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ENVIRONMENTAL NECESSITY AND SUFFICIENCY:  
THE CASE OF THE RAFT RIVER PROJECT

J. F. Kunze and S. G. Spencer

EG&G Idaho, Inc.  
Idaho Falls, Idaho

Long before it was drilled, the Raft River geothermal reservoir in southern Idaho was correctly characterized by geothermometry as a moderate-temperature resource. Three deep-hole wells have since been drilled into the paleozoic quartz-monzonite basement, reaching the predicted 150°C (300°F) temperatures well before encountering the poorly-fractured basement. Described below is the environmental program that began prior to drilling and accompanied the development of a complete well field for a 5-MW(e) [40-MW(th)] pilot plant.

ii) possible seismic activity from changes in reservoir pressures or fault lubrication?

5. Could the near-surface domestic aquifer be contaminated either during drilling or later during production and injection?

6. Could well testing, construction activities, or cooling-tower operation cause atmospheric contamination?

Initial Considerations

A primary concern was to involve all organizations having an interest in the area's environment. Figure 1 shows the matrix of organizations whose involvement and help was solicited. The names with asterisks are those organizations which received funding to participate, in return for specific data and evaluations of the existing environment.

The major environmental concerns initially addressed were as follows:

1. The area is a fragile desert environment which once was a rich grazing area, a high steppe-grass country, prior to its being overgrazed in the latter part of the 19th century. Precipitation on the valley floor averages 25 cm (10 in.) per year.

2. Sensitive species could be disturbed by noise or habitat encroachment during drilling and construction.

3. Historical materials and artifacts could be destroyed. The area was traversed by the old Oregon-California trail.

4. With injection of the geothermal fluids being a planned necessity because of the huge quantities that must be flowed (42 L/sec/net-MW-output, or 680 gpm), would there be:

i) selective subsidence if the injected fluids are not of full quantity or do not mix with the producing reservoir?

	AIR	WATER	PHYSIOGRAPHY	BIOLOGICAL	HUMAN	INTEGRATED PROGRAM
IDAHO NATIONAL ENGINEERING LAB	X	X	X	X	X	X
ERDA - IDAHO OPERATIONS	X					X
U.S. EPA		X				X
U.S. FISH AND WILDLIFE				X		
U.S. SOIL CONSERVATION SERVICE			X			
NOAA	X					
U.S. BUREAU OF LAND MANAGEMENT				X		X
U.S. GEOLOGICAL SURVEY		X	X			
U.S. BUREAU OF RECLAMATION		X				
ID DEPT OF WATER RESOURCES		X				
ID BUREAU OF MINES AND GEOLOGY		X				
ID DEPT OF FISH AND GAME				X		
ID DEPT OF HEALTH AND WELFARE	X	X				X
BATTELLE HUMAN AFFAIRS*					X	
BATTELLE NORTHWEST		X				
U OF UTAH RESEARCH INSTITUTE*	X			X		X
U OF UTAH*		X	X	X		
IDAHO STATE U*				X	X	
U OF IDAHO*		X		X		
BRIGHAM YOUNG U*				X		
U OF CALIFORNIA - BERKELEY*			X			
COLORADO SCHOOL OF MINES*						
UTAH STATE U*		X	X	X		
PRIVATE CONSULTANTS*	X	X	X	X	X	X
SERVICE COMPANIES*	X	X				

Fig. 1 Primary Participants in Raft River Environmental Program

The Fragile Ecosystem

The baseline assessments of the biota were conducted by three universities -- University of Utah, Idaho State University, and Brigham Young University. The significant aspects that can be

labeled fragile were:

1. The ferruginous hawk nesting grounds. Though the species is not officially threatened or endangered, the Raft River Valley is one of its few habitats. Figure 2 shows the nesting sites, with suggested 1-mile radius exclusion areas.

2. Sage grouse strutting grounds and brood-rearing areas. This species' environment is being encroached upon throughout the West.

The recommendations were made to prohibit drilling and construction during nesting periods. These recommendations are inadequate as a permanent solution--instead, an evaluation of the disturbance-effects patterns has been planned during the small pilot-plant programs, before major geothermal development begins.

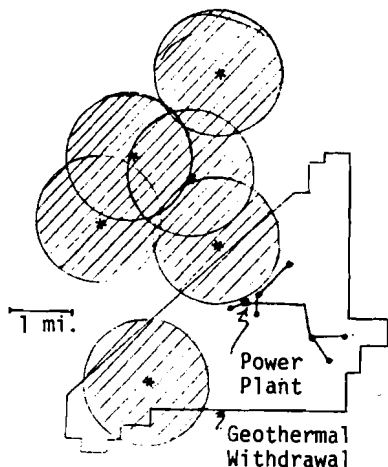


Fig. 2 Ferruginous Hawk Nests and Buffer Zones

Seismics

The Colorado School of Mines, under contract during 1974, conducted a study of the natural microseismic activity in the valley. During the entire 90 days of the study, only seven events with S-P times of less than 2.0 sec (corresponding to epicentral distances of less than 17 km) were detected. The scarcity of events and the low magnitude of their force seem to indicate that the area is more closely related to the aseismic Snake River Plain than to the active Basin and Range Province. Though naturally aseismic, the valley could become active as a result of long-term production and injection of the geothermal resource. Therefore, monitoring of microseismic activity is continuing, with four stations operating in the valley.

