures.

Castle Creek, Catherine Creek, Birch Creek, and numerous intermittent streams drain from the Owyhee Mountains into the Snake River. Limited stream flow data are available for this region. Several ground water rights, most of which are for irrigation and stock watering purposes, involve geothermal waters.

Ecology

The KGRA is located primarily in the Salt Desert shrub habitat. Overgrazed areas exhibit invasion by annual grasses such as cheatgrass. Extensive riparian habitat exists along the Snake River in the northern part of the KGRA. A large variety of wildlife inhabit the area, including ruminants, large predators, songbirds, raptors, reptiles, waterfowl, and upland gamebirds.

The Birds of Prey Natural Area encompasses 12 546 ha along the Snake River Canyon which provides nesting and hunting habitat for the densest known nesting population of birds of prey in the world. Each year well over 1000 eagles, falcons, hawks, and other birds of prey return to a 130-km reach of the canyon to court, mate, and rear young. This concentration of raptors annually includes an estimated 5% of the world's total nesting population of prairie falcons.

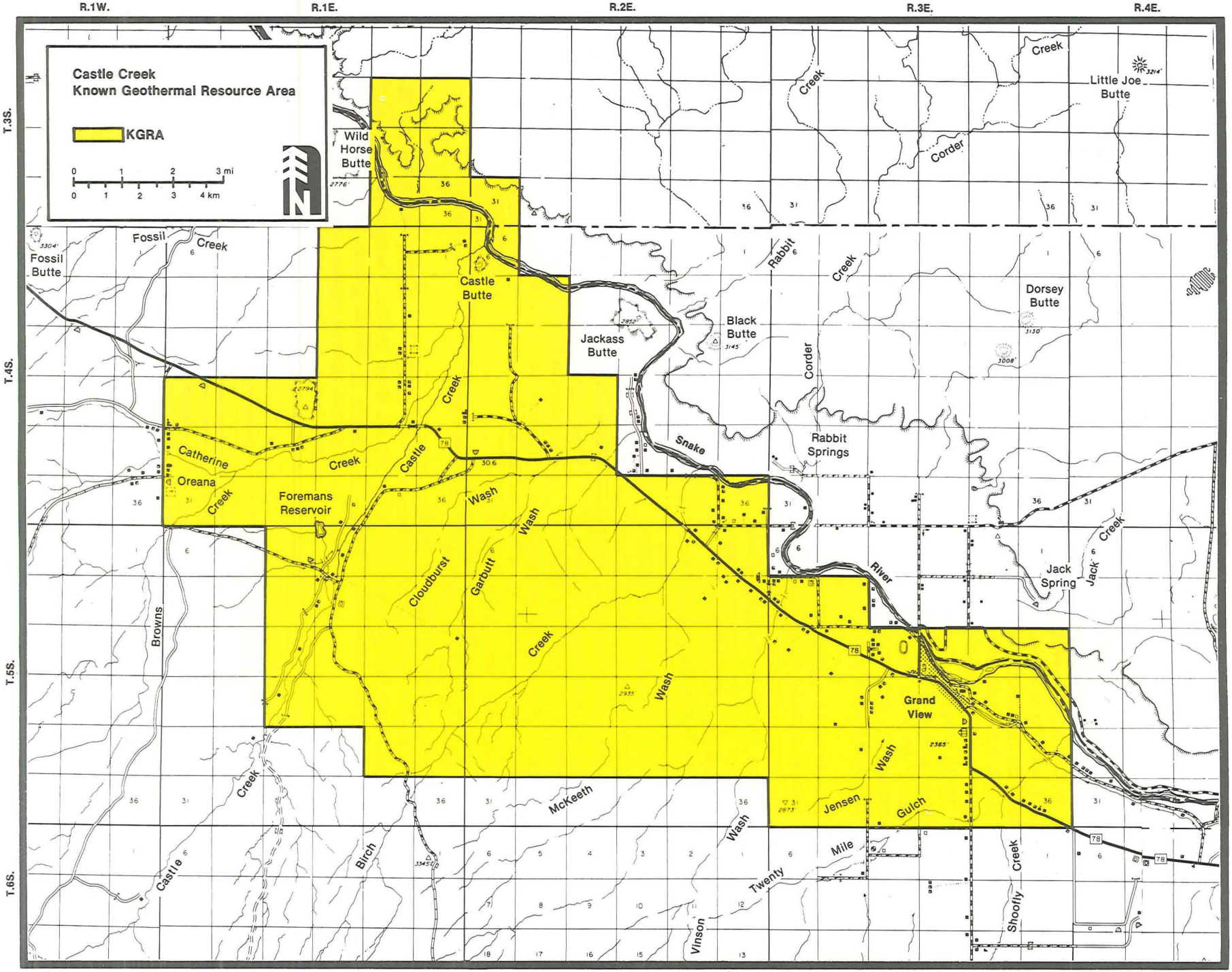


Figure 10. Map of Castle Creek KGRA.

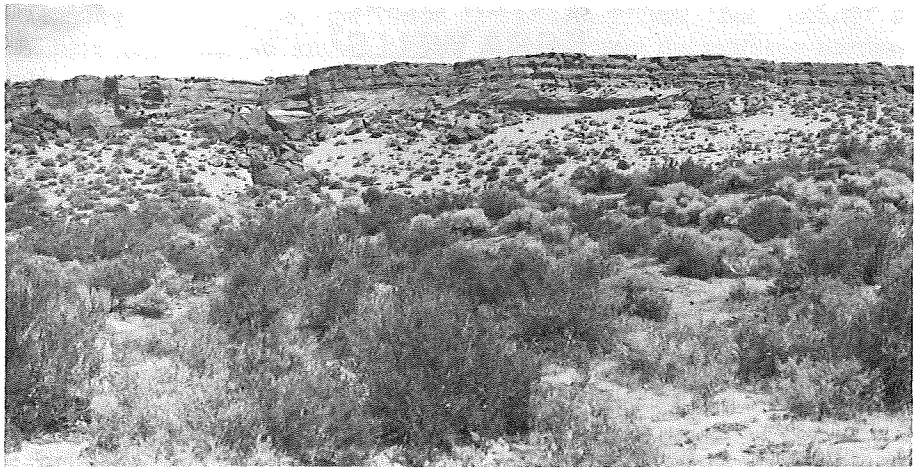


Figure 11. Castle Creek KGRA.

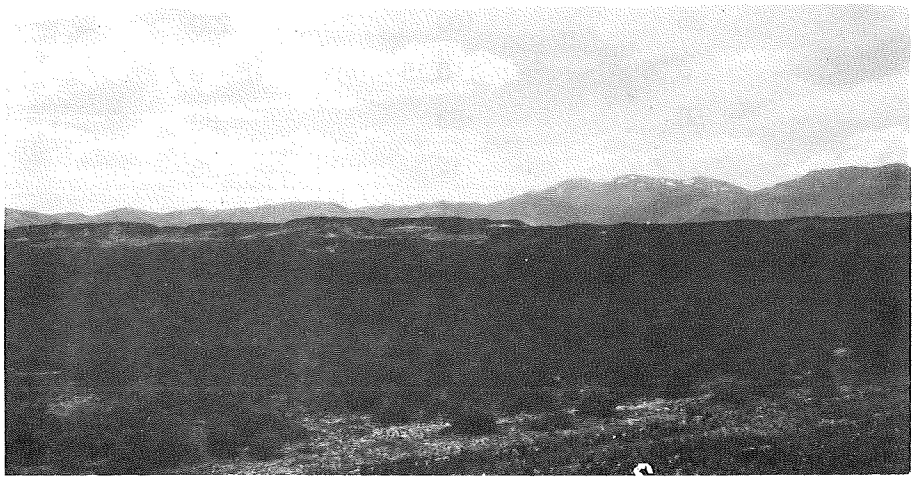


Figure 12. Castle Creek KGRA, looking west.

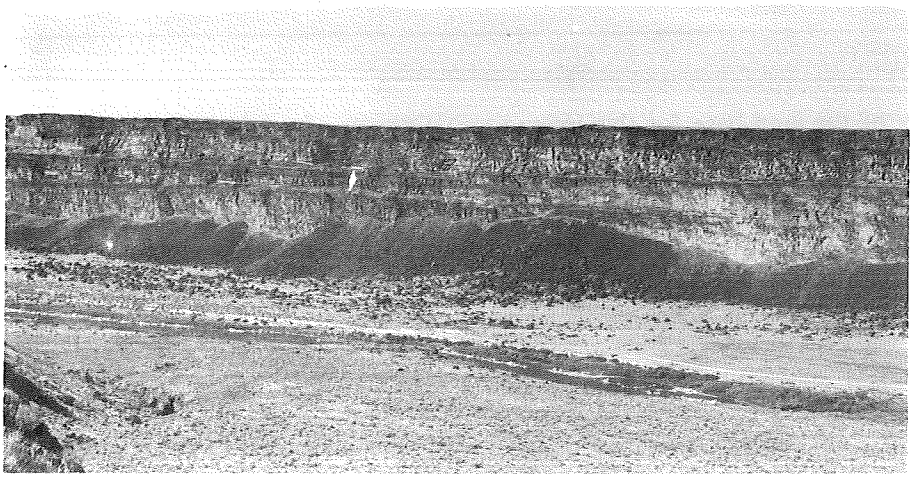


Figure 13. Snake River Canyon and Birds of Prey Natural Area.

TABLE 4. TYPICAL WATER QUALITY — CASTLE CREEK KGRA WELLS[1]

	Well 3S-1E-35DAC1	Well 4S-1E-29CCD1	Well 5S-2E-2CDA1	Well 5S-3E-28BCC1
Temperature (°C)	20	70	37	65
Depth (m)	91	927	750	774
Discharge (l/second)	0	93	0.6	0
B (mg/l)	0.0	0.0	0.0	0.0
Ca (mg/l)	43	1.2	9.9	0.8
K (mg/l)	6	0.8	22	1.3
Mg (mg/l)	9.9	0.0	2.00	0.0
Na (mg/l)	35	100	250	97
NH_3 (mg/l)	0.06	0.15	0.2	0.62
SiO_2 (mg/l)	55	83	89	98
Cl^- (mg/l)	7.7	12	25	15
$CO_3^{=}$ (mg/l)	0	51	0.0	67
F^- (mg/l)	2.1	12.0	6.4	21.00
HCO_3^- (mg/l)	246	69	675	27
$NO_3^{=}$ (mg/l)	0.01	0	0.01	0
$PO_4^{=}$ (mg/l)	0.07	0.01	0.06	0.02
$SO_4^{=}$ (mg/l)	25	39	3.4	9.8
Conductivity (µmhos)	440	476	1099	437
pH	7.8	9.2	7.5	9.4
TDS	304	332	739	323

The majority of the land base for this unique ecosystem is publicly owned and administered by the BLM. In 1968 the Bureau initiated action to provide permanent protection to the raptors nesting in the Snake River Canyon. These efforts resulted in the designation of a 333 000-ha study area called the Birds of Prey Natural Area.

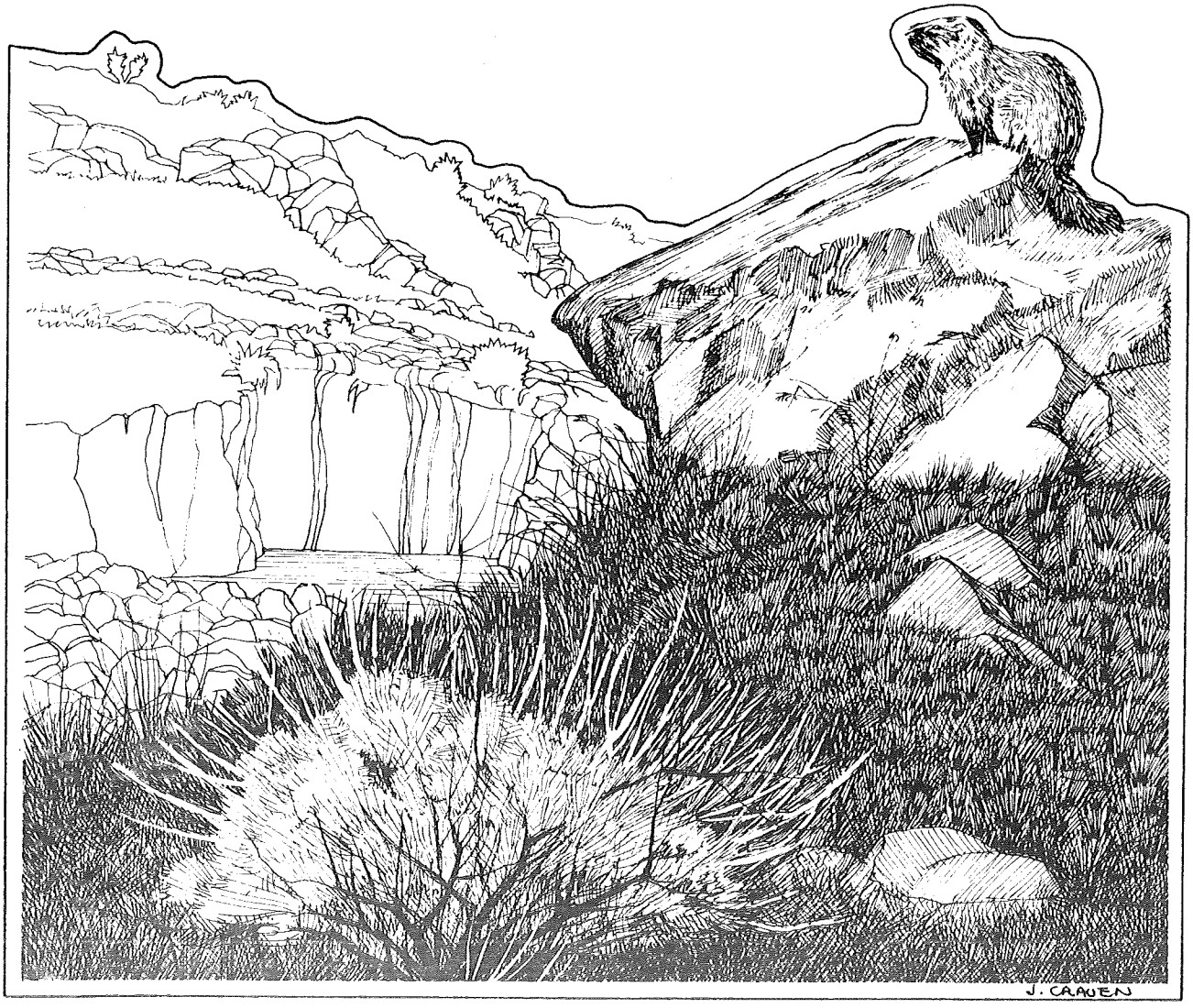
In 1978 the BLM initiated a study to identify additional lands necessary to sustain the unique birds of prey ecosystem. Based upon the findings of this study, the Bureau specified 209 000 ha of public land within and adjacent to the Snake River Canyon. In mid-1979 the BLM submitted to Secretary of the Interior Cecil D. Andrus its research findings, management plan, and proposed legislation to establish the Snake River Birds of Prey National Conservation Area.

Socioeconomic and Heritage Resources

The city of Grandview (population 348; 1975 census), located in Owyhee County, is the only population center within the KGRA.

Limited archaeological surveys of the Castle Creek KGRA have identified 46 known sites. These include villages, campsites, quarries, rockshelters, and lithic scatters, most in the Snake River Canyon. The alternate southern route of the Oregon Trail has clearly discernible ruts throughout the southeast-northwest length of the KGRA. The potential for campsites or cabins along this path is high, but no thorough survey has been made.

4.0 Bruneau KGRA



4.0 Bruneau KGRA

The Bruneau KGRA is located in eastern Owyhee County on the Bruneau River (Figures 14 through 17). The Bruneau River Canyon is considered the steepest canyon in the United States and is being reviewed for wild and scenic river status. Of the 2072 ha in the KGRA, 1052 are controlled by the Bureau of Land Management.

This KGRA is part of the large thermal anomaly that includes the Castle Creek KGRA (see the previous section). Early use of hot springs in the area included Pence Ranch, the oldest settlement in the valley, which boasted a swimming pool supplied from springs. At Indian Bathtub Hot Springs, the springs form a falls into the tub area, the walls of which are covered with pictographs. Chemical analyses from wells and springs in the KGRA are shown in Table 5. Fluoride levels are high in thermal waters, even in waters of low total dissolved solids.

Physical Environment

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 fluviatile sedimentary deposits of the Idaho Group dating from Early Pliocene time. Freshwater gastropod and plant fossils as well as camel, rhinoceros, beaver, and rodent skeletal remains occur in the Late Pliocene Chalk Hills Formation. Upper Pleistocene terrace gravels are exposed along the margins of the Bruneau Valley, and alluvial deposits form the valley flood plain.

Underlying fault zones appear active, although historic records indicate the area is relatively aseismic. Geothermal development could result in subsidence if the geothermal system is connected to shallower aquifers of unconsolidated sediments.

The local topography consists of steep, highly dissected breaklands and wide valley flood plains. Total relief is about 120 m and mean elevation approximately 825 m mean sea level (MSL). Soils are calcareous, shallow, and gravelly on the plateau, coarse and loamy in the valley.

The KGRA is located in a semiarid desert characterized by 200 mm annual precipitation and temperatures ranging from -28 to 40°C. No adverse weather conditions have been documented; occasional dust storms or thunderstorms may be expected.

The Bruneau River, which has an average annual discharge of 3.6×10^8 m^3, is the only perennial stream in the area. Water levels in the area range from 18 m below land surface to piezometric levels of 18 m above land surface. A total of 412 l/second is appropriated from wells within the KGRA. Information is not available on water right status of diverted water from the Bruneau River. Conflicts may occur over water rights established for irrigation activity if significant geothermal development occurs.

Ecology

The Bruneau Plateau is in the sagebrush habitat which covers much of Owyhee County. This area lies on the eastern edge of the Birds of Prey Natural Area impact zone, and raptors utilize the Bruneau Canyon. Extensive riparian vegetation in the valley provides important game and nongame habitat. Although the upper Bruneau River supports trout and whitefish, nongame species are dominant below Hot Creek.

Socioeconomic and Heritage Resources

The total population of Owyhee County is 7900 (1976 census), with the city of Bruneau (population 100) nearest to the KGRA. A population increase of 23% took place in the county between 1970 and 1976, 66% of which migrated into the area. Population forecasts based on existing economic conditions project a 1% annual increase through the year 2000. The county unemployment rate in 1977 was 4.6%, and per capita income was $3232 in 1976. Agriculture accounts for 26% of the total earnings.

Known archaeological sites are limited to one small campsite near the mouth of the canyon at the southern edge of the KGRA. Historic records document an Indian winter village at Hot Springs and fishing camps downriver from the KGRA.

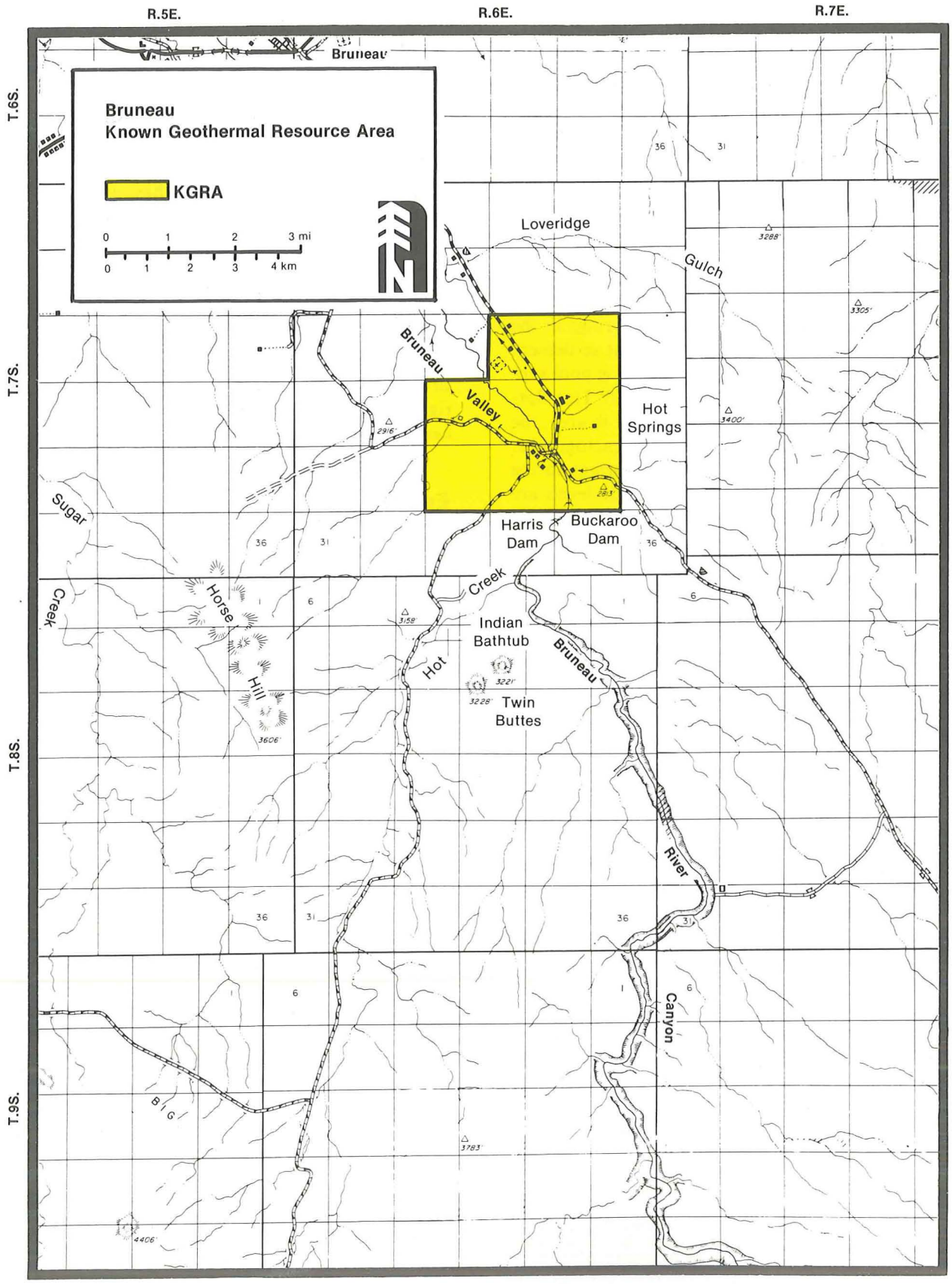


Figure 14. Map of Bruneau KGRA.

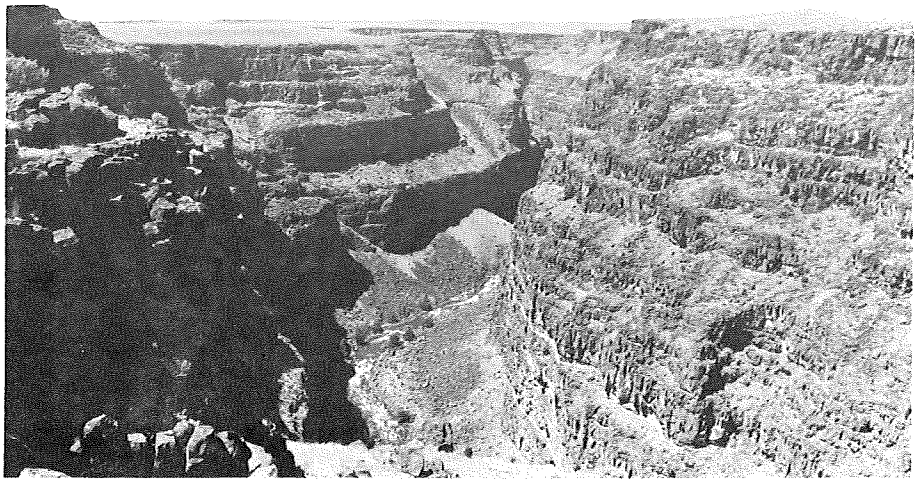


Figure 15. Bruneau Canyon.

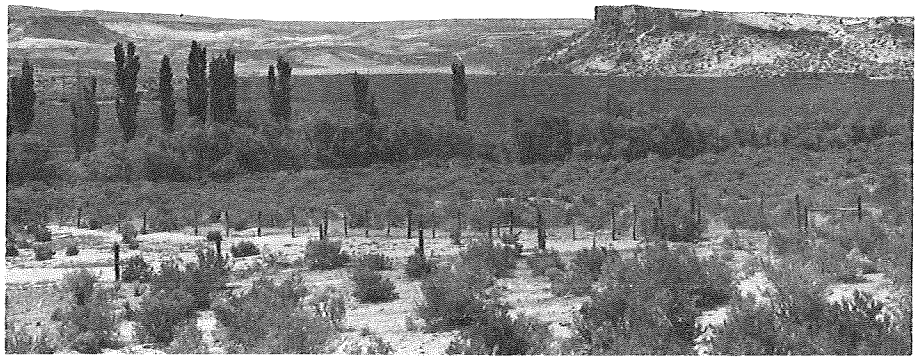


Figure 16. Bruneau River Valley.

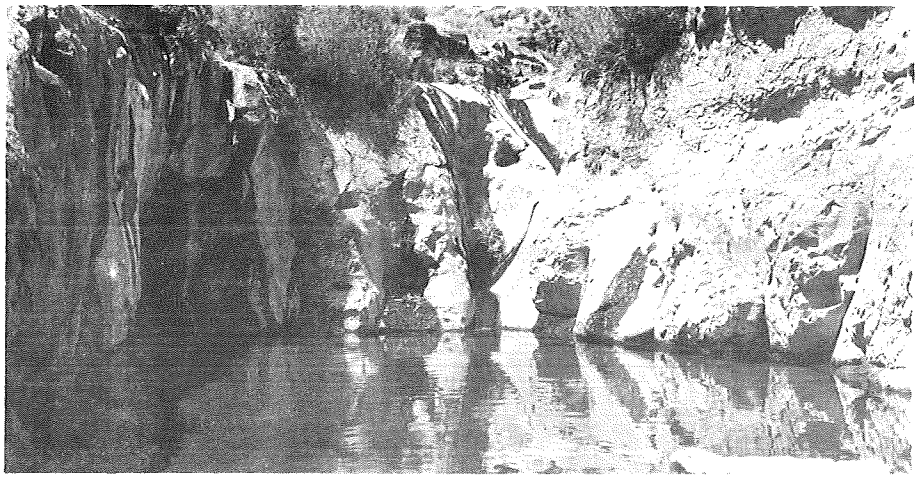
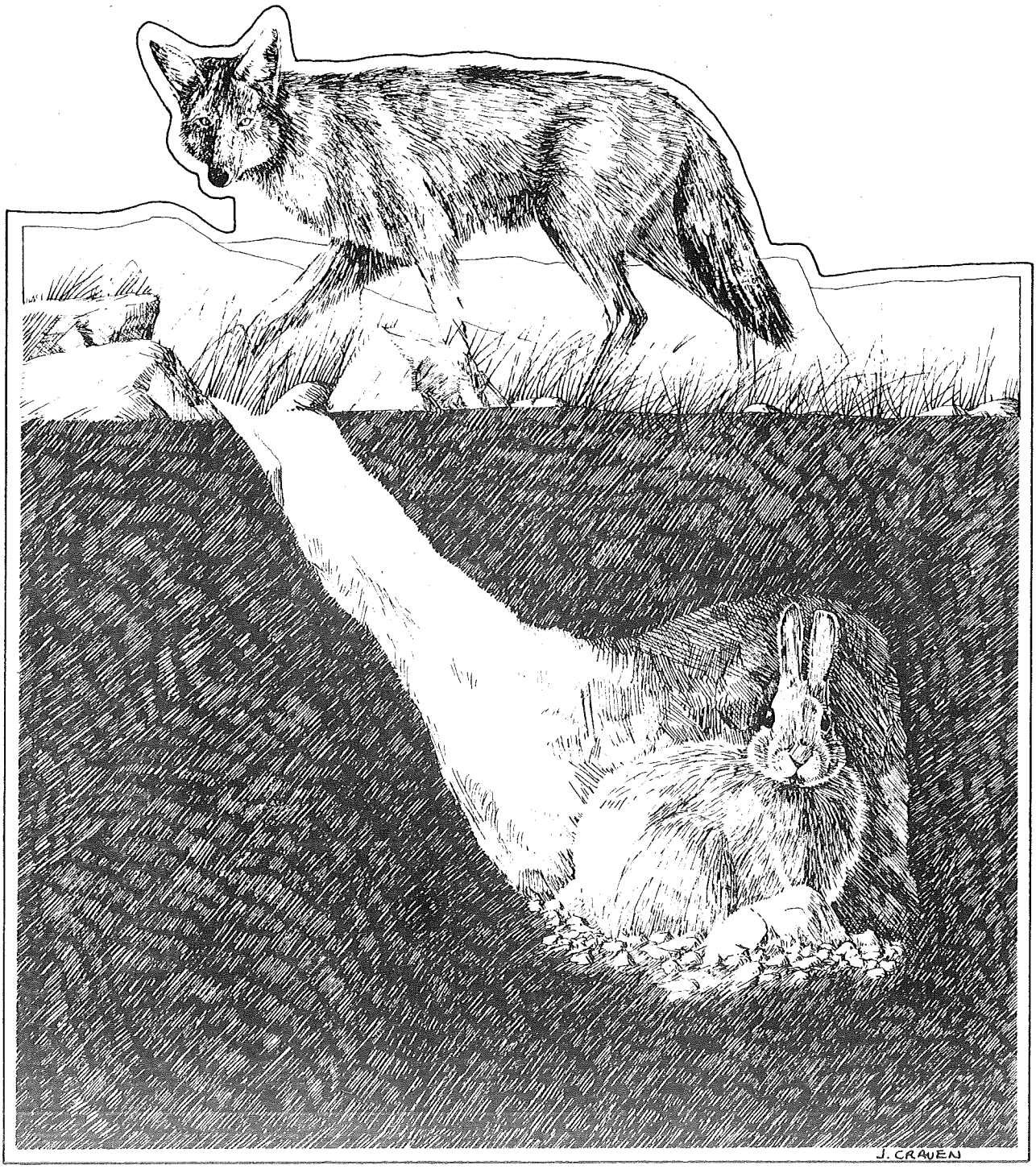


Figure 17. Indian Bathtub.

TABLE 5. CHEMICAL ANALYSES — BRUNEAU KGRA WELLS AND SPRINGS[1]

	Well 7S-6E-23BBB1	Well 7S-6E-23CAD1	Well 7S-6E-26ADA1	Indian Bathtub Hot Springs	Hot Springs Well 7S-6E-21DBC1
Temperature (°C)	47	44	38	39	43
Depth (m)	—	396	305	—	232
Discharge (l/second)	0	0	65	28	0
B (mg/l)	0.0	0.0	0.0	0.0	0.0
Ca (mg/l)	9	12	16	6.5	5.9
K (mg/l)	6.1	7.2	6.9	6.7	4.6
Mg (mg/l)	1.2	1.1	2.8	0.6	0.3
Na (mg/l)	51	53	36	53	54
NH_3 (mg/l)	0.0	0.12	0.10	0.08	0.07
SiO_2 (mg/l)	75	100	82	87	82
Cl^- (mg/l)	9	8.7	8.6	9.1	9.0
$CO_3^{=}$ (mg/l)	0.0	0.0	0.0	5.0	7.00
F^- (mg/l)	10.0	8.2	3.1	6.0	12.00
HCO_3^- (mg/l)	110	126	134	113	91
$NO_3^{=}$ (mg/l)	1.3	0.54	0.66	0.66	0.28
$PO_4^{=}$ (mg/l)	0.0	0.01	0.02	0.06	0
$SO_4^{=}$ (mg/l)	17	17	15	15	18
Conductivity (µmhos)	287	327	288	300	287
pH	7.2	8.3	8.0	8.3	8.5
TDS	233	269	236	245	237

5.0 Mountain Home KGRA



5.0 Mountain Home KGRA

The Mountain Home KGRA encompasses 3853 ha at the foot of the Mount Bennett Hills in Elmore County, a few miles east of Mountain Home (Figures 18 through 21). The KGRA consists of farmlands located in the stream valleys where forage crops are grown, and Bureau of Land Management lands where grazing is the major use.

In the early 1900s, the hot springs were considered the hottest in the State and were used as a medicinal drink. Thermal wells and springs are found throughout Elmore County, and interest has been expressed in developing the resource for space heating at the Mountain Home Air Force Base. Limited information is available on the geothermal resource potential, although prospects of hotter water at depth are possible.[1] Chemical analyses from two wells in the area are shown in Table 6.

Physical Environment

The Mountain Home KGRA is located on the downfaulted side of the Snake River graben. The Idavada volcanics form the Mount Bennett Hills and underlie the KGRA. Rock units exposed at the surface in the KGRA are interbedded lava flows and lacustrine and fluviatile sedimentary deposits of the Idaho Group dating from the Pliocene age. Soils are moderately deep and well drained, although an indurated hardpan at 15 to 30 cm restricts the permeability. Disturbed soils on slopes exceeding 2% are subject to erosion.

The subsurface geology may be subject to subsidence, and an in-depth analysis of this potential is needed before extensive geothermal development. Historic records show no seismic activity within 80 km of the KGRA.

The arid climate and widely contrasting daily and annual temperatures are characteristic of the Mountain Home KGRA. Average wind speeds range from 13 to 18 km/hour, with occasional moderate dust storms occurring during warmer months. Air pollution monitoring indicates an average annual release of particulates from point sources of 139 000 kg/year near Mountain Home.

Four low-discharge perennial streams transect the KGRA and drain from the Mount Bennett Hills down to the Snake River. The availability of ground water to wells in the vicinity of the KGRA ranges from 1.2 l/second for the flatlands, to more than 125 l/second along the Mount Bennett Hills front. The arid nature of the area has limited irrigation activity.

Ecology

The KGRA is located within the Tall Sagebrush habitat and has been modified by grazing. Mule deer use this area for winter browse and sage grouse for strutting grounds. Little aquatic information is available for the few perennial streams in the KGRA.

Socioeconomic and Heritage Resources

Mountain Home (populaton 6811; 1975 census) and Glenns Ferry (population 1449; 1975 census) are the two principal population centers for Elmore County (population 19 500). Federal employees housed at the Mountain Home Air Force Base are not included in these population figures. A population increase of 16.5% took place between 1970 and 1976, primarily in rural areas. Population forecasts indicate a small but steady growth in population, employment, labor force, and school enrollment with continued net migration outward. The county unemployment rate was 6 to 7% for the period from 1974 to 1977. Per capita income for 1976 was $5184.

Limited archaeological surveys have not identified any prehistoric sites within the KGRA. Historic features include the Oregon Trail which left ruts from southeast to northwest across the KGRA and later the Kelton or Salt Lake Road across the northeast corner. One cabin remains from this period.

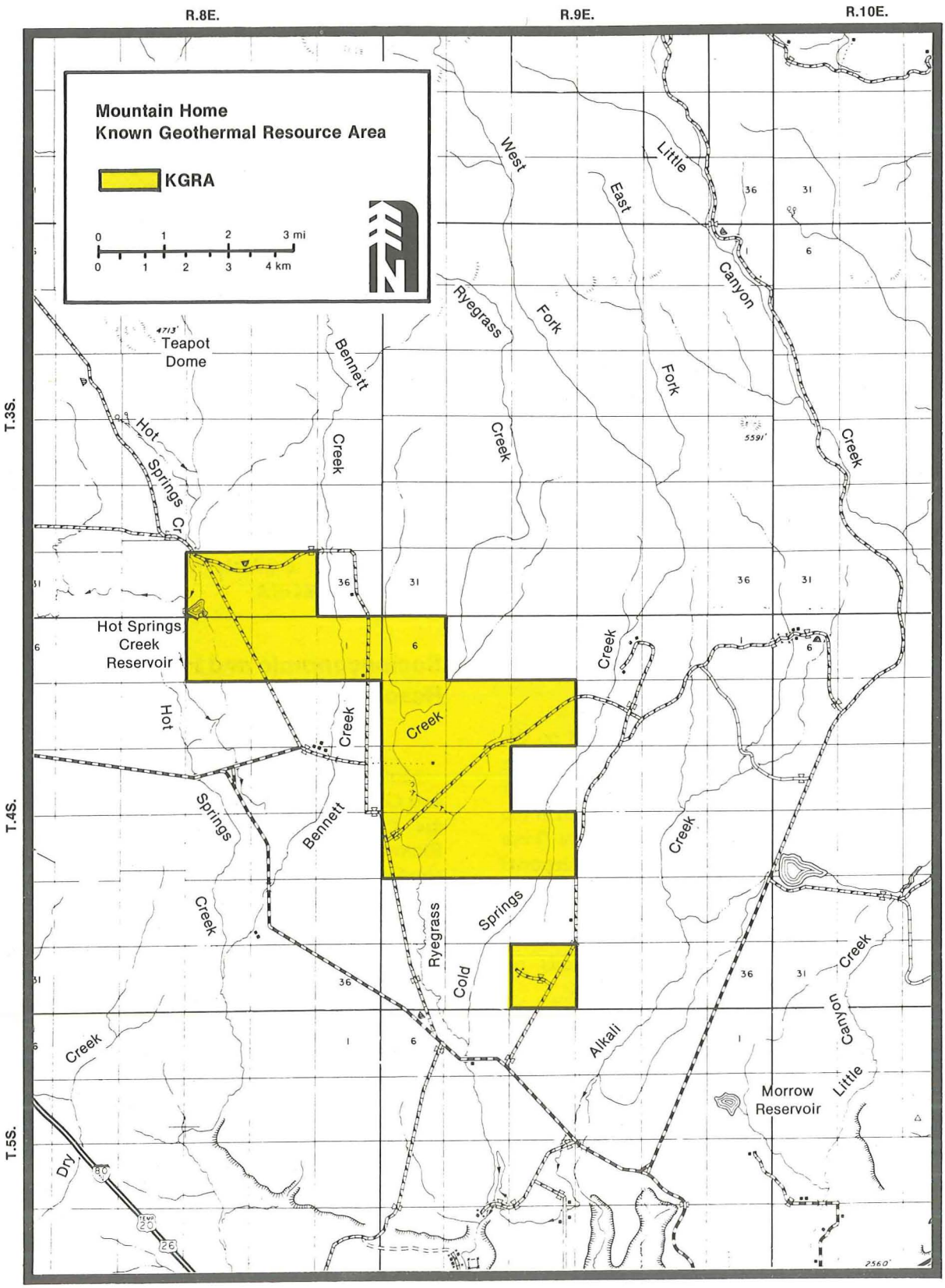


Figure 18. Map of Mountain Home KGRA.

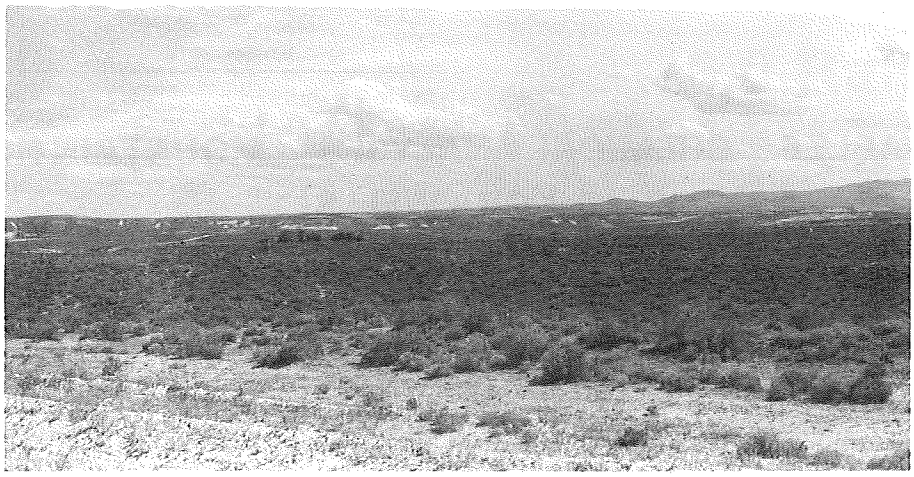


Figure 19. Mountain Home KGRA.

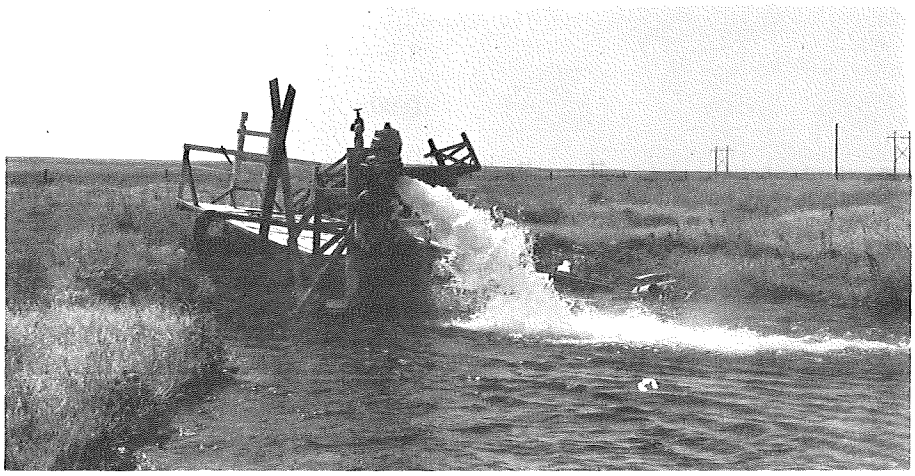


Figure 20. Hot Well in Mountain Home KGRA.

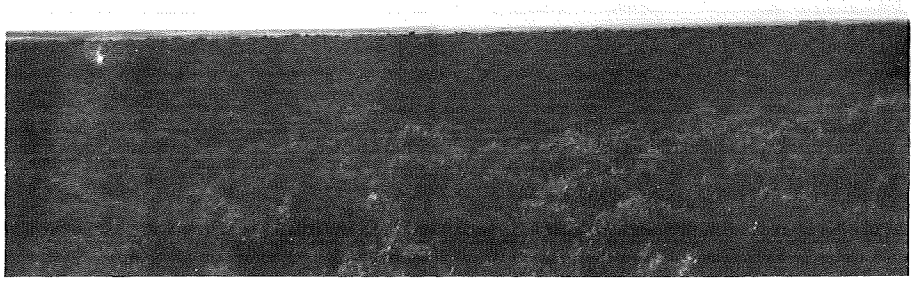
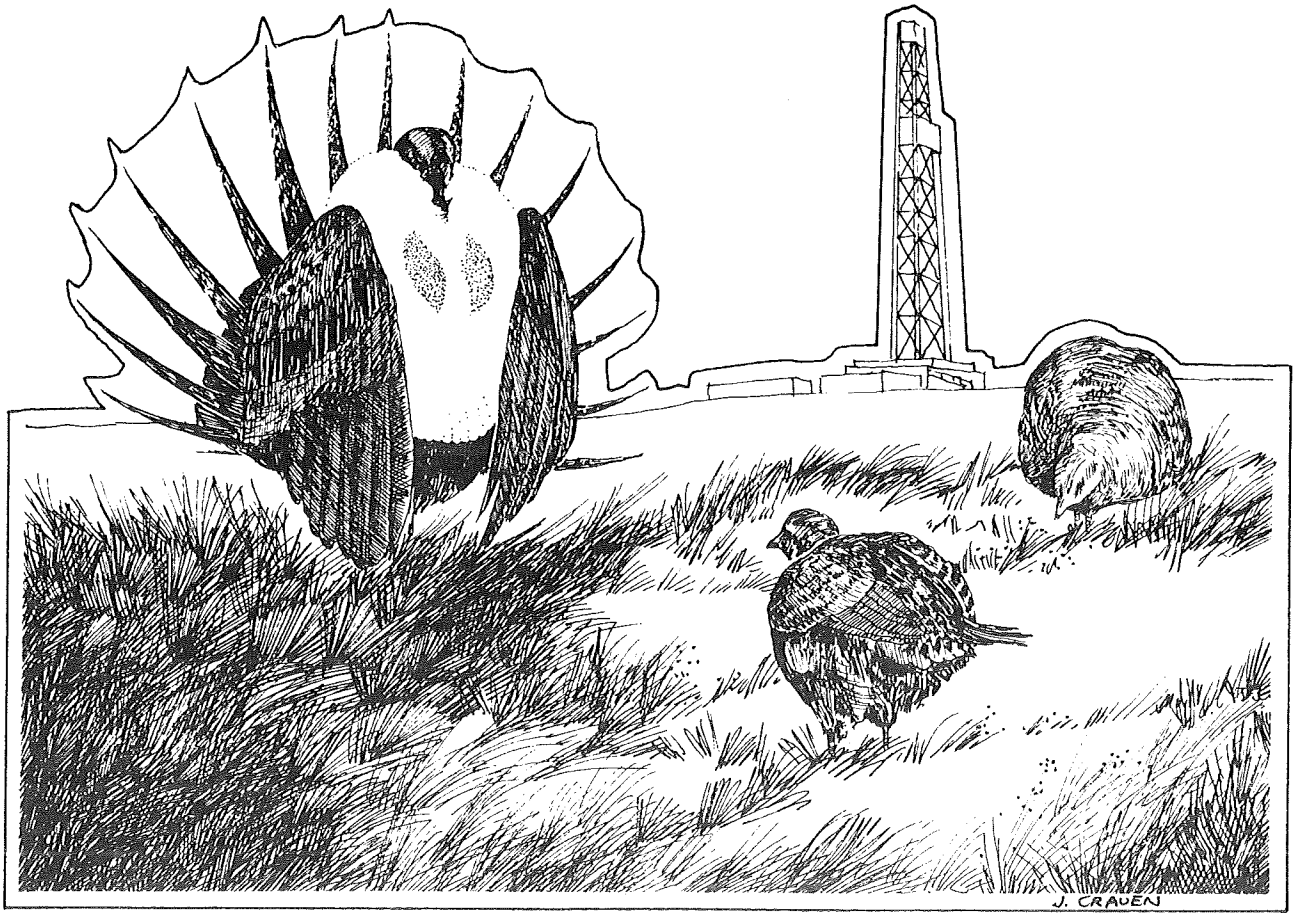


Figure 21. Northern portion of the Mountain Home KGRA.

TABLE 6. CHEMICAL ANALYSES – MOUNTAIN HOME KGRA WELLS[1]

	Well 3S-8E-36CAD1	Well 4S-9E-8ACA1
Temperature (°C)	68	62
Depth (m)	183	358
Discharge (l/second)	44	0
B (mg/l)	0.0	0.0
Ca (mg/l)	1.5	0.9
K (mg/l)	0.80	0.80
Mg (mg/l)	0.0	0.0
Na (mg/l)	87	82
NH_3 (mg/l)	0.0	0.0
SiO_2 (mg/l)	86	85
Cl^- (mg/l)	4.5	3.2
$CO_3^{=}$ (mg/l)	50	41
F^- (mg/l)	17.00	16.00
HCO_3^- (mg/l)	74	81
$NO_3^{=}$ (mg/l)	0.06	0.05
$PO_4^{=}$ (mg/l)	0.04	0.03
$SO_4^{=}$ (mg/l)	14	14
Conductivity (µmhos)	382	387
pH	8.5	9.2
TDS	297	282

6.0 Raft River KGRA



6.0 Raft River KGRA

The Raft River KGRA encompasses 11 750 ha and is the most studied geothermal area in Idaho (Figures 22 through 25). Thermal waters are believed to originate in deep fault systems and circulate up through extensive fracture systems. Water of 90°C is encountered at depths as shallow as 125 m in two irrigation wells in the center of the KGRA. At present the geothermal fluids are used to heat a small commercial greenhouse operation. The U.S. Department of Energy has applied to withdraw 1980 ha of national resource land for the purposes of geothermal research and development. Deep well drilling began in 1975; to date seven production and injection wells have been drilled which tap resources as hot as 150°C. Chemistry of three of these wells is shown in Table 7. The primary objective of the research is to demonstrate the feasibility of utilizing moderate-temperature fluids to generate power with binary cycles. Numerous direct application experiments are conducted in conjunction with the construction and proposed operation of a 5-MW(e) pilot power plant.

Physical Environment

The Raft River Valley trends north-south and is bounded on the east, west, and south by fault-block mountain ranges. Early Tertiary Laramide thrusting accounts for the lack of Paleozoic and Mesozoic sediments in the valley. The major faults in the basin trend north-south along the base of the tilted fault-block mountains. The rock units in the area may be divided into two broad categories: (1) Cenozoic volcanic, sedimentary rocks, and alluviun underlying the valleys, and (2) pre-Tertiary sedimentary, igneous, and metamorphic rocks forming the surrounding mountains. The basement rock in the area has been described as Precambrian intruded quartz monzonite and quartzofeldspathic gneiss. In the geothermal withdrawal area, the Precambrian metamorphics are unconformably overlain by the tuffaceous siltstones and sandstones of the Salt Lake Formation. A series of geophysical surveys have been conducted, all of which indicate a locus of heat flow just east of the Raft River Narrows, at the interpolated intersection of the Bridge Fault and the Narrows Structure. The heat source is probably a combination of radiation from a shallow, underlying magma and residual heat from fault friction. The most favorable aspects of the resource are the thickness of the insulating layer (≃1200 m) and the apparent abundance of recharge water.

Subsidence of as much as 0.8 m has been detected in the lower end of the Raft River Valley and is thought to be a result of water level declines of as much as 30 m due to irrigation pumping. Subsidence may occur as a result of geothermal development, particularly if that development affects water levels in the shallow, unconsolidated aquifers. Historic records show three minor earthquakes within 30 to 50 km to the west of the KGRA. A microseismic survey conducted in 1976 indicated an average event rate of 0.2 events per day with magnitudes greater than 0.0. The scarcity of events and the extremely low magnitudes suggest the valley is related to the aseismic Snake River Plain rather than the active basin and range province.

The Raft River Valley is classified as a cold desert steppe with evaporation exceeding precipitation. Climate is influenced by topography, ranging from subhumid in the mountains to semiarid in the valley. Temperatures in the valley average 8°C with extremes of -33 and 40°C. Inversions occur approximately 40% of the time during the summer and 50% of the time during the winter, which is typical of the region. Particulate sampling in the valley indicates that the primary 24-hour standard is exceeded a few times a year due to windblown dust.

The Raft River Basin was closed in 1963 to further appropriation of ground water because of declining water levels in the lower end of the valley. This closure currently includes the geothermal resource. The Raft River is the only perennial stream in the KGRA. Approximately two-thirds of the total yield of the basin moves as ground water in the shallow alluvial and sedimentary formations. The quality of ground water varies both with depth and with location in the KGRA. The quality of wells to the west and east of the geothermal area is relatively high; total dissolved solids average 650 mg/l. Irrigation wells in the vicinity of the geothermal area show the influence of upward leakage from the geothermal resource. Temperature, fluoride, and total dissolved solids increase significantly in these wells. The primary concerns to geothermal development in this KGRA are effects on the water supply and water quality in the shallower aquifers which have been developed for irrigation.

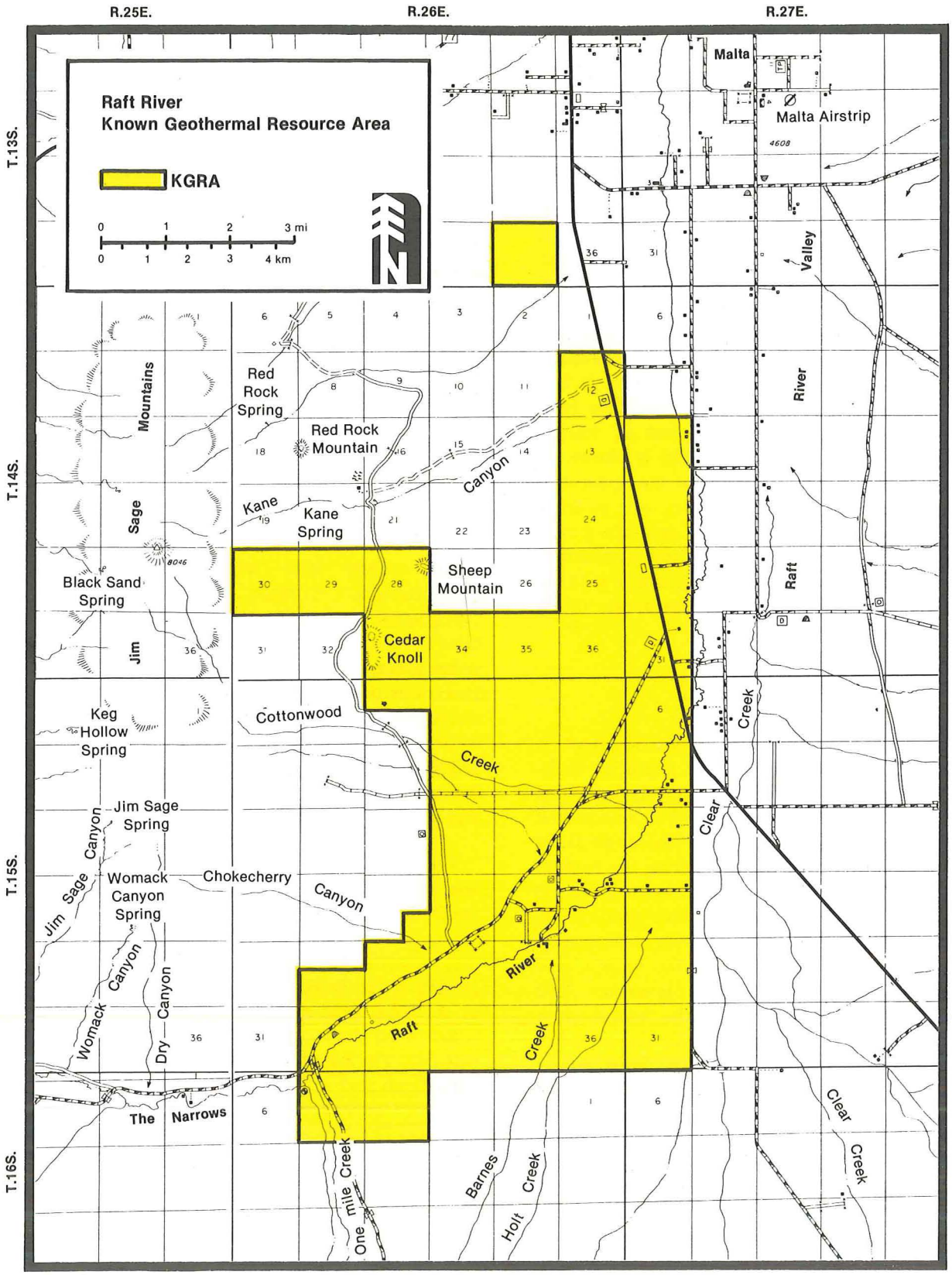


Figure 22. Map of Raft River KGRA.

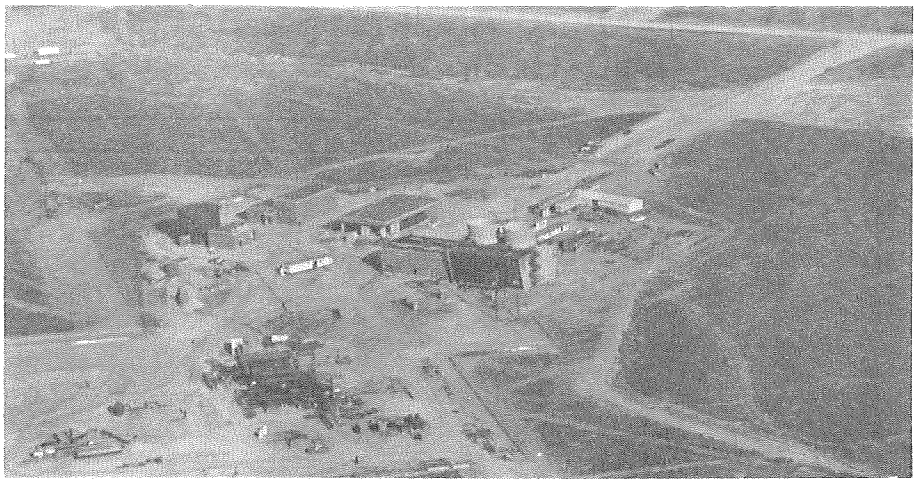


Figure 23. Raft River geothermal site.

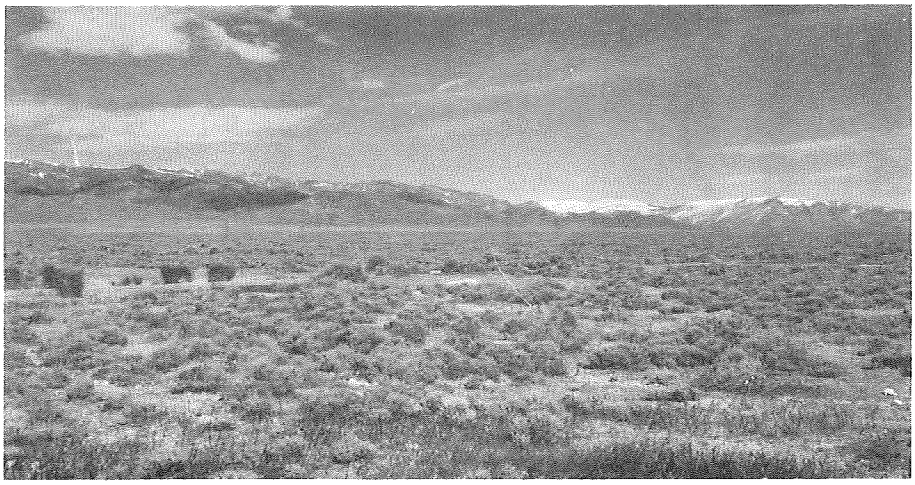


Figure 24. Jim Sage Mountains.

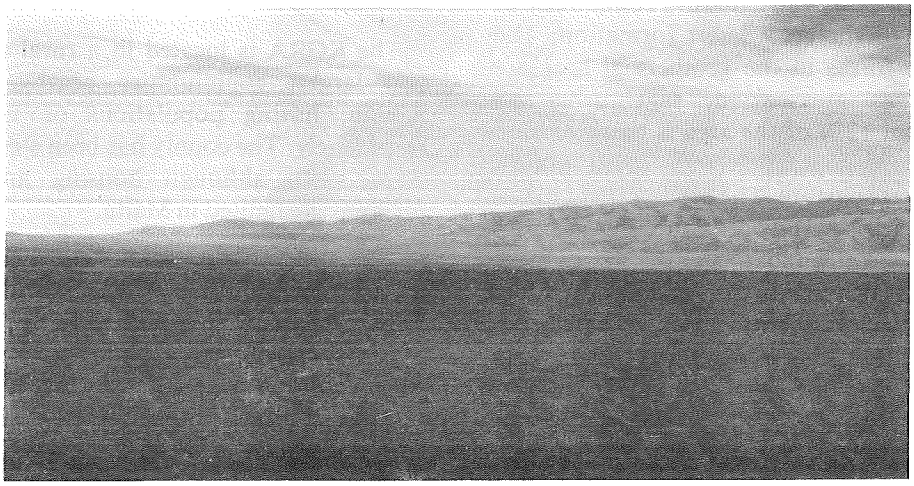


Figure 25. Raft River KGRA from the Narrows.

TABLE 7. CHEMICAL ANALYSES – RAFT RIVER GEOTHERMAL WELLS

	Well RRGE-1	Well RRGE-3	Well RRGI-6
Depth (m)	1520	1804	1176
Ca (mg/l)	53	127	199
K (mg/l)	33	103	32
Li (mg/l)	1.6	3.4	5.1
Mg (mg/l)	0.6	1.0	1.4
Na (mg/l)	469	1245	2020
Sr (mg/l)	1.4	5.2	8.0
SiO_2 (mg/l)	134	158	91
Cl^- (mg/l)	709	2116	3636
$CO_3^=$ (mg/l)	0.0	0.0	0.0
F^- (mg/l)	5.7	3.7	5.8
HCO_3^- (mg/l)	34	26	62
$SO_4^=$ (mg/l)	40	44	60
Conductivity (µmhos)	2987	7997	11 594
pH	7.3	7.2	7.3
TDS	1607	4280	6330

Ecology

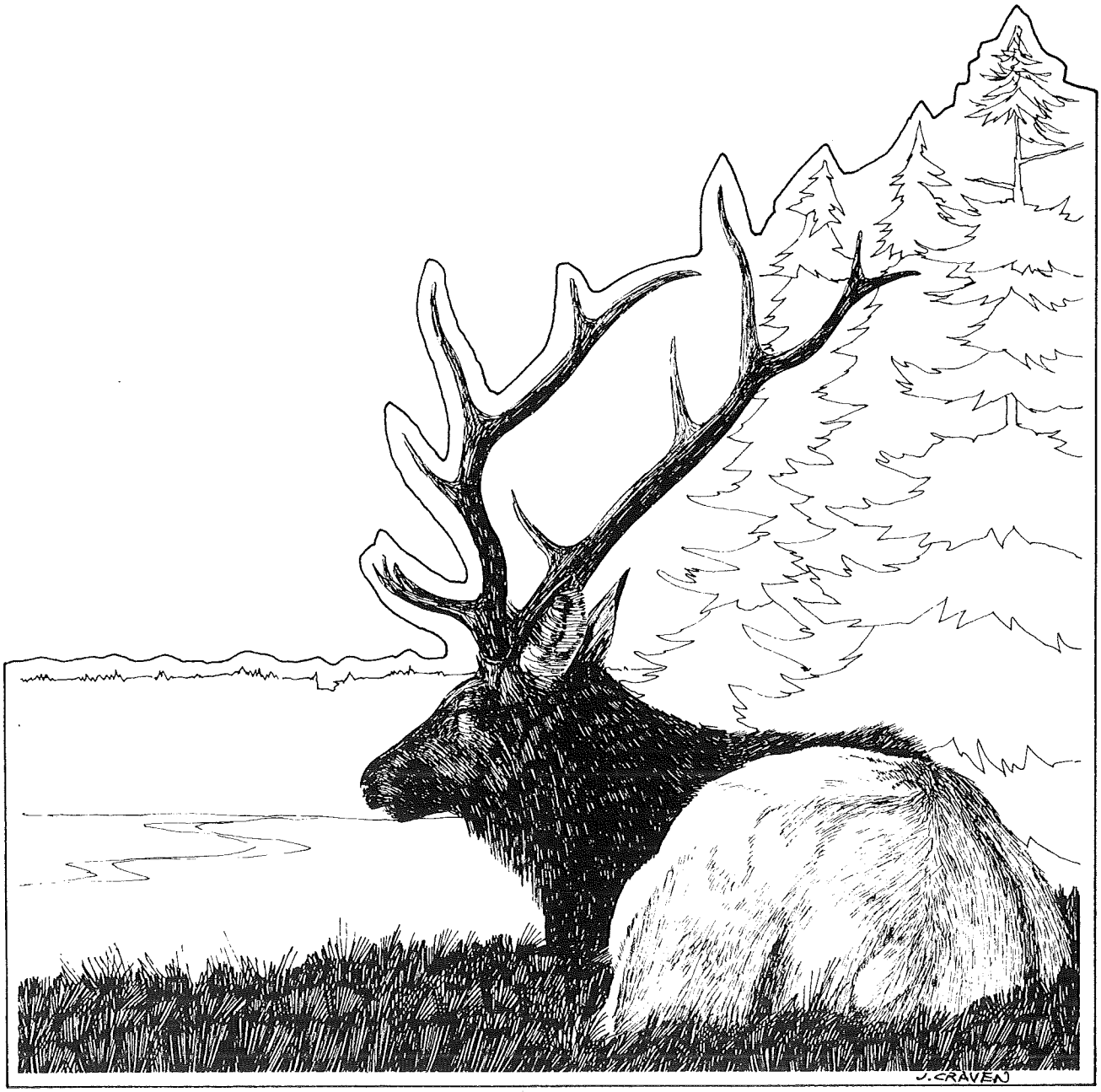
The KGRA supports an extensive community of plants typical of the cold desert formation. The dominant life forms in the geothermal area are shrubs such as greasewood, sagebrush, and saltbush. About 12% of the area is being utilized for agricultural crops, primarily small grains, alfalfa, and grass pasture. The predominant mammals are the small herbivorous rodents. Six sensitive species are known to inhabit the KGRA. The most important of these is the ferruginous hawk, which nests near the sagebrush-juniper ecotone in the KGRA. This specie is extremely sensitive to human disturbance during nesting and is prone to nest desertion. The U.S. Fish and Wildlife Service has located active nests in the KGRA and surrounding areas. These nests are protected by the BLM during the nesting period through the use of buffer zones.

Socioeconomic and Heritage Resources

The KGRA is located in a rural area with the two largest communities nearby, Malta and Albion, having populations of 196 and 226, respectively. The county has been steadily growing since 1960, although housing and education facilities are limited in Malta.

A survey of archaeological resources in the KGRA located 7 sites and 13 finds. The presence of six sites within a 2.5-km stretch of the Raft River indicates a high-density site area, and subsurface resources probably exist in the immediate locale. Three emigrant trails pass through the Raft River Valley. One, the Salt Lake Alternate to the California Trails, passes just south of the KGRA and is protected by the BLM.

7.0 Island Park/Yellowstone KGRA



7.0 Island Park/Yellowstone KGRAs

These two KGRAs are located within the boundaries of what the U.S. Forest Service has classified as the Island Park Geothermal Area (IPGA) (Figures 26 through 30). The Yellowstone KGRA, which contains 5730 ha, borders Yellowstone National Park on the west, and the Island Park KGRA consists of scattered parcels in the center of the region. The majority of land is administered by the U.S. Forest Service and the Bureau of Land Management. Within the acreage are some private lands with mineral rights reserved by the Federal Government. Although no Federal leasing has yet occurred within the KGRA, all State lands in the region offered for lease have been leased.

Limited information is available on the geothermal potential of this area. The extensive interest in geothermal leasing appears to be based solely on the area's proximity to Yellowstone National Park. The general absence of hot springs indicates an old system, and resistivity data imply that the caldera has cooled.[1]

Physical Environment

A major portion of the IPGA is located within the Island Park caldera, a large volcanic feature situated between the eastern Snake River Plain and Yellowstone National Park. The IPGA is characterized by past volcanic activity, which has deposited rhyolite and basaltic flows. The subsurface distribution of geologic units is defined in a general way and only for parts of the IPGA because subsurface data are not available. The faults associated with the land collapse that created the caldera are superimposed on fault blocks that trend north to northwest. The Island Park area is flanked on the north and east by the Intermountain Seismic Belt; however, Island Park is unusual by its lack of seismicity.

The IPGA is characterized by an average precipitation ranging from 450 to 750 mm/year. The summers are cool, dry, and short; while the spring, fall, and winter are cold and wet. Numerous springs occur within the IPGA; some are perennial and others are ephemeral. The two largest springs, Big Springs and Warm River Spring, each discharge about 5760 l/second to Henrys Fork and Warm River. The water chemistry of Big Springs is shown in Table 8. Three significant watersheds in the IPGA include the South Fork of the Madison River in Montana, Henrys Fork primarily in Idaho, and Falls River in Wyoming and Idaho. The mean annual discharge for Henrys Fork near Ashton is 41 000 l/second, and Falls River near the point where it leaves the IPGA is 22 000 l/second. Discharge data for the South Fork of the Madison River are not adequate to determine annual flow.

Total relief is about 1000 m with a range of 2560 to 1570 m mean sea level (MSL). The soils have been derived from the products of weathering of rock in situ and from materials transported by wind, water, and glaciers. In most locations, fractured bedrock lies beneath the soil at a depth of more than 100 cm. The soils have good porosity and permeability.

Ecology

Vegetation in the IPGA is typical of the Rocky Mountain Douglas fir forest province. Riparian habitats are characterized by sedges, rushes, and grasses with a shrubby overstory of willows, dogwood, hawthorne, and alder. Wildlife of special concern are the grizzly bear, northern Rocky Mountain wolf, Canada lynx, fisher, wolverine, trumpeter swan, sharp-tailed grouse, ferruginous hawk, prairie falcon, American peregrine falcon, and northern bald eagle.

Socioeconomic and Heritage Resources

The major communities within Fremont County are St. Anthony (population 3021; 1975 census), Ashton (population 1300; 1975 census), Island Park (population 152; 1975 census), and West Yellowstone (population 823; 1975 census). About 44% of the population is classified as rural nonfarm, 33% urban, and 23% rural farm. Population forecasts based on existing conditions project a 61% increase in Fremont County by the year 2000, a 2% annual growth rate. The unemployment rate was about 6.4% in mid-1978. Per capita income in 1974 was $4752.

No archaeological survey has been conducted within the bounds of these KGRAs.

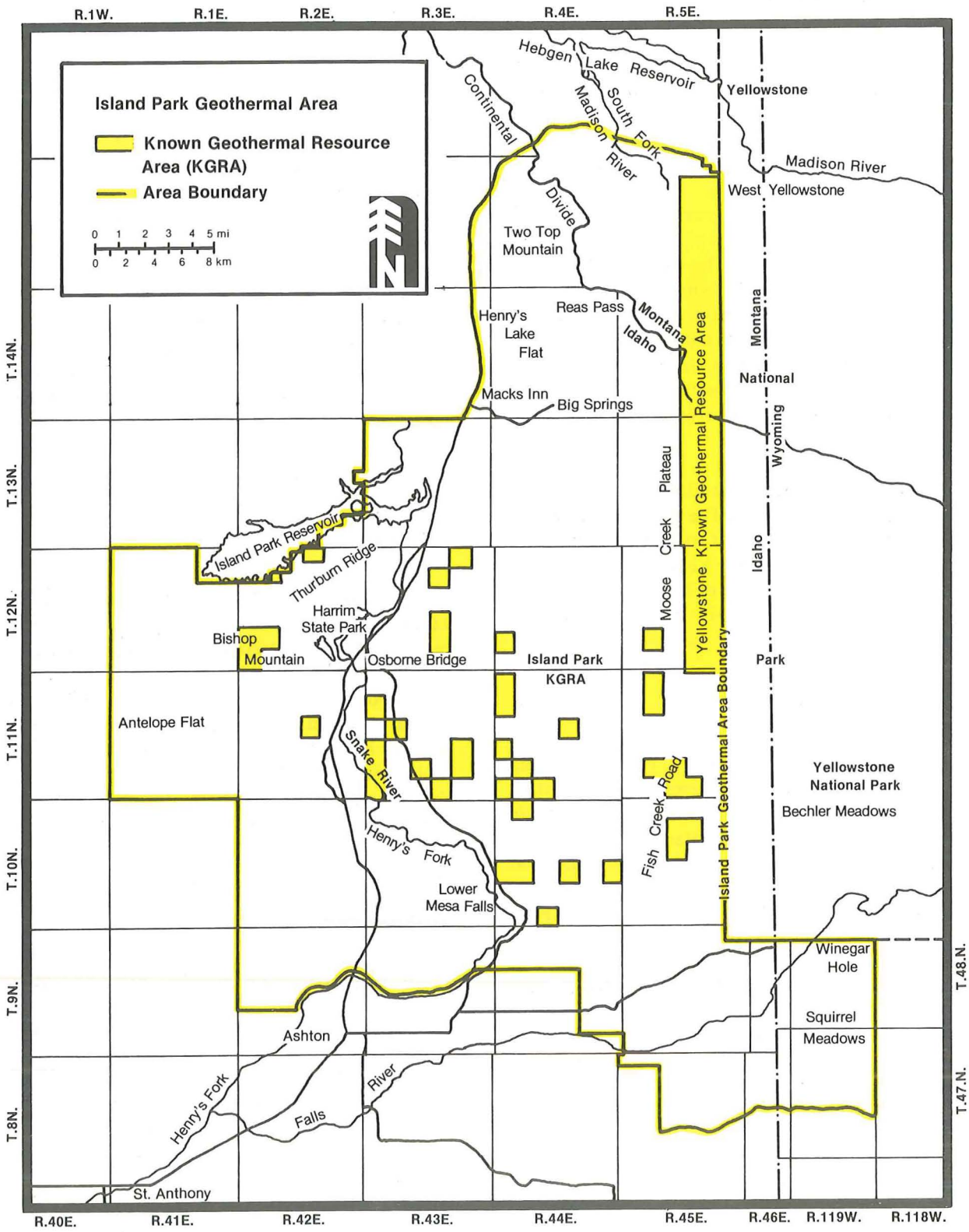


Figure 26. Map of IPGA.

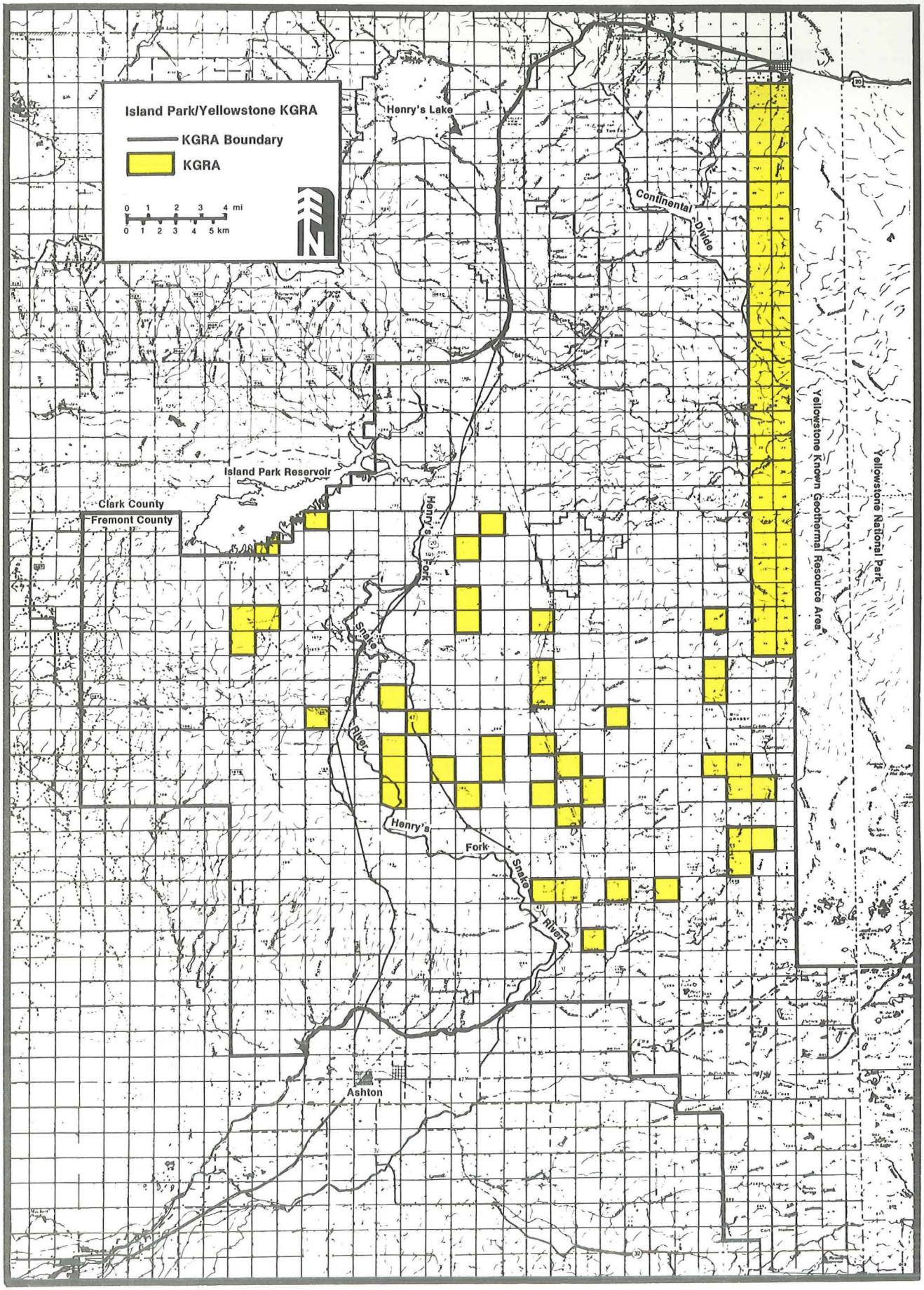


Figure 27. Map of Island Park and Yellowstone KGRAs.

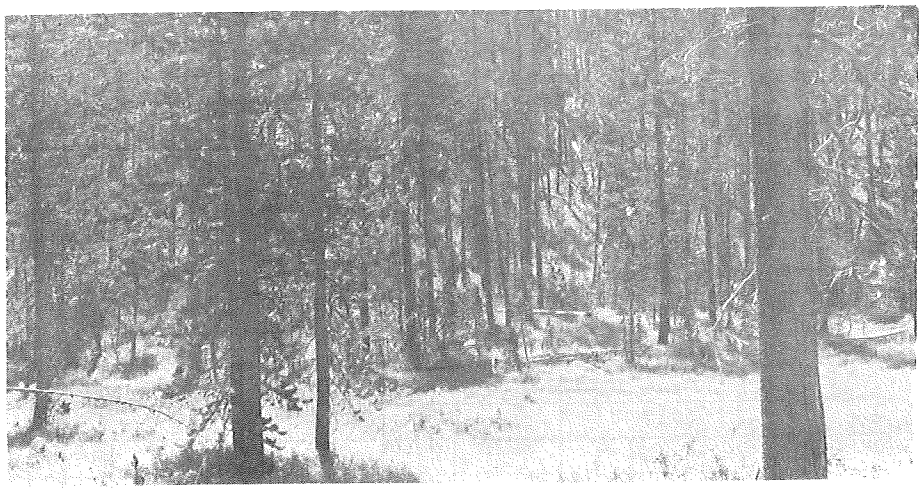


Figure 28. Island Park KGRA.

Figure 29. Snow Creek in Island Park KGRA.

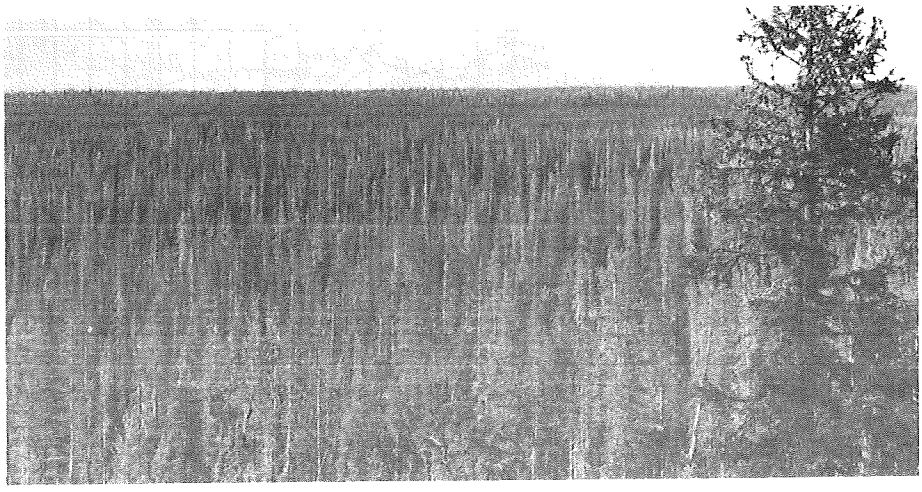


Figure 30. Yellowstone Park KGRA.

TABLE 8. ANALYSIS OF WATER CHEMISTRY — BIG SPRINGS[1] 14N-44E-34BBC1S

Surface Temperature (°C)	12
B (mg/l)	0.0
Ca (mg/l)	5.6
K (mg/l)	3.0
Mg (mg/l)	0.6
Na (mg/l)	14
NH_3 (mg/l)	0
SiO_2 (mg/l)	47
Cl^- (mg/l)	2.5
$CO_3^=$ (mg/l)	0.0
F^- (mg/l)	3.1
HCO_3^- (mg/l)	46
$NO_3^=$ (mg/l)	0.05
$SO_4^=$ (mg/l)	3.2
Specific Conductance (μmhos)	102
pH	6.4
TDS	101

EVALUATION OF DATA BASE

The environmental data base for the Snake Plain KGRAs has been evaluated for its adequacy. "Adequate data," as used in this report, are those data required to analyze potential impacts prior to development and to evaluate specific environmental impacts following development. A series of tables in Appendix A present an overview of the data base in the KGRAs.

Following completion of the data evaluation, an assessment was made of the baseline studies which would provide needed data in areas where geothermal development is likely to occur. These areas are not limited to the eight KGRA boundaries. A description of these areas and the proposed studies to be performed follows.

Description of Study Areas

Further environmental studies should be performed at Vulcan Hot Springs, Weiser-Crane Creek, Boise-Caldwell, Castle Creek, Bruneau, and Mountain Home (Figure 31). The selection of these areas was based on preliminary environmental analyses[3,4] and an assessment of the geothermal potential.[1,2,5,6,7,8,9] Each represents an area where (a) the geothermal resources are considered adequate for electrical generation or direct applications, (b) there has been interest expressed in development, and (c) the environmental concerns warrant further evaluation. Table 9 represents a summary of each area under consideration, and detailed descriptions follow.

Geothermometry studies for the Vulcan Hot Springs KGRA indicate a potential resource temperature of 135 to 147°C.[1] This resource could be suitable for power generation using a binary cycle; estimates by McClain[5] project a resource capacity of 50 MW. The geothermal fluids appear to be assocated with fractures in the granitic rocks of the Idaho Batholith. The land included in the KGRA is isolated, and snow restricts access in the winter. Peregrine falcon nesting areas have been located within the KGRA; the upper reach of the South Fork is protected for salmon spawning. Access to the area is not limited as a powerline corridor runs within 10 km of the KGRA.

The Crane Creek KGRA is located in an area of regional geothermal activity which extends along the Weiser River north to McCall. The best prospects for development appear to be within and around the KGRA, with predicted temperatures of 166 to 176°C, and the area surrounding Weiser Hot Springs with predicted temperatures of 141 to 156°C.[6] All of the area could be developed for a wide variety of direct uses, ranging from onion dehydration to gasohol production. Significant interest has been expressed locally in developing the resource, and several projects are in the conceptual design phase. Over half of the land in the KGRA has been withheld from geothermal leasing because of potential critical habitat, soil erosion, and archaeological resources.

Predicted resource temperatures in the Castle Creek KGRA are 110°C,[6] and the resource appears to be widespread. Data from the existing warm wells scattered throughout the area indicate there is a good chance of encountering artesian

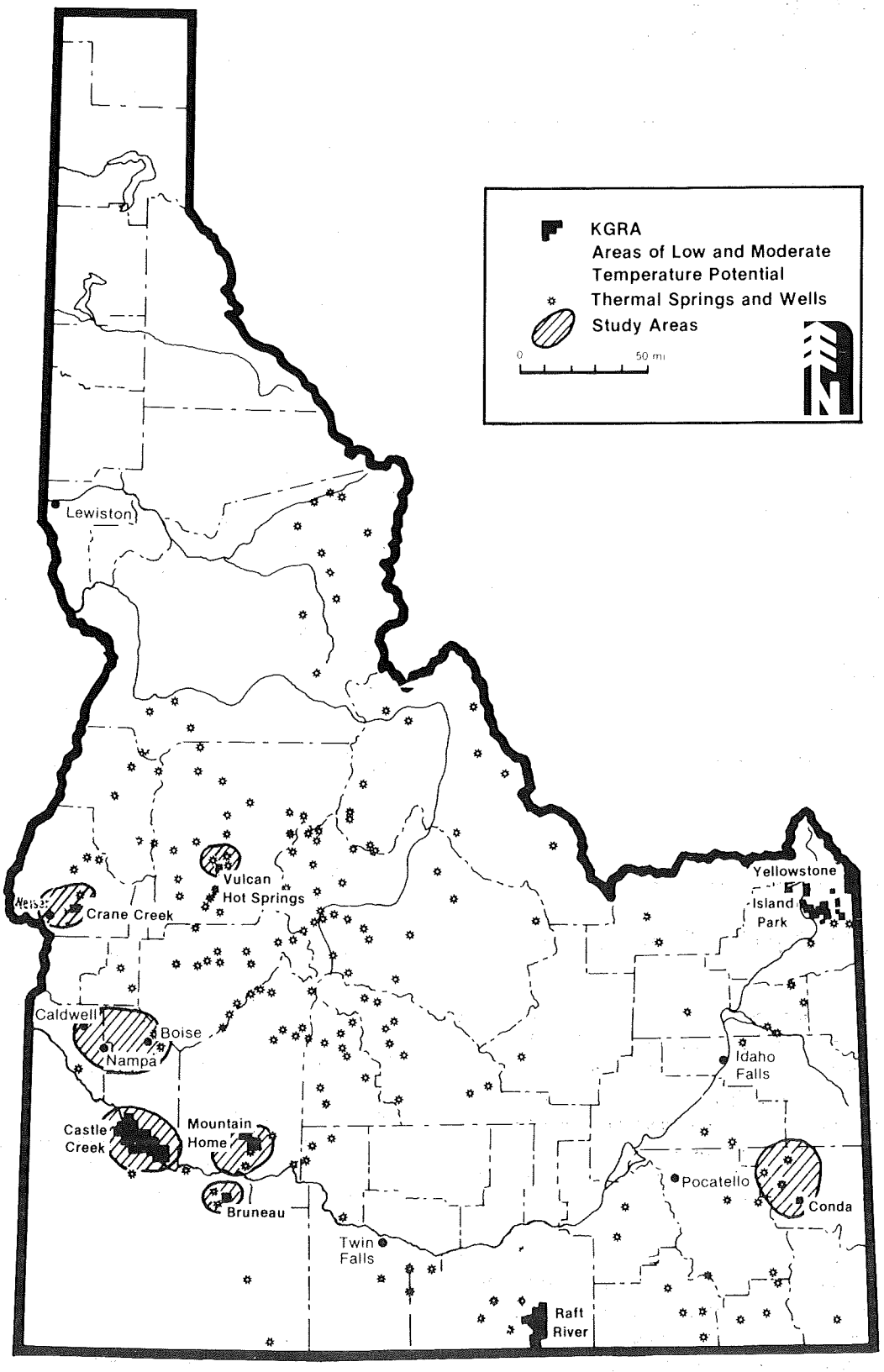


Figure 31. Areas for proposed future work.

TABLE 9. GEOTHERMAL RESOURCE POTENTIAL SUMMARY FOR PROPOSED STUDY AREAS

Area	Predicted Resource Temperature (°C)	Primary Development	Development Status	Development Advantages	Development Disadvantages
Vulcan Hot Springs	135 to 147	power (binary)	no leases granted	high temperature	Forest Service land, remote location, supply uncertain
Weiser-Crane Creek	141 to 176	direct applications, industrial, power	several direct use facilities in planning stage	high temperature, resource availability known, market present, nearby transportaion routes	land constraints, varied jurisdictions
Boise-Caldwell	50 to 120	direct applications, space heating	space heating being expanded, other direct use facilities in planning stage	market present, nearby transportation routes	lack of resource definition
Castle Creek	110	direct applications	direct use facilities in planning storage	resource availability known	market lacking, transportation
Bruneau	110	direct applications	direct use facilities in planning stage	resource availability known, nearby transportation routes	market lacking
Mountain Home	130	direct applications, space heating	resource definition tests in progress	market present, high temperature	lack of resource definition

hot water at depths of 1000 m throughout the area. The region has limited potential for large-scale industrial development, although there is a sizeable market for numerous small-scale applications such as alfalfa drying, barley sprouting, grain drying, and greenhousing. The Birds of Prey Natural Area borders the northern part of the KGRA, and some of the lands in the KGRA are within the hunting range of the raptors. Quality of the geothermal fluids is excellent, with the exception of fluoride (5 to 30 mg/l), indicating that there may be some disposal problems.

The resource potential in the Bruneau KGRA is similar to that of Castle Creek, with predicted temperature of less than 110°C. The KGRA has a much better potential for industrial siting because of the availability of transportation facilities. As with Castle Creek, a well drilled anywhere in the area will probably encounter geothermal fluids at depths of 300 to 1000 m under artesian pressure. The Bruneau River south of the KGRA is under consideration for Scenic River status.

Of the five KGRAs under consideration, the Mountain Home KGRA appears to have the least potential for geothermal development. High temperatures have been encountered in the rock at depth, but there is some uncertainty about the availability of hot water. The hottest springs occur near the mountain front, 20 km east of the town of Mountain Home. There is considerable interest in utilizing geothermal resources at Mountain Home Air Force Base, and institutional restrictions are less there than on any of the surrounding lands.

The area within Idaho which has the optimal potential for near-term development is in the western Snake River Plain between Boise and Caldwell. This area has the greatest population density and industrial development in the State. This area ranked highest in the State for a market penetration analysis of direct applications. The existing geothermal space heating system in Boise is being expanded and may eventually include most of central Boise. Numerous warm wells occur in the Nampa-Caldwell area, and geothermal developers are considering greenhousing and aquaculture as well as conversion of industrial processing plants. Water quality in general is good, although fluoride contents range as high as 24 mg/l; thus a potential disposal problem exists. Nearly all of the land under consideration is privately owned.

Work Scope

The studies included below were determined from an analysis of the existing environmental information, identified environmental concerns, and knowledge of the geothermal resource and potential development. A matrix of the work that should be undertaken based on the environmental concerns is shown in Table 10 and details follow. No evaluation of existing environmental data has been completed for the Conda KGRA-Grays Lake area in southeastern Idaho. Therefore, it is proposed that an overview be completed for this area before it is added to the six areas included in this proposal.

Air Quality, Meteorology, and Noise

With the exception of the Boise area, limited information is available on ambient air quality anywhere in the State. Increased particulate levels will not be a major barrier to geothermal development, although there is general concern about particulate levels in the State. Particulate levels resulting from fugitive dust are high enough to exceed standards for some areas in the southern part of Idaho. Studies in the Raft River KGRA indicate that geothermal development can increase particulate levels in two ways: (1) by increasing the amount of cleared land and traffic on unpaved roads, and (2) generation of particles (Na, Cl, K, Mg) from evaporated geothermal fluids.

It is recommended that levels of particulates be characterized in each of the areas, particularly in the Vulcan Hot Springs area where air quality is expected to be extremely good. A meteorological station should be established in each area except Boise to provide input on wind speed and direction, precipitation, and temperature. Semiannual surveys of background noise should be made and existing sources characterized.

Initial resource evaluations[7] indicate that some hydrogen sulfide is present in nearly all the thermal waters in Idaho. However, most of the H_2S concentrations are less than 0.02% of the noncondensable gases, and releases from geothermal developments are not expected to be a problem. Therefore, no further hydrogen sulfide characterization studies are recommended.

TABLE 10. SUMMARY OF WORK TO BE INCLUDED IN PROPOSED STUDY[a]

Program Element	Vulcan	Weiser-Crane Creek	Boise-Caldwell	Castle Creek	Bruneau	Mountain Home
Air Quality	3 b	2 b	2 b	2 b	2 b	2 b
Water Quality and Water Supply	4 b	4 b	5 b	5 b	5 b	4 b
Noise	3 b	2 b	3 b	3 b	2 b	2 b
Induced Seismicity	4 b	4 b	4 b	4 b	4 b	4 b
Subsidence	2 b	2 b	3 b	4 b	4 b	4 b
Socioeconomics	2 a	3 a	2 a	3 a	2 a	2 a
Ecology	4 c	2 c	2 c	4 c	2 c	2 c
Heritage Resources	2 d	4 c	2 d	2 d	2 d	2 d
Soils	4 c	4 c	2 c	2 c	2 c	2 c

a. Key

Status of Data	Level of Concern
a. sufficient for baseline	1. little or no concern
b. more data required	2. limited concern
c. further evaluation of studies in progress required	3. moderate concern; further study warranted
d. site specific nature requires evaluation for individual developments	4. major concern; further study required
	5. serious concern; further study mandatory

Soils

The primary impact of geothermal development on soils will be erosion. Although general information on soil types is available for each of the geothermal areas, little is available on engineering characteristics, including erosion potential. Several agencies, including the Soils Conservation Service, the Bureau of Land Management, and the U.S. Forest Service, conduct soil surveys on public and private lands in Idaho; thus, any surveys should be coordinated with these agencies to obtain soils information in the areas where development is imminent.

Geology

There is limited information available on the geology of the designated KGRAs in Idaho. Information on regional geology is available for the six areas under consideration, but site-specific data are available only for Boise. Some proprietary data have been generated as a result of geothermal and oil and gas exploration in the State, but these data are currently unavailable.

At this time agencies do not have enough geologic information for most of the State to properly define the geothermal resource potential.

This lack of data also restricts any consideration of potential environmental impacts and evaluations of environmental concerns. Much more geologic information of a site-specific nature is required to evaluate the potential for induced seismicity and subsidence. In addition, geologic data are necessary to make land use judgments and to determine the engineering characteristics of geologic units.

Recommendations include obtaining geologic maps on standard USGS 7-1/2-minute quadrangles encompassing the areas under consideration. The field work should emphasize delineation of faults in the mapped areas, because faults apparently control the geothermal resources in these areas. In addition, driller's logs should be carefully studied to add a third dimension to the surficial geology.

Seismicity

Although the areas under consideration are in seismic risk zone 2, the potential for induced seismicity is a concern because the geothermal resources appear to be originating in fault-controlled systems. Maximum probable earthquake accelerations for these areas range from 0.07 g to 0.5 g.

Only limited macroseismic information is available for these areas; with the exception of some work in Boise, no microseismic surveys have been completed. A 100-day microseismic survey should be conducted in each of the geothermal areas to characterize the existing level of seismic activity. This information should be coordinated with fault mapping and knowledge of the geothermal resources to predict the influence of development on the seismic activity and to evaluate the impact of increased seismic activity on structures and facilities in the areas.

Subsidence

Subsidence can occur whenever large quantities of fluids are withdrawn from relatively unconsolidated formations. Injection can reduce the potential for subsidence, but will probably not be a common practice for much of the direct applications planned in many of the geothermal areas. Even where injection is practiced, there is the danger of "short-circuiting" the geothermal system. If the injecton field is located some distance from the production field to reduce this danger, local elevation changes may result.

Little is known about the potential for subsidence in any of the areas under consideration; therefore, the first phase of any study should assess the potential for subsidence in each of the areas based on information from wells in the area (coordinated with U.S. Geological Survey). If this assessment indicates that there is a high potential in several areas, then high-order leveling should be instituted. Where subsidence may occur as a result of pumping shallow aquifers, leveling is recommended to provide legal defense in the event of suit against the geothermal developer. Preliminary analyses indicate that the potential for subsidence is highest at Bruneau, Mountain Home, and Castle Creek, and these should be the first candidates for leveling.

Hydrology and Water Quality

Water resources are sensitive issues in Idaho; as a result, potential impacts to water resources from geothermal development are the primary public and agency concerns in Idaho. Since the identified geothermal resources are hydrothermal, geothermal development can affect both the supply and quality of surface water and ground water resources. The impact of development on water supply depends to a great extent on the degree of communication between the geothermal resource and other water resources. Evaluating such communication is difficult; however, some evaluations can be made if geochemical data are available. Before detailed hydrologic studies are recommended in each area, surface and ground water sampling programs should be instituted to provide water quality and geochemical information. Data from streams and from aquifers now in use can form the base for an assessment of the degree of communication between resources and an evaluation of how development may affect that communication. It has been shown that dramatic changes in water quality can occur where aquifers are a mix of warm and cold water.

The effect of changes in surface water chemistry can best be measured by monitoring aquatic biota. This is being done in only six places in Idaho, none of which are near the areas under consideration. In those locations where geothermal development might affect surface quality, stream life sampling

stations should be established. These data should be evaluated in conjunction with water chemistry and streamflow information. Stream gages are in operation on perennial streams in each of the six areas except for Vulcan, and data from these gages should be incorporated.

Studies should be coordinated with ground water level monitoring programs conducted by the Idaho Department of Water Resources and the USGS. Information on water level fluctuations should be combined with an evaluation of water use in each area and information from irrigation well logs to produce a summary watershed analysis. Until the water quality evaluation work is completed, no additional hydrologic monitoring should be implemented.

Water quality and geochemical studies should be based on detailed sampling of surface water and ground water resources in each area under consideration. Samples should be collected periodically for up to 2 years from designated sampling points.

Ecology

There is not sufficient existing data compiled to determine what key ecosystem features should be reevaluated periodically to determine impacts from geothermal development. A coordinated study at each area is recommended to generate the needed data. A study of this nature should be conducted on a regional basis.

Heritage Resources

Cultural resources are protected by Federal legislation which requires identification and preservation of heritage materials on Federal lands or on lands affected by federally sponsored or licensed projects. An overview of the known paleontological, archaeological, and historic architectural sites within the five western KGRAs in Idaho was compiled in the first phase of this program. However, the site-specific nature of heritage resources does not lend itself to baseline characterization which would be cost prohibitive for all land within the KGRAs. When future geothermal developments involving ground disturbance are planned, it is recommended that site-specific surveys be conducted at that time.

The potential for heritage resources is very high in the Crane Creek KGRA and is affecting some of the leasing in this area. A sample survey of the lands included in the boundaries of the KGRA will provide valuable information on existing resource materials and will enable the BLM to determine the specific areas that should be excluded from development. An additional effort should look at the applicability of the 25-year old Idaho code for the disruption of resources on State lands. No further study is recommended; site-specific surveys are the responsibility of the developer once development sites have been located.

Socioeconomics and Demography

The population, housing, and economic data base are adequate at this time; all data are county-wide rather than site-specific as a function of the rural nature of Idaho. Current data are based on the 1970 census and thus are not useful in high growth areas such as Boise. It is recommended that population and related housing data not be reevaluated until 1981, following the 1980 census. A comprehensive economic analysis for the areas of interest should be coordinated with information on market penetration and the economic feasiblity of geothermal development.

Conda KGRA-Grays Lake Area

In January 1978, the USGS designated a 1039-ha area in southeastern Idaho as the ninth and smallest KGRA in the State. Located 16 km northeast of the town of Soda Springs, the competitive interest Conda KGRA is located entirely on public land administered by the BLM.

Since the Conda KGRA was officially designated after the overview phase of the Snake River Basin study was initiated, it was not included in that work. However, to consistently prepare an environmental data base for areas of significant geothermal potential within Idaho, a data compilation and evaluation effort should be performed for the Conda KGRA and the nearby Grays Lake area. This should include the following tasks:

1. Compile and evaluate available environmental data pertaining to air

quality, meteorology, soils, geology, subsidence, seismicity, water quality, hydrology, terrestrial and aquatic flora and fauna, socioeconomics, demography, and heritage resources

2. Coordinate with other Government agencies, State departments, and interested groups to identify what additional data are needed to establish an appropriate environmental data base prior to extensive geothermal development in the area

3. Develop a plan for obtaining supplemental data required to establish the regional Snake River Basin environmental overview and data base.

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Appendix A
Summary of Special Environmental Concerns

TABLE A-1. GEOLOGY - SPECIAL CONCERNS

KGRA	Adequacy of Existing Geologic Data: Surficial Data	Adequacy of Existing Geologic Data: Subsurface Data	Evaluation of Needed Geologic Information: Surficial Data	Evaluation of Needed Geologic Information: Subsurface Data
Vulcan			Incomplete status of geologic mapping.	Incomplete status of subsurface geology and geophysical data. Delineation of bedrock faults is necessary. An assessment of trends of Tertiary intrusive rocks across central Idaho and Oregon would be valuable.
Crane Creek			Incomplete status of geologic mapping.	Subsurface lithologies and locations of faults without surface, expressions are not known. The depth to the basement is not presently known.
Castle Creek			Incomplete status of geologic mapping. Delineation of surface geology.	Fault displacements need to be studied. Additional well logging and lithologic description. Depth to basement, basement configuration and thickness of silicic volcanics is not known.
Bruneau	X[a]		Delineation of faults is necessary.	The thickness of silicic volcanic rocks must be verified. Depth to basement lithologies must be studied more thoroughly. Delineation of faults is necessary.
Mountain Home	X		Delineation of faults concealed by the Bruneau Formation is needed.	General information needed.
Raft River	X	X		Delineation of subsurface geologic structure. Fault displacements need to be studied. Further well logging and better lithologic description.

TABLE A-1. (continued)

KGRA	Adequacy of Existing Geologic Data: Surficial Data	Adequacy of Existing Geologic Data: Subsurface Data	Evaluation of Needed Geologic Information: Surficial Data	Evaluation of Needed Geologic Information: Subsurface Data
Island Park/ Yellowstone	X		Additional delineation of faults.	Incomplete evaluation of subsurface geology, including depth to basement, structure, and lithologies.

a. X indicates that sufficient data are available for an initial geothermal environmental assessment.

TABLE A-2. SEISMICITY - SUMMARY OF CONCERNS

KGRA	Adequacy of Existing Seismic Data	Evaluation of Needed Seismic Data	Assessment of Potential Seismic Activity
Vulcan		Geologic mapping is needed. Microseismic surveys of sufficient duration would allow the delineation of zones of seismicity.	Swarm activity occurred in 1979 within 15 km of this KGRA.
Crane Creek		Aerial reconnaissance and a detailed analysis of anomalous sites is needed. Microseismic monitoring is necessary to establish baseline data in the Cascade-Sweet zone.	1976 to 1977 data show significant seismic activity to the northeast of the KGRA.
Castle Creek		Detailed geologic mapping is required. Acquisition of seismic reflection data would aid in delineation of subsurface faults. Microseismic surveys monitoring activity over long periods from holes would help to determine if the area is seismic.	Nearby areas exhibit relatively high seismic activity.
Bruneau		Detailed geologic mapping is required. Acquisition of seismic reflection data would aid in delineation of subsurface faults. Microseismic surveys monitoring activity over long periods from holes would help to determine if the area is seismic.	Nearby areas exhibit relatively high seismic activity.

TABLE A-2. (continued)

KGRA	Adequacy of Existing Seismic Data	Evaluation of Needed Seismic Data	Assessment of Potential Seismic Activity
Mountain Home		Detailed geologic mapping is required. Acquisition of seismic reflection data would aid in delineation of subsurface faults. Microseismic surveys monitoring activity over long periods from holes would help to determine if the area is seismic.	Nearby areas exhibit relatively high seismic activity.
Raft River	X[a]	A 1976 microseismicity survey conducted by the Colorado School of Mines recorded seven microseismic events in the area over 90 days. A seismic survey is currently underway to introduce additional data.	Although adjacent to the intermountain seismic zone, evidence indicates a closer association with the aseismic Snake River Plain.
Island Park/ Yellowstone		Seismic reflection data would aid in delineation of subsurface faults. Microseismic monitoring of the region would prove useful in evaluation of the potential seismic hazard.	In 1959 an earthquake of magnitude 7.1 shook the area around Hebgen Lake, Montana. The shocks affected the entire Island Park Geothermal Area.

a. X indicates that sufficient data are available for an initial geothermal environmental assessment.

TABLE A-3. CLIMATE AND METEOROLOGY -- SUMMARY OF CONCERNS

KGRA	Adequacy of the Existing Environmental Data	Adverse Weather Conditions
Vulcan		Hail up to one cm in diameter falls in this area. Strong valley winds uproot trees in shallow soil that are poorly anchored.
Crane Creek		Occasional thunderstorms and hail of little consequence.
Castle Creek		Occasional moderate dust storms or thunderstorms.
Bruneau		Occasional moderate dust storms or thunderstorms.
Mountain Home		Occasional, moderate dust storms. Occasional recordings of funnel clouds or tornados. Destructive winds are rare.
Raft River	X[a]	Occasional severe dust storms and moderate thunderstorms.
Island Park/ Yellowstone	X	Occasional high intensity, short-duration thunderstorms.

a. X indicates that sufficient data are available for an initial geothermal environmental assessment.

TABLE A-4. SUBSIDENCE -- SUMMARY OF CONCERNS

KGRA	Adequacy of Existing Subsidence Data	Evaluation of Needed Subsidence Information	Assessment of Potential Subsidence Hazards
Vulcan	X[a]		It is hypothesized that subsidence in this area would be caused by water level drawdowns in regions of fracturing or altered bedrock.
Crane Creek	X	It is necessary to determine whether thermal waters are meteoric waters recycled at depth or older waters that are upwelling. Developments could trigger water level declines.	Geologic materials of the area appear susceptible to subsidence.
Castle Creek	X	It is necessary to determine if deep aquifers are recharging shallow ground water systems due to the potential of subsequent water level drawdown.	Geologic materials of the area appear susceptible to subsidence. Heavy irrigational use may cause a decline in water levels. Development could accelerate the declines.
Bruneau	X	It is necessary to determine if deep aquifers are recharging shallow ground water systems due to the potential of subsequent water level drawdown.	Geologic materials of the area appear susceptible to subsidence. Heavy irrigational use may cause a decline in water levels. Development could accelerate the declines.
Mountain Home		Repeated leveling data would be necessary to assess if subsidence is occurring in this area. Laboratory compaction tests would allow an estimate of compaction potential.	Geologic materials of the area appear susceptible to subsidence. Ground water level declines of more than 20 feet from 1968 to 1977 occurred to the south.

TABLE A-4. (continued)

KGRA	Adequacy of Existing Subsidence Data	Evaluation of Needed Subsidence Information	Assessment of Potential Subsidence Hazards
Raft River	X	Repeated leveling data would be necessary to assess if subsidence is occurring in this area. Laboratory compaction tests would allow an estimate of compaction potential.	A survey determined that as much as 0.9 m of subsidence had occurred in the lower Raft River Valley as a result of irrigation pumping; development could affect subsidence.
Island Park/ Yellowstone		Leveling data would be necessary to assess if subsidence has occurred. Laboratory compaction tests would be useful.	Following the collapse of the land surface associated with the IPGA caldera, there has been no recognized land subsidence. The rock types at depth provide adequate support and are physically incapable of causing subsidence.

a. X indicates that sufficient data are available for an initial geothermal environmental assessment.

TABLE A-5. SOILS -- SUMMARY OF CONCERNS

KGRA	Land and Water Use Conflicts	Soil Limitations General: Shallow, Immature, Sparsely Vegetated Soils	Topographic Limitations General: Steep Slopes	Drainage Limitations General: Poorly Drained, River Bottoms and Flood Plains	Specific Limitations
Vulcan		Highly erodible soil.	0 to 60% slope gradient throughout the area.		Heavily forested.
Crane Creek	Valleys are utilized for farmland, and terraces are dissected.		Steep slopes.	Shallow, stony soils.	
Castle Creek	Irrigated farmlands and rangeland for livestock present a conflict.				
Bruneau	Irrigated farmlands and rangeland for livestock present a conflict.				
Mountain Home	Irrigated farmlands and rangeland for livestock present conflicts. Geothermal resources are used by ranchers for irrigation or space heating.			Cemented, calcareous pan layers inhibit percolation, increasing surface runoff potential. Saturated topographic lows present limitations to certain types of geothermal development.	

TABLE A-5. (continued)

KGRA	Land and Water Use Conflicts	Soil Limitations General: Shallow, Immature, Sparsely Vegetated Soils	Topographic Limitations General: Steep Slopes	Drainage Limitations General: Poorly Drained, River Bottoms and Flood Plains	Specific Limitations
Raft River	Irrigation of farmlands and rangeland for livestock present a conflict. The basin is closed to any additional ground water resource development.			The Raft River is the only perennial stream in the geothermal area.	Closure of the Raft River Basin to appropriation of water resources as a result of declining water levels in the lower end of the valley.
Island Park/ Yellowstone	Many wells are used for municipal, domestic and livestock use; only a few are used for irrigation.	The soils may limit development in some areas.	The topography could prevent development in some areas.		The IPGA and its close proximity to Yellowstone Park may inhibit development.

TABLE A-6. SUMMARY OF CONCERNS -- HYDROLOGY AND WATER QUALITY

KGRA	Adequacy of Existing Hydrologic Data				Special Concerns			
	Definition of Ground Water Flow	Outline of the Water Balance into the KGRA or Adjacent Drainage Basins	Water Quality Data for Ground and Surface Waters	Consumptive Water Use Data	Water Rights Limitations	Water Use Limitations	Environmental Limitations	Specific Limitations
Vulcan					Water rights downstream of the KGRA boundary must be considered.		Environmental disturbance to streams that support anadromous fish population. Vulcan Hot Springs and Warm Lake areas support much recreational activity. Geothermal development may decrease the aesthetic value of this area.	
Crane Creek			X[a]		Adjudication of all water rights is needed.	Major conflicts with established irrigation activity. Proposed multipurpose dam at the Galloway Site on the Weiser River.		
Castle Creek					A possible violation may result of the instream minimum flow law and water permit for power issued to Idaho Power Co. Adjudication of all water rights is needed.	Major conflicts with established irrigation activity. Proposed Swan Falls-Guffey Power project on the Snake River.	Environmental disturbance of the Federal Birds of Prey Sanctuary along the Snake River.	High fluoride content of ground waters.

TABLE A-6. (continued)

KGRA	Adequacy of Existing Hydrologic Data				Special Concerns			
	Definition of Ground Water Flow	Outline of the Water Balance into the KGRA or Adjacent Drainage Basins	Water Quality Data for Ground and Surface Waters	Consumptive Water Use Data	Water Rights Limitations	Water Use Limitations	Environmental Limitations	Specific Limitations
Bruneau					Adjudication of all water rights is needed.	Major conflicts with established irrigation activity. U.S.D.O.D gunnery range.	Aquifer pollution due to waste disposal. This area is under study for inclusion in the National Wild and Scenic River System.	High fluoride content of ground waters.
Mountain Home					Adjudication of all water rights is needed.	Minimal conflicts with established irrigation activity.		
Raft River	X		X		Raft River Basin is closed to additional ground water development.	Major conflicts with established irrigation activity.	Aquifer pollution due to waste disposal and injection.	Some high fluorides are present in ground water supplies.
Island Park/ Yellowstone					Adjudication of all water rights is needed.		Potential impact to elk and deer migration route.	Specific limitations may occur due to the proximity to the National Park.

a. X indicates that sufficient data are available for an initial geothermal environmental assessment.

TABLE A-7. TERRESTRIAL ECOLOGY AND BIRDS OF PREY -- SUMMARY OF CONCERNS

KGRA	Location	Species of Special Concern: Plant	Species of Special Concern: Animal	Other Concerns and Recommendations
Vulcan	Area is located on a wet meadow habitat.		Elk.	Developing the KGRA imposes a serious risk on reducing elk numbers because it disturbs a major calving ground. Mule deer migration and Chinook salmon breeding may also be disturbed.
Crane Creek	Area is located within the Tall Sagebrush habitat.		Mule deer, pronghorn, California quail, chukar, white-faced ibis, Idaho ground squirrel, and over wintering fowl.	Additional information is needed to clarify the status of the white-faced ibis and the Idaho ground squirrel before development begins. Key species populations maintained by extensive riparian vegetation should be adequately protected.
Castle Creek	Area occupies much of the limited Salt Desert shrub habitat. One third of the area overlaps the Snake River Birds of Prey Natural Area.	A Stragalus Mulfordiae "Milk-vetch."	Chukar, prairie falcon, peregrine falcon, bald eagle, osprey, and over-wintering waterfowl.	A reduction in extensive riparian vegetation habitat could limit game and nongame species population. Present proposed boundaries of the Castle Creek and Bruneau KGRAs should be reevaluated to ease impact on the terrestrial ecology.
Bruneau	Area occupies a fraction of the Tall Sagebrush habitat.	Same as above.	Same as above.	Same as above.
Mountain Home	Area is located entirely within the Tall Sagebrush habitat.	Primula cusickiana "Primrose."	Mule deer, sage grouse.	Consideration must be given to the reduction in mule deer and sage grouse populations if the habitat is altered extensively.

TABLE A-7. (continued)

KGRA	Location	Species of Special Concern: Plant	Species of Special Concern: Animal	Other Concerns and Recommendations
Raft River	Area is located within the cold desert formation.		Mule deer, prong-horn antelope, ferruginous hawk, prairie falcon, bald eagle, and golden eagle.	The dominant plant life forms are shrubs of the xenophytic or halophytic types such as greasewood, sagebrush, and saltbrush. No plant species have as yet been declared threatened or endangered. No species of wildlife known to occur in the geothermal development area are presently listed as endangered or threatened. But the uncertain status of the ferruginous hawk, prairie falcon, and transient eagles are of concern.
Island Park/ Yellowstone	Area is located within the Rocky Mountain Douglas fir forest province.		Grizzly bear, northern Rocky Mountain wolf, Canada Lynx, fisher, wolverine, trumpeter swan, sharptailed grouse, ferruginous hawk, prairie fal-con, American peregrine falcon, and northern bald eagle.	Elk migrate along distinct routes through the IPGA. Elk from Yellowtone National Park and surrounding portions of the Targhee and Gallatin National Forests also use these routes. Approximately 200 elk winter on the IPGA. The mule deer is an important big game species in Idaho, Wyoming, and Montana. The entire IPGA is summer range in fair to good condition. Moose are distributed throughout the IPGA and it provides extensive winter range. The IPGA is located in the Pacific waterfowl flyway and is utilized by over a million waterfowl.

a. X indicates that sufficient data are available for an initial geothermal environmental assessment.

TABLE A-8. HERITAGE RESOURCES -- SUMMARY OF CONCERNS

KGRA	Paleontological Data	Prehistoric Data	Historic Data	Paleontological	Prehistoric	Historic
Vulcan			X[a]	Although the data base is undeveloped, the potential for producing significant remains is low due to the nature of the rock type in the KGRA.	Two prehistoric lithic scatters discovered in dense vegetation suggest that more sites are present. Nez Perce and Shoshoni exploitation of this area is probable. Evidence suggests that the KGRA has been exploited by human population for 10 000 years.	
Crane Creek				Upper Miocene faunal remains in the Payette Formation are used as lithologic contact designation for the Columbia Plateau bedded sequence.	Folsom projectile points dated to 10 900 years ago attest to a cultural time and depth throughout the KGRA and vicinity. Artifacts including Midvale complex materials (4000 to 7000 years) and similar Sangler site remains (600 years) may be present here. Nez Perce and Shoshoni Indians exploited the lower Weiser Valley.	Historic archaeological and architectural resources are of great variety and potentially of significance in this area.
Castle Creek				Fossil-rich Pliocene and Pleistocene deposits (including fossil horse assemblages of the Hagerman section are potentially found in this KGRA and adjacent areas.	Lithic resource sites and large village sites in the Snake River Canyon suggest a rich prehistoric data base within the KGRA. The canyon-plateau-uplands region is believed to have supported prehistoric cultures from 8000 years ago. Mixed groups of Shoshoni and N. Paiute occupied this area.	Euroamericans traveled and homesteaded along the South Route of the Oregon Trail which runs along the northwest-southeast length of the KGRA. The Oregon Trail is receiving Federal identification for preservation. Grand View and Clark's ferries operated within the KGRA.
Bruneau				Molluscan, plant and vertebrate fauna are preserved in in the Chalk Hills, Glenns Ferry, and Bruneau Formations.	Olsen found over 200 cultural sites in the Bruneau Canyon in 1937 (the records are unpublished and lost) and a small campsite at the southern KGRA border was verified. Shoshoni winter villages and camps were most likely established at hot springs on the western KGRA border. A survey unearthed 173 prehistoric sites adjacent to the KGRA that date 10 000 years.	Homesteads, early schools, or community structures may occur in this KGRA.

TABLE A-8. (continued)

KGRA	Paleontological Data	Prehistoric Data	Historic Data	Paleontological	Prehistoric	Historic
Raft River				No systematic paleontological studies have been conducted along the Raft River or in the valley. However, numerous mid-to-late Pleistocene fossils (of the elephant-camel-horse-bison biocenotic group) have been found in the unconsolidated gravels along the Snake River. This could indicate that paleontological finds are possible in the Raft River area although none have been found.	The hukandeka or hikandeka (seed-eaters) roamed between the Snake River Plain and the Great Salt Lake, relying principally on the riparian or riverine zone. Ethnographic data indicate that the nuts of the pinyon were used. The Raft River area appears to be part of a cultural-ecological system that includes south-central Idaho, northwestern Utah and northeastern Nevada. The Raft River area is considered to be archaeologically significant.	Two sites are listed in the National Register of Historic Sites and Places. The City of Rocks with visible wagon train tracks and Granite Pass (part of the California Trail). Other points of interest include Reed Spring, a known emigrant resting area, and the Earncliff Post Office, a stagecoach station. The Raft River was an eminent crossroad during western expansion because of its geographic location and natural resources.
Island Park/ Yellowstone					Evidence from the IPGA and surrounding regions indicates that human occupation dates back 12 000 years. The IPGA was used seasonally or as a migration route. The eastern Shoshone tribes (Snake) were the most common summer migrants through the area. Other tribes which are thought to have spent some time in the area include Blackfeet, Crow, and Flathead.	Trapping was an important activity in the areas. Many Indian campsites and historic sites of white settlers occur within the IPGA, mostly on private land.

a. X indicates that sufficient data are available for an initial geothermal environmental assessment.

TABLE A-9. SOCIOECONOMIC LIMITATIONS -- SUMMARY OF CONCERNS

	Adequacy of Existing Socioeconomic Data Concerning:	General Limitations
Population	X[a]	Population data for the principal centers are outdated.
Labor Force	X	Counties with low local unemployment numbers may have a difficult time meeting the labor demands of a new industry.
Economic Structure/ Employment	X	
Retail Trade	X	Several counties in the study region have relatively few retail establishments. Existing retail capacity must be related to potential population changes in an impact assessment.
Wholesale Trade	X	Wholesaling is generally concentrated in urban areas. Data on wholesale activity at the county or regional level is limited.
Selected Services	X	Rural areas offer a limited number and range of selective service.
Manufacturing	X	The activity is largely concentrated in Ada and Canyon Counties. A shift from rural-agricultural to nonrural-manufacturing culture will not be without problems.
Income Distribution Data	X	Owyhee and Washington Counties are characterized by a high percentage of families below the poverty line. The study region is considered a below average income area in a below average income state. Geothermal development could have a differential impact on different income groups.

TABLE A-9. (continued)

	Adequacy of Existing Socioeconomic Data Concerning:	General Limitations
Agriculture	X	Agricultural land resources and utilization are challenged by geothermal development. Specific land uses in the vicinity of the KGRAs need to be inventoried. The off-farm labor activity of farmers impacted by geothermal development must be considered. Data collection is necessary to discern whether farmers are interested in industrial jobs or seeking occupational change.
Mining	X	
Baseline Projections of Population and Economic Activity	X	
The Public Sector/ Public Finance Data	X	
Education	X	Significant industrialization can lead to large impacts on the area's education system.
Crime	X	There is a chance that the crime rate will increase with significant industrialization.
Health Care	X	Data collection efforts should be aimed at identifying specific locations of hospitals and doctor's offices in the vicinity of the KGRAs.

TABLE A-9. (continued)

	Adequacy of Existing Socioeconomic Data Concerning:	General Limitations
Land Use	X	Leasing of land for geothermal development will require environmental impact statements and permits from environmental agencies.
Recreation	X	

a. X indicates that sufficient data are available for an initial geothermal environmental assessment.

Appendix B
Rules and Regulations

APPENDIX B

RULES AND REGULATIONS

LEASING AUTHORITY[a]

Federal

Leasing of geothermal resources on public, acquired, and withdrawn lands is authorized by the *Geothermal Steam Act of 1970.* The administration of the regulations for this law is directed by the Bureau of Land Management (BLM). Another set of regulations covering the exploration, development, and production operations under Federal lease is administered by the U.S. Geological Survey (USGS).

In accord with a memorandum of understanding among the BLM, USGS, and the Fish and Wildlife Service, an internal document, the BLM, in cooperation with the Geological Survey, formulates the general requirements of geothermal leases. They issue special stipulations, as necessary, which often are concerned with environmental protection. The BLM is responsible for monitoring and compliance with environmental protection requirements outside the operating area, and the USGS examines operations to ensure compliance.

In addition to any action required by the applicable Federal, State, and local environmental standards, the lessee is ordered by the BLM regulations to take the following specific actions:

1. *Pesticides and herbicides.* The lessee shall comply with all rules issued by the Department of the Interior and the Environmental Protection Agency pertaining to the use of poisonous substances on public lands.

2. *Water pollution.* The lessee shall conduct lease operations and maintenance in accordance with Federal and State water quality standards and public health and safety standards, and applicable local water quality standards and public health and safety standards. Toxic materials shall not be released into any surface waters or underground waters. Reinjection of waste geothermal fluids into geothermal or other suitable aquifers is to be managed in accord with the lessee's plan of operation.

3. *Air pollution.* The lessee shall control emissions from operations in accordance with Federal and State air quality standards and applicable local air quality standards.

4. *Erosion control.* The lessee shall minimize disturbance to vegetation, drainage channels, and stream banks. The lessee shall employ such soil and resource conservation and protective measures on the leased lands as the Supervisor deems necessary.

5. *Noise control.* The lessee shall control noise emissions from operations in accordance with Federal and State noise emission standards and applicable local noise emission standards.

6. *Sanitation and waste disposal.* The lessee shall remove or dispose of all waste material generated in connection with the exploration, development, production, and transportation operations in a manner set forth in the approved plan of operation.

7. *Land subsidence, seismic activity.* The lessee shall take precautions necessary to minimize land subsidence or seismic activity which could result from production of geothermal resources and the disposal of waste fluid where such activity could damage or curtail the use of the geothermal resources or other resources, or other uses of the land and take such measures as stipulated to: (a) monitor operations for land subsidence and for

a. "Survey of Environmental Regulations Applying to Geothermal Exploration, Development, and Use," WAPORA, Inc., Washington, D.C. Feb., 1978. 245 pp.— EPA Report No. EPA-600/7-78-014; NTIS Accession No. PB281023.

seismic activity, and (b) maintain and, when requested, make available to the lessor, records of all monitoring activities.

8. *Aesthetics.* The lessee shall take aesthetics into account in the planning, design, and construction of facilities on the leased premises.

9. *Fish and wildlife.* The lessee shall employ such measures as are deemed necessary to protect fish and wildlife and their habitat.

10. *Antiquities and historical sites.* The lessee shall conduct activities on discovered, known, or suspected archaeological, paleontological, or historical sites in accordance with lease terms or specific instructions.

11. *Restoration.* The lessee shall provide for the restoration of all disturbed lands in an approved manner.

The USGS regulations do not reference local environmental control requirements but the BLM document does. Due to this distinction, a lessee may be confronted with a situation in which the stipulations to his lease, reference and incorporate applicable local standards, which are preempted by omission in the USGS operating regulations. Geothermal Resource Operations (GRO) orders offer a means for minimizing potential problems generated by the minor differences between BLM leases and USGS operating requirements.

Geothermal resources operation orders are formal orders issued by USGS to supplement the general regulations by detailing the procedures for operations in a given area or region. The purpose of this arrangement is to allow consideration of more area-specific operating and environmental conditions.

The USGS has issued seven GROs. They are:

1. GRO Order Number 1 — Exploratory Operations

2. GRO Order Number 2 — Drilling, Completion, and Spacing of Geothermal Wells

3. GRO Order Number 3 — Plugging and Abandonment of Wells

4. GRO Order Number 4 — General Environmental Protection Requirements

5. GRO Order Number 5 — Reports and Forms

6. GRO Order Number 6 — Pipelines and Surface Production Facilities

7. GRO Order Number 7 — Production and Royalty Measurement, Equipment and Testing Procedures.

While appropriate environmental protection and reclamation measures are generally required by the GROs, it is, as indicated above, GRO Order Number 4, promulgated on August 15, 1975, which mandates environmental protection for all stages of exploration and development in Federal geothermal resource lands located in the USGS central and western regions.

Generally speaking, regardless of its stated purpose, some of the provisions of GRO Order Number 4 which are incorporated by reference into BLM leases are weaker and more ambiguous than the language of the regulations or the lease. Its overall effect will probably be determined largely by the seriousness with which lessees accept the order and how strenuously the Supervisor enforces it.

Relevant Federal and State environmental standards are usually made applicable along with existing technology, but local and/or regional standards apply only in certain instances. Exceptions to compliance with any of the standards can be granted by the Supervisor on a case-by-case basis. Conversely, he may establish more stringent standards by field order, usually in the form of special stipulations.

The lessee's overall general responsibility to protect the environment is to:

1. Provide maximum protection to the environment during exploration and development operations

2. Rehabilitate impacted areas

3. Protect by all necessary means the public health and safety

4. Conduct operations in compliance with all applicable Federal laws and executive orders.

Monitoring of "readily identifiable localized environmental impacts" caused by the activities specifically under the lessee's control shall be conducted by the lessee. Frequency of such monitoring activity will be decided by the Supervisor who will consider each site's conditions in establishing the monitoring rates. As described above, a year of baseline data on air, water quality, noise, seismic and land subsidence activities, and ecological systems must be generated before production goes on stream.

The following impacts and accompanying requirements are set out in the Order as being "protectable:"

1. *Aesthetics.* Visual impact, where feasible, shall be minimized by careful site selection. The facilities should be constructed so as to blend with their natural surroundings.

2. *Land use and reclamation.* Essentially, USGS requires that geothermal operations disturb land, water, and vegetation as little as possible. Operations and reclamation procedures are subject to approval by the Supervisor and the surface management agency involved (BLM, Forest Service). Since multiple use of the leased land is allowed, geothermal operations are not to interfere unreasonably with other authorized uses. Entry to fragile areas must be controlled by limited access routes or by use of special vehicles.

3. *Public Access.* Such access is to be unrestrained except when circumstances mandate controlled access to:

   a. Protect public health and safety

   b. Prevent undue interference with operations or security

   c. Protect the public, wildlife, and livestock from hazardous geothermal activity.

4. *Recreation.* Areas designed for recreation near geothermal areas are to be "adequately protected" from degradation. Development sites are to be located 61 m from established recreation sites and accompanying access routes. The Supervisor, however, may allow the lessee to relocate the recreation site if the surface management agency agrees to the change.

5. *Slope stability and erosion control.* Mitigating measures for soil and natural resource protection are required to prevent sedimentation from occurring in waterways.

6. *Biota.* Mitigation measures required to protect endangered or threatened flora and fauna may exceed those required by the lease. Under the Endangered Species Act, reclamation and restocking of destroyed flora and fauna by the lessee is required if the area will not naturally recover.

7. *Cultural resources protection.* The lessee may not disturb "any known cemetery or burial ground of any group or culture." Preservation of historic sites shall be in accordance with Executive Order 11593 ("Protection and Enhancement of the Cultural Environment") and conducted with the lessee's "due diligence." Caution must be exercised by BLM/USGS and the applicant to protect historically important areas. Even if historic properties are not listed in the Historic Register, local public interest might necessitate mitigating measures by a lessee in order to offset adverse public opinion.

8. *Subsidence and seismicity.* Land subsidence shall be prevented by surveys and by adequate record keeping of operations. If the Supervisor finds that subsidence is potentially significant or that it has occurred, then he may reduce or terminate operations or require seismograph monitoring equipment. Surveys shall be conducted in accordance with County/State requirements, and bench marks shall be established before "prolonged" production begins.

9. *Pollution and waste disposal.* All Federal and State standards with respect to air, land, water, and noise pollution must be complied with by the lessee. Additionally, erosion control and any waste disposal shall be conducted in compliance with such laws. This section is divided into various categories, with emphasis placed on control of water pollution. Requirements set out for various forms of pollution are:

   a. Natural water shall not be contaminated by the lessee. The rest of the environment shall be only minimally affected.

   b. If disposal of harmful liquids (including toxic and heated substances) cannot meet the standards, the liquids are to be injected back into a geothermal well or any other formation approved by the Supervisor.

   c. The Supervisor's approval is necessary for disposal of solid wastes at approved sites.

   d. Federal, State, or regional air pollution standards are the criteria for air emissions and the lessee must obtain any necessary permits for air emissions from the appropriate air pollution control agency. This permit plus required reports must be submitted to the Supervisor.

   e. No water pollution is permitted to occur by reason of pits and sumps. The lessee has to reasonably restore the aesthetic and natural resource values of the area when the use of pits and sumps ceases.

   f. The lessee is required to train operating personnel in pollution prevention methods.

In addition to the above requirmenets, noise levels may not exceed 65 dB(A) unless all residents located within 0.8 km of the operation agree to an increased level or an emergency arises. The ambient noise level used for ranking the permissibility of additional noise is "the minimum sound level at the relevant place and time in the absence of the source noise and shall include consideration for the type of land use, and the season, atmospheric conditions, and the time of day." Noise parameters can be established by the Supervisor, after assessment, in accordance with Federal or State criteria with adjustments for specific site conditions.

Noise levels are to be measured at 0.8 km from the source or at the lease boundary line, whichever is greater. Noise meters shall be those that meet U.S. Standard Specifications. Measurements shall be made at least 3 m from a structure and 1 m above ground level. Site variables, such as weather conditions, are to be taken into consideration.

State of Idaho

The State Board of Land Commissioners is authorized by the *Geothermal Resources Leasing Acts of 1972* to lease the geothermal resources on State owned lands with the minerals reserved to the State.

Drilling Authority

The Idaho Department of Water Resources is the regulatory agency for the drilling, operation, maintenance, and abandonment of all geothermal wells. This Department also has other regulatory jurisdiction over related operations and environmental hazards pertaining to exploration, development, and use of geothermal resources.

The standards set by the Department of Water Resources apply only to wells 305 m or deeper, including those drilled for exploratory purposes. Wells shallower than 305 m are not covered "even though the well may be for seismic work, heat flow, or other exploration." These limitations, however, are evidently open to interpretation.

The rules give the Department very specific authority over drilling practices and well spacing. A permit is required to drill a well, modify an existing one, or convert a production well to an injection well.

IDAHO STATE GEOTHERMAL RESOURCE AREA CLASSIFICATION

Authority

The Idaho Department of Water Resources, through authority granted by the Idaho Code, states the Director shall have the authority to, and may designate any area of the State, a geothermal resource area where the Director finds or has reason to believe that such designation is necessary to protect the geothermal resource from waste and to protect other resources of the State from contamination or waste.

Classification Factors

Any relevant data or information pertaining to the classification of lands as Geothermal Resource Areas (GRAs) in the State of Idaho fall into four categories:

1. Geology, including geochemical and geophysical data
2. Competitive interests
3. Nearby discoveries to already classified areas
4. Other: any pertinent geological, engineering, and/or economic data may be considered along with other available data in determining GRAs. New methods of evaluation may be incorporated from time to time as they become available, and various new theories may be applied to determining GRAs as they are proposed.

Conditions (Authority 42-4003 G&H)

1. No person shall drill a well for any purpose to a depth of 900 m or more below land surface in a designated GRA without first obtaining a permit under the provisions of this section. Such permits shall be in addition to any permit required by other provisions of law.
2. The owner of any well constructed or being constructed pursuant to the Idaho Code, which encounters a geothermal resource, and who intends or desires to utilize such resource, shall make application for a geothermal permit as required under this section, provided, however, that no additional filing fee shall be required.

Permitting

The Idaho Department of Water Resources is responsible for issuing permits for geothermal development in the State. Two types of permits are available, the Geothermal Permit and the Water Right Permit; one or both may be issued.

The Geothermal Permit is a regulatory permit which subjects the investigator and developer to construction criteria and bonding requirements. The permit application identifies the applicant, responsible contact parties, the extent and location of the activity, and the proposed method of exploration often identified as the drilling prospectus. The Geothermal Permit often contains a dozen or more conditions of approval. Examples of these are:

1. Stringent casing requirements
2. Blow out prevention equipment
3. Logging requirements
4. Bonding requirements above the normal $10 000
5. Lining of mud pits, and
6. Road construction requirements.

The Geothermal Permit demonstrates that every precaution has been taken in the event of an accident and resultant litigation.

The Water Right Permit is based on the basic water law to protect the individual through orderly development of the resources. It is an appropriation doctrine meaning that "the first in time is the first in right." The doctrine indicates, in the broadest sense, anyone who develops a geothermal well for the purpose of space heating

does not need to apply for and receive a Geothermal Permit but is required to file for a water right. Hot water users (space heating) are protected by the water right laws.

The Water Right Permit may provide greater protecion to the applicants in place of a Geothermal Permit. However, geothermal exploration and development is in its very early stages of growth, and no one is sure how the courts might react to one permit or the other as they apply to resource or individual protection. It may prove best to obtain both permits as the time and cost is minimal when considered in the overall cost of the projects.

Appendix C
Summary of Public Workshops

APPENDIX C

SUMMARY OF PUBLIC WORKSHOPS

FIRST WORKSHOP

A workshop was held in Boise, Idaho, on July 20, 1978, with participants from local, State, and Federal agencies; universities; and the private sector. Industry, although invited to attend, was not well represented. The objective of the workshop was to identify and discuss issues of concern in each of the Idaho known geothermal resource areas (KGRAs). Discussion groups were established for the following topics: (a) water quality and hydrology; (b) air quality and meteorology; (c) geology, subsidence, and seismicity; (d) socioeconomics and demography; and (e) flora and fauna. The groups identified concerns for their respective topics and suggested methods to mitigate such problems.

Water Quality and Hydrology

The primary considerations identified by the water quality and hydrology group are:

1. Resource definition: is "geothermal" a water or a mineral resource?

2. Lack of knowledge of the geothermal resource, including data on hydrologic boundaries, aquifer recharge, water quality of the geothermal resource, pressure changes, resource life span, and interrelationships of hot fluids, surface waters, and shallow ground water systems.

3. Disposal of spent fluids: surface discharge versus injection.

4. Need for a monitoring network to include chemical parameters, temperature, water levels, and pressure of the geothermal aquifer.

5. Institutional factors: water laws (rights and usage) and water quality standards.

Geology, Subsidence, and Seismicity

The primary considerations identified by the geology, subsidence, and seismicity group are:

1. Lack of data about Idaho KGRAs

2. The need for quality data, including geologic mapping, geophysical mapping, subsidence and seismic monitoring, and test-well information.

Flora, Fauna, and Soils

The primary considerations identified by the flora, fauna, and soils group are:

1. Need for a complete environmental study prior to geothermal development (including predictable impacts on the biotic environment)

2. Potential sensitive areas identified include: (a) raptor nesting sites; (b) antelope kidding grounds; (c) big game migration routes; (d) natural streams, springs, and lakes; and (e) soils with high erosion hazard

3. Factors related to surface water impacts: (a) depletion/reduction of flows; (b) thermal/chemical enrichment; (c) increased siltation from erosion; and (d) effects on sensitive or endangered species dependent on local waters.

Air Quality and Aesthetics

The primary considerations identified by the air quality and aesthetics group are:

1. Air quality impacts received little attention, since closed systems should mitigate problems associated with emission of H_2S and other noxious gases

2. The positive impact of replacing fossil fuels with geothermal energy for space heating was identified

3. Long-term noise effects were assessed as being insignificant, with cooling-tower noise similar to the low hum of a waterfall

4. Aesthetic impacts were assessed as "beauty is in the eyes, ears, nose, and pocketbook of the beholder."

Socioeconomics and Demography

The primary concerns identified by the socioeconomics and demography group are:

1. Population increases in previously rural, nonindustrial areas will increase demands for urban services, increase tax revenues, and require land-use planning and control systems

2. Geothermal development will result in cost-of-living increases (housing and taxes), will likely impact existing industries, and could result in the need for development of adequate commmunity leaders, depending on the extent of the development.

Each group was presented with a "simulated environment" (Figure C-1) and asked to indicate areas which they would consider for geothermal development given existing conditions (e.g., land ownership and use, protected habitat, migration routes, heritage resources, water resources, and known geothermal phenomena). The objective of this exercise was to require the participants to set their priorities relative to resource use, considering all components of the environment. The results yielded information relative to the concerns of the public, developers, and regulatory agencies, while identifying concerns and potential conflicts. Land-use priorities, as established by responses of all participants to a questionnaire, were as follows:

1. Watershed protection

2. Consideration for fish and wildlife

3. Agriculture

4. Geothermal development for direct-use applications

5. Geothermal development for electrical production

6. Range

7. Timber

8. Visual aesthetics

9. Roadless/wilderness areas

10. Minerals

11. Nonmotorized recreation

12. Archaeological/historical resources

13. Motorized recreation.

SECOND WORKSHOP

A second workshop was held in Boise, Idaho, on January 9 through 10, 1979. An estimated 80 people attended the sessions. Presentations at the workshop included:

1. Snake River Basin Overview and Status of the Five Southwestern Idaho KGRAs

2. Geothermal Resource Potential in Idaho

3. BLM: Concerns, Policy, and Geothermal Leasing

4. Forest Service Considerations and Geothermal Leasing

5. Heritage Resource Management in Relationship to Idaho Geothermal Development

6. Geothermal Development in Southwest Idaho: The Socioeconomic Climate

7. An Overview of the Climate and Meteorology of Southwestern Idaho and the Five KGRAs

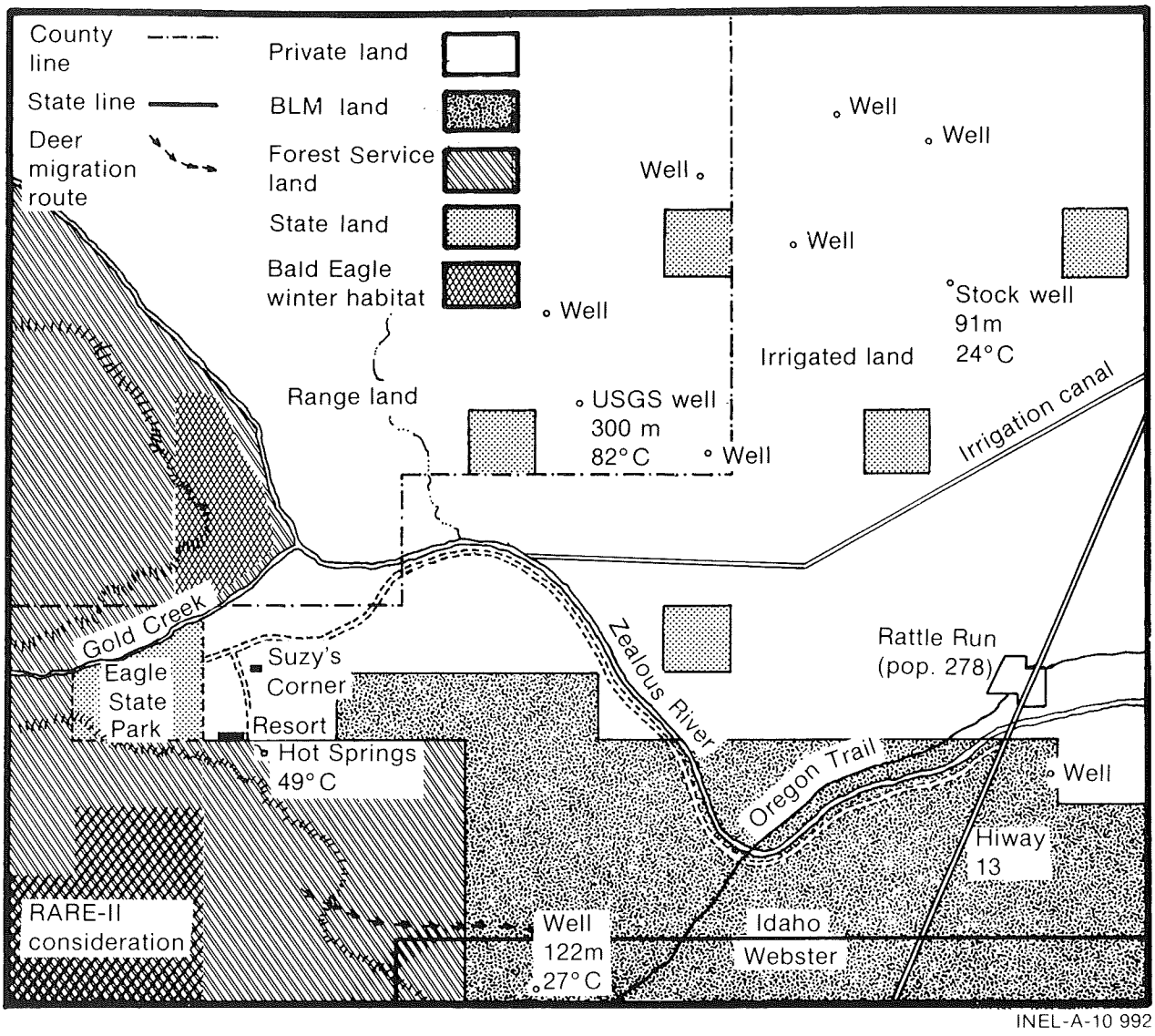


Figure C-1. Simulated geothermal environment.

8. Ambient Air Quality of Southwestern Idaho

9. Importance of the Birds of Prey Resource on KGRAs

10. Implications of KGRA Development on Terrestrial Ecology

11. Existing Soil Surveys and Land Use in the Snake River Basin KGRAs

12. A General Geology of the Designated KGRAs, Southwestern Idaho

13. A Seismic Profile of Five KGRAs, Southwestern Idaho

14. Subsidence History and Potential for Five KGRAs, Southwestern Idaho

15. Geothermal Permits and Water Rights: Resource Protection vs. Individual Protection

16. Water Quality and Hydrologic Aspects of Snake River Basin KGRAs

17. Geothermal Resource Development in Idaho: Ranking Natural Resource Commitments.

The information presented at the workshop was used to supplement the overview study. Several of the presentations could not be integrated into a specific area of the report and have been summarized below.

Geothermal Resource Potential in Idaho

The Idaho Office of Energy has completed an initial analysis of the potential for development of Idaho's geothermal resources. The model was based on the weighted analysis of resource potential, market potential, and institutional considerations of eight sites. The overall ranking of these sites was Caldwell (highest), Boise, Weiser, Mountain Home, Crane Creek, Bruneau, Castle Creek, and Vulcan (lowest). Vulcan and Crane Creek ranked highest on resource potential. Caldwell and Boise ranked highest in market potential, while Vulcan ranked lowest. Weiser, Boise, and Bruneau had the lowest institutional restrictions, while Crane Creek and Vulcan had the highest.

BLM: Concerns, Policy, and Geothermal Leasing

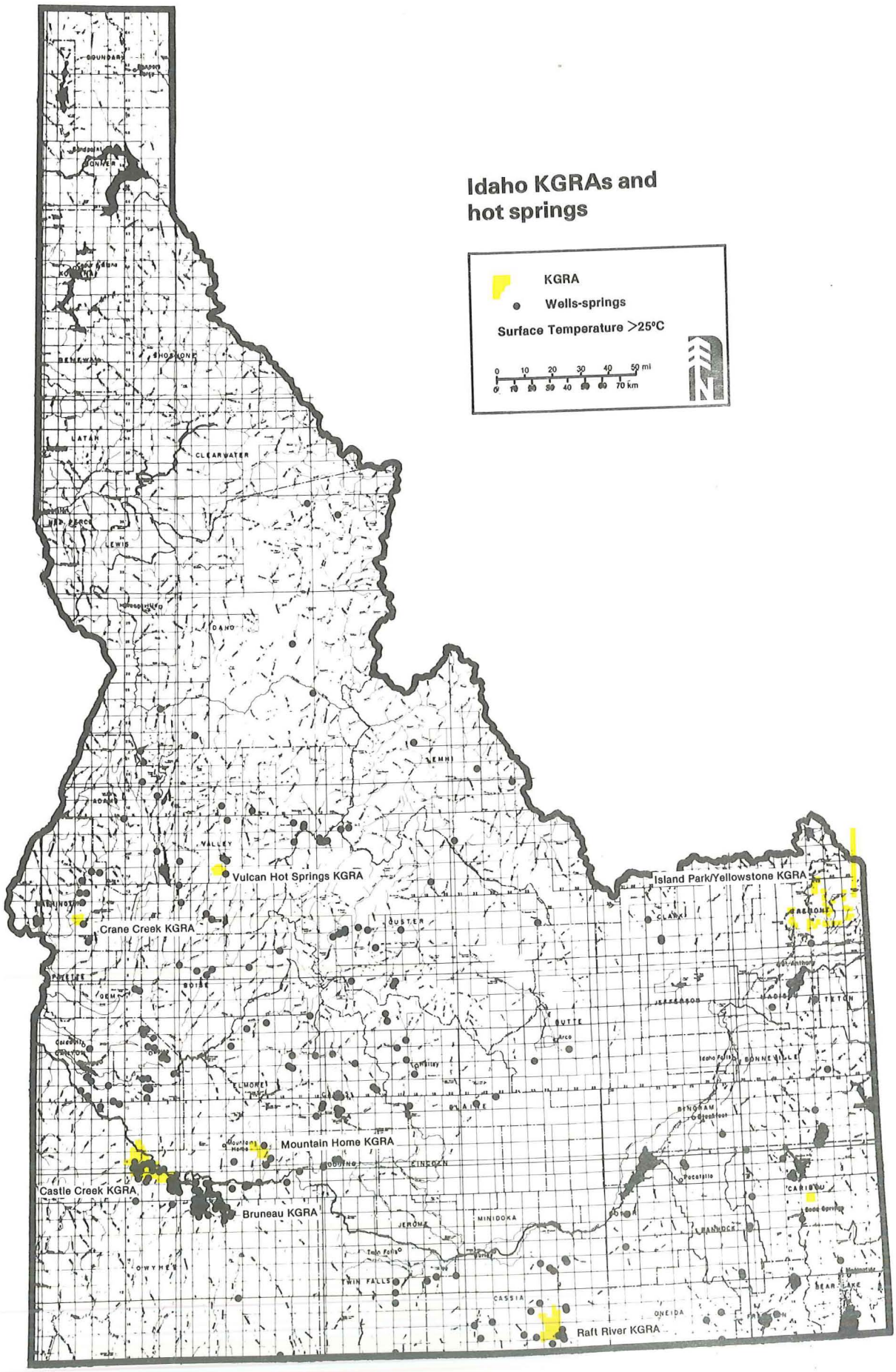
BLM concerns include lack of resource identification, cost of environmental and regulatory requirements, and conflicts with other land uses. Leases are currently in suspension pending the proposed expansion of the Birds of Prey Natural Area, the results of a curlew study in the Parma area, approval of the environmental statement for the Island Park geothermal area, and the analysis of lands to be included in agricultural land development. Recommendations include allowing resource identification prior to initiating regulatory procedures, and simplifying these procedures and the number of agencies involved in the review process.

Forest Service Considerations and Geothermal Leasing

The Forest Service has issued one lease out of 302 applications in the State. Numerous delays can result in the multistep, multiagency review process. In areas where land-use plans exist, there may be enough information to prepare an environmental analysis. Lease applications which require an environmental analysis can be delayed for years.

Geothermal Resource Development in Idaho: Ranking Natural Resource Commitments

A panel considered the question of integrating geothermal developments with other resources in the State. The Idaho Department of Water Resources has ranked geothermal as a fourth priority behind water rights, dam safety, and water quality. The Forest Service has been given a directive from the Chief to give geothermal development high priority. Much of the Forest Service effort has been spent on the Island Park Geothermal area. In the BLM minerals program oil and gas development has been given priority in the eastern districts, while geothermal has priority in the western district. The BLM's range program will maintain top priority.


Idaho KGRAs and hot springs
KGRA
Wells-springs
Surface Temperature >25°C
0 10 20 30 40 50 mi
0 10 20 30 40 50 60 70 km
Vulcan Hot Springs KGRA
Crane Creek KGRA
Island Park/Yellowstone KGRA
Mountain Home KGRA
Castle Creek KGRA
Bruneau KGRA
Raft River KGRA
BOUNDARY
BENEWAH
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