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IDAHO GEOTHERMAL R&D PROJECT REPORT

For Period March 16, 1974 to July 15, 1974

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ABSTRACT

The Idaho Geothermal R&D Project was initially charted by the Division of Applied Technology in December 1973. This report covers the period March 16, 1974 to July 15, 1974. A brief summary of the work during this period is given in Section 1.0, with more detailed discussions in subsequent sections.

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SUMMARY

1. The U.S. Geological Survey resumed its field work with both roving dipole and Schlumberger deep resistivity probing, refractive seismic measurements (using explosive sources), and continuation of the general geological mapping.
2. The shallow (<100 ft) well drilling program was completed in June 1974. This program studied the ground water patterns and will be of considerable value when large quantities of cooling water are pumped from the aquifer. Well temperatures indicated where hot water is leaking up into the cold water aquifer. Approximately 32 useable monitor holes were drilled.
3. At a meeting in Boise on July 10, attended by members of the USGS, Idaho Water Administration, Aerojet Nuclear Company, AEC, and private consultants, five possible sites were chosen for the drilling of 3 to possibly 5 intermediate depth wells. These wells are to be approximately 300 meters (1000 ft) deep and serve for the purposes of verifying geophysical and geological data and for gaining additional hydrological information. Justice Core Drilling of Meridian, Idaho, has been contracted to do the drilling for USGS. Work started on the first hole during the latter part of July.
4. Efforts continued in planning and arranging for the first deep exploratory holes (2000 meter, 6500 ft depth is being considered). The assistance and advice of the Nevada Operations Office of AEC and its drilling contractors have been most useful. Attempts to order casing are continuing during this period of escalating prices and continued short supply.
5. Detailed conceptual design of an R&D oriented (i.e., to provide testing flexibility) dual flash steam power plant using 150°C (302°F) geothermal water was completed. Flash points were 121°C (250°F) and 96°C (205°F). A detailed cost estimate was completed and an independent estimate also obtained from a commercial A&E firm.

6. Design considerations of a binary (organic fluid) vs a steam power plant were continued. In particular, the advantages of cooler condenser temperatures for organic fluid cycles were examined in detail showing the order of a 20% increase in net plant output under expected conditions in the Raft River Valley, when aquifer cooling water is used instead of wet cooling tower water.
7. During this period, a task was initiated to develop for the AEC a National Program Plan for research and development aimed at the non-electric utilization of geothermal energy. It is suspected that a major impact on the US energy situation could be made by such uses of geothermal energy as for space heating, process heat, and agricultural application.
8. A document has been prepared by ANC on the national participation of non-governmental agencies in a government sponsored geothermal research and development project with the attendant benefits of all parties concerned. (Not yet published)
9. An independent assessment of the environmental considerations for the project was completed by S. R. Swanson of the University of Utah, under a joint grant from the USAEC and Raft River Rural Electric Cooperative.*

* Copies of this report can be obtained from the project office or from the University of Utah, Dept. of Mechanical Engineering.

BACKGROUND INFORMATION

The area of Southern Idaho is one of the most promising regions within the United States for near surface, economically recoverable geothermal energy. It is identified by geologists as the younger end of a major Volcanic Rift Province (the Snake River Plain). The Raft River Valley is a faulted, north-south trending sedimentary basin intersecting this major volcanic rift. It is in the Raft River Basin that a number of wells, drilled for irrigation purposes, unexpectedly yielded warm to hot water. Two such wells drilled over 30 years ago and bottoming at 128 meters (420 ft) and 165 meters (540 ft) have been continuously yielding boiling water under artesian flow typically flowing 4 l/sec (60 gpm). These wells are near the Malta, Idaho headquarters of the Raft River Rural Electric Cooperative, Inc., an REA financed power company serving 10,000 square miles of Southcentral Idaho, Northwestern Utah, and Northeastern Nevada.

The occurrence of the boiling water in the Malta, Idaho area prompted the Raft River Rural Electric Cooperative to conduct preliminary geological investigations beginning in 1971 pertinent to the possibility of establishing a geothermal power plant in the area for the production of electricity. Simultaneously, the Coop. management began securing geothermal leases on the private land owned by its members.