Subsidence

When benchmarks were releveled by the USGS in 1974, it became apparent that significant elevation changes had occurred in the northern part of the valley. Two types of movement were suggested; regional movements, probably as a result of tectonism, and a cone of subsidence of more than 0.8 m (2.6 ft) in an area of groundwater decline. The USGS line has been extended to include a grid around the production-injection field. No subsidence has been detected to date, although geothermal fluids have been produced and reservoir pressures have declined. Extensometers are being installed at various depths in the near-surface and geothermal aquifers to differentiate among: 1) subsidence that may result from production of the geothermal resource; 2) that which results from pressure declines in upper aquifers hydraulically connected to the geothermal resource; and 3) that which results from normal groundwater withdrawal for irrigation.

Water Quality Monitoring

Because of the major dependence on water for irrigation and domestic purposes in the area, the possible contamination of these supplies has been of prime concern. Both the surface and groundwaters have been sampled frequently during the past four years. Several irrigation wells show the influence of natural leakage from the geothermal resource (see Table 1). Because injection may alter or enhance this natural communication, a series of monitor wells has been drilled to depths of from 150 to 460 m.

TABLE 1

	RRGE-1	RRGE-3	Typical Irrigation Well*	Raft River
Depth, m. (ft)	1521 (4989)	1790 (5840)	110 (360)	--
T(°C)	147	149	29	18
pH	Avg. 7.2	6.3 to 7.5	7.7	8.4
Conductivity	3373	9530	4400	1060
Ca	53.5	193	92	104
K	31.3	97.2	19.6	9
Li	1.5	3.1	1.7	0.04
Na	445	1185	777	92
Cl <sup>-</sup>	776	2170	1257	220
F <sup>-</sup>	6.3	4.6	5.1	.72
HCO <sup>-</sup> <sub>3</sub>	63.9	44.4	131	229

\* Near geothermal wells

Air Quality

Geothermal power plants at the Geysers in California have at times faced stiff opposition from environmentalists claiming that air quality standards had been violated. The primary concern was H<sub>2</sub>S; secondarily, water vapor was a concern

(in essence it would be an "enrichment" to the arid climate of that region). Because of the poor image regarding air quality attached to ideas of geothermal development, a very thorough baseline study was begun at Raft River shortly after the first well "came in."

Both high-volume and low-volume air samplers were installed near the site and 15 miles to the north of Malta, the only nearby town. A complete meteorological system was installed, and pollution-monitoring cameras were mounted, aimed principally toward Pocatello (80 miles to the northeast) and the Salt Lake Valley (80 miles to the southeast).

The air samplers picked up significant quantities of phosphates (from local farming operations) and of sulphates (identified as those characteristic of the smelting operations in the Salt Lake Valley). Pollution monitoring showed very significant ingress over the Strevell Pass from Salt Lake, with minor (1/4 as much) ingress from the Pocatello area.

Injection of most of the used geothermal fluid at Raft River is intended, except for that to be used beneficially for agriculture and aquaculture. Furthermore, H<sub>2</sub>S has never exceeded 0.15 ppm in any of the deep wells. These factors alone would indicate that the extensive air-quality monitoring program was technically unessential. But when one deals with a preconceived negative image of geothermal development and air quality, it is politically essential to establish a thorough baseline for comparison at a later time.

#### Today's Concerns

Most of the initial concerns listed above have been adequately addressed and evaluated well in advance of developing a geothermal area in the valley. However, there remain two concerns which were not appropriately recognized until the wells were drilled and certain reservoir evaluation results were available:

1. Operation of the production and injection wells may well affect the near-surface aquifer. It is not certain that these effects will be detrimental, however.

2. Water consumption from wet cooling towers in a moderate-temperature geothermal power plant is three to five times greater, per unit net electric output power, than for fossil or nuclear power plants.

Better evaluation of the vertical connections in the aquifers, of the natural convective flows among strata, and of the chemistry of the various strata is the major data requirement for the current phase of the environmental program. Presently, the near-surface aquifer does not appear to be much purer than the geothermal aquifer. There seem to be connections between these aquifers, which implies that consumptive use of any water affects the inventory of the domestic and agriculture water resources in the valley.

#### Conclusions

The Raft River environmental program was designed to address the concerns associated with geothermal development. As development progressed, and more data became available, more emphasis was placed on particular concerns. The program is continually being modified to reflect these changes. The baseline-characterization studies represent an investment of \$400,000. The environmental report preparation represents an additional \$100,000. Routine monitoring of the parameters that may be affected by geothermal development is costing \$150,000 per year. Is this excessive for a \$15 million pilot plant development? Certainly we would hope to learn from the early pilot programs what environmental parameters are sensitive to geothermal development, and which are not, so that costs can be reduced. Geothermal developments tend to involve small quantities of power, with small environmental impact. Environmental study costs should be adjusted according to the potential impact.

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