In 1973, Aerojet Nuclear Company, prime contractor to the U.S. Atomic Energy Commission at the National Reactor Testing Station (40 miles north of the Raft River Rural Electrical Coop. service area), initiated a preliminary engineering and feasibility study, including assistance in gathering additional geophysical information from the Raft River Valley.⁽¹⁾

Unlike the anomalous Geysers hot dry steam field in Northern California, the Raft River Valley geothermal resource is a hot water field (approximately 150°C) very similar to most of the identified geothermal potential resources in the Northwest. These temperatures are not currently attractive in the US for commercial production of electric power. Neither the

economic parameters nor even the most economically and technically feasible power extraction techniques are yet identified for these low temperature heat sources. Though the salinity of these waters is generally low (compared to the Cerro Prieto field, for instance), still the use of this water has not been adapted for long-term heat exchanger application.

Should further geological and geophysical work now underway by the US Geological Survey in cooperation with the AEC confirm the suitability of the Raft River resource for a research and development project and should funding be made available, the AEC through its contractor will design and install a geothermal plant. Raft River Rural Electric Cooperative has offered to arrange for the continued leasing of the private-land geothermal rights on which it now has an option. The utility has also offered to provide for the electrical connections and for the beneficial consumptive use of the power. The AEC contractor (probably assisted by the USGS) will actively monitor and "manage" the geothermal field, which though highly convective exists in a region where ground water supplies have been shown to be quite sensitive to withdrawal rates. Re-injection of the geothermal water is a necessity for recharge and environmental considerations. If once-through cooling water is used (from the cold water aquifer) rather than cooling towers, it also will be re-injected back into the shallow aquifer.

The Raft River area appears attractive for demonstrating the harnessing of the power producing potential in warm, not hot, water. With only 150°C (302°F) water anticipated, conventional steam turbine systems appear only marginal for normal applications. But, the Raft River Valley's near surface aquifer is quite cold, approximately 10°C (50°F). With such a cold temperature heat sink, 150°C water becomes quite attractive from a Carnot efficiency viewpoint. A low boiling point organic fluid is also a prime candidate for the working fluid, but the economic advantages of such a system compared to steam have not yet been established.

The demonstration power plant will contain a steam and/or a binary (organic fluid) cycle depending upon final temperatures and mineral content of the hot water. Initial operation of the plant is anticipated to be in 1978, provided adequate and timely funding is available. More details about the geology of the area, its apparent geothermal potential, and the general characteristics of the various power cycles being considered can be obtained from Reference 1.

The overall goals of the project are basically as follows:

1. To demonstrate the extraction of energy from a hydrothermal field utilizing full reinjection of the waste fluid. The reinjected fluid is to contribute to the fluid recharge of the hydrothermal field, with minimum environmental degradation and minimum degradation of the thermal heat source.
2. To demonstrate the design and operational characteristics of a geothermal electric power plant operating from a reservoir temperature well below the limits (170°C or 338°F) now considered to be economically attractive for commercial development.
3. To consider the most efficient and effective utilization of the resource available, including the possibility of non-electrical applications for the heat.

The activities in the previous quarter are included in Reference 2.

3.0 GEOLOGY AND GEOPHYSICS

3.1 Shallow Well Drilling Program

The drilling of shallow (≤ 100 ft) hydrology wells of 0.14 meter (5-1/2 in.) diameter through the Raft River Narrows area has been completed with a total of 32 wells being drilled. Figure 1 shows the locations. The highest temperature encountered was 48°C (118°F) at the bottom two wells, one 30 ft deep, the other 40 ft deep, both located east of the Narrows. Though these shallow wells were intended to study the near surface water flow pattern, temperatures of this magnitude this close to the surface may indicate an escape of thermal water from a conduit between a deep geothermal reservoir and a shallow cold water aquifer.

Supporting the above hot water leakage hypothesis is the experience of the USGS in drilling of a well for additional hydrological studies. The well in question was drilled just north of the flowing BLM well 33°C (92°F). Originally drilled to a depth of 320 ft, the well had a standing head measured 7 ft from the surface. The "static" equilibrium temperature of this well was 90°C (194°F) at the 320 ft depth, indicating leakage of thermal water into the cold water system. Recently the USGS moved back onto the well site and drilled the hole to a depth of 407 ft when another interesting thermal water occurrence took place. While drilling this extension, the thermal water was passed at 375 ft with colder water being encountered below this depth. The new static head was 21 ft below the surface. The change in water temperature does indeed indicate a mixing of thermal water with cold ground water along a leakage zone of the thermal conduit. The change in head between the two conditions is probably the result of water column density differences. Though no flowing or pumping tests have been attempted, several other mechanisms may be at work in this well--for instance:

1. The thermal water may have hydrothermally altered the sediments both above and below the warm water zone and pore pressure may have increased between these altered layers.

2. The dissolved solids themselves contained with the thermal water might be causing the warm zone to have higher pore pressure.
3. A lithologic difference occurring in the sediments occupied by the two zones may be having an effect on the pressure created within each of them.

The significance of these considerations for such a shallow well may be of more academic interest at present. Plans to flow and/or pump the well are being held in abeyance.

3.2 U.S. Geological Survey Studies

Additional geophysical surveys were conducted in late spring by the USGS for further understanding of the geologic and hydrologic picture of the Raft River Valley. The principal measurements were deep resistivity and refractive seismics. The resistivity profile was scoped initially using the random bipole method with one radiating point and several hundred detector positions. After brief analysis of that data, USGS then performed Schlumberger array (long line) measurements on selected lines of interest. The seismic measurements were made to determine major changes in refractive index. Large explosive charges, generally placed about 10 ft below ground level, were utilized.

To the north, at the lower end of the valley, the USGS is also doing extensive geologic mapping, to determine the structure in that area and apply this knowledge to understanding the overall geologic situation in the area. In recent years the use of microearthquake detection (-2 to 4 on the Richter Scale) has become a significant tool in the locating of geothermal areas. Currently the Colorado School of Mines is conducting a microearthquake study within the Raft River Valley. Using two single component geophones telemetered to the recording trailer and one three component geophone at the trailer, data will be recorded during most of this summer. The results of these geologic and geophysical surveys should be available by the fall

of 1974. A permanent microearthquake recording system will be installed in early fall prior to any deep drilling and withdrawal of geothermal liquids.

3.3 Intermediate Depth Wells

In order to gain a better direct understanding of the subsurface conditions prior to deep (approximately 2000 meters) well drilling, the USGS has been planning to drill several intermediate depth holes (typically 300 meters) of an exploratory nature, i.e., nominally 4 in. in diameter.

The USGS held a full day meeting in Boise on July 10 to determine suitable locations for these holes. The morning was spent reviewing all the data available and making suggestions as to drilling sites and priorities. Although the resistivity and seismic data analyses were not completed with section plots, preliminary results gave an interesting outlook.

Low resistivity (ρ) could mean one of three things; 1) salt water, 2) clay beds, or 3) hot geothermal water. Salt water in this area is ruled out. Due to the large changes in resistivity at short distances indicating faulting, the clay beds are ruled out. Two areas of low ρ are of interest, a narrow N-S strip a little east of the Schmitt well turning at the Narrows road to follow the road several miles, and the second is a heart-shaped low ρ area (both on the order of 4 ohm-meters) south of Mrs. Crank's home in an E-W direction with the west lobe moving up towards the hot gravel pit. Some expressed the opinion that a very shallow hot water system may be leaking up from a N-S fault between the Schmitt well and the Malta Highway. The low ρ area south of Mrs. Crank's greenhouses is much thicker and somewhat deeper. *

A number of new gravity stations were added especially in the Narrows Area and south of Sheep Mountain. Little difference from the original gravity map is seen except near the mouth of the Narrows where a closed

* Information of a more complete nature is not yet available from USGS at the present time.

gravity high anomaly is indicated. The reason is unknown but may be an indication of a submerged dike across the Narrows. Aerial magnetics have verified several dikes east of the Narrows as well as basement at approximately the 6000 ft depth. (See Figure 1)

Age dating on some of the youngest lava flows in the Jim Sage range give ages of approximately 8.4 to 10 million years. The plug domes around and including Sheep Mountain and Round Mountain date approximately 7-8 million years. These ages are too old to be of any value for heat sources, themselves. Alluvium fans from Jim Sage date about 1/4 million years. However, predicted and located faults seem to intersect in the low resistivity areas and may be providing the conduits for either deep circulation sources of water or water from buried plutons.

USGS described the criteria for selection of the drilling sites as follows: (Listed in order of preference)

1. Center of Section 12, T15S, R26E. This hole west of bridge on the Narrows road would checkout the narrow low ρ strip. The interesting area will be about 800 ft deep, but plans are to drill to about 1200 feet.
2. SE 1/4 Section 15, T15S, R26E. The faulting in this area has been mapped. Low velocity seismic signals as well as inflection in gravity also indicates faulting. Drilling will verify this faulting near the edge of the low ρ strip.
3. NE 1/4 SE 1/4 Section 11, T15S, R26E. High ρ , high velocity area at this point will give contrast to the opposite geophysical values (give us an idea of what we don't want).
4. SW 1/4 Section 19, T15S, R27E. This area is in the low ρ heart shaped piece on private land, on which exploratory agreements are available.
5. In the Narrows Area, position not picked but would be in the closed gravity high area mentioned previously.

These locations are identified on Figure 2. The reasons for mid-depth drilling are to: 1) verify geology/geophysical models, 2) understand the geothermal system, 3) determine geothermal source characteristics, and 4) determine recharge-discharge characteristics of the system.

Petrological examinations have now been completed on the drilling chips supplied to Boise State University from the three wildcat oil wells* in the Raft River Valley. Results of these examinations as well as the drilling records, mud logs, and lithology logs will be used for information purposes in estimating the costs of drilling of the first deep geothermal test holes. The petrological examinations will continue as cores are made available from the mid-depth drilling.**

* The three oil and gas wells were drilled in the Valley, 10 to 25 miles from the suspected geothermal field, in the fall of 1973 and early summer of 1974 by a commercial gas exploration company. All wells have since been abandoned. One began to spout hot water three weeks after being abandoned. That flow has since been controlled.

** The petrological studies of the drill chip samples are being sponsored by the Idaho Nuclear Energy Commission. The intermediate depth drilling is to be supported in part by the Pacific Northwest Regional Commission.

Fig. 2 Intermediate Cored Test Wells (approximately 1000 feet deep)
(wells numbered in order of their preference)

4.0 POWER CYCLE STUDIES AND POWER PLANT DESIGN

A construction project data sheet (Schedule 44) was completed and submitted to the AEC in May for a double-flash steam geothermal power plant with a net electrical capacity of 12,000 kW(e). The double-flash system provides a gross power increase of almost 40% over the single-flash system per unit of brine flow. The increased power output is believed to warrant the increased cost of an additional flasher, an additional turbine and increased condenser and cooling tower capacity, principally because it gives better utilization to geothermal resources. Further parametric studies were made on the binary (organic fluid) cycle encompassing heat exchangers, review of working fluids, effect of condenser cooling water temperature, component size, and rough costs.

4.1 Steam Plant Design and Cost

4.1.1 Steam Plant Design

The steam plant consists of high and low pressure flasher and separator units to produce high and low pressure steam which is directed to the high and low pressure steam turbines for driving the electrical generator. A summary of operating conditions is given in Table I. The geothermal water requirement of 2.31×10^6 kg/hr (5.1×10^6 lb/hr) comes from approximately 6 wells (4,000 to 6,000 ft depths expected), each producing about 1700* gpm of water at 150°C (302°F). The steam generating system is a two-stage flash system, assumed to consist of four first-stage flashers and separators, four second-stage flashers and separators, and four water accumulator tanks (only three of each are required to produce full power). The high pressure flash stage (30 psia 121°C (250°F) at inlet) produces about 63% and the low pressure flash stage (13 psia 96°C (206°F) at inlet) produces about 37% of the total power. Preliminary discussion with potential vendors indicates that the turbine will probably be double-flow with three stages in each direction. The low pressure (second flash) steam will be admitted at the latter stages. The exhaust steam will be condensed in a barometric or jet condenser (depending upon the amount of noncondensable gasses in the steam). The approximate size of the barometric

* Typical yields from wells of this depth from throughout the world.

Table I

Summary of Double Flash System

Initial brine temperature = 300°F

Flow = 5.1×10^6 lb/hr (10,200 gpm)

	Flash #1	Flash #2
<u>Flasher/Separator/Turbine Conditions</u>		
Flasher operating pressure, psia	30	13
Flasher operating temperature, °F	250.3	205.9
Flasher inlet enthalpy (liquid, Btu/lb)	269.59	218.82
Ratio of steam to initial brine flow	0.0537	0.04362
Steam produced (100% quality), lb/hr	273,870	222,460
Nominal turbine steam flow, lb/hr	246,483	200,215
Nominal power at overall efficiency = 68%, MW (15.1)	9.52	5.56
Maximum power (using full steam production), MW (16.7)	10.58	6.18
Turbine inlet enthalpy*, Btu/lb	1164.1	1148.1
Turbine Δh isentropic, Btu/lb	194	139.45
Turbine exit enthalpy at stage efficiency = 80%, Btu/lb	1009	1036
Turbine exit moisture, %	10.1	7.3
<u>Condenser Conditions</u>		
Condenser pressure, "Hg Abs	3"	3"
Ratio of cooling water flow to steam flow	28.41	30.57
Condenser cooling water flow, gpm	15,563	13,603
Temperature of cooling water inlet, °F	75	75
Temperature of cooling water outlet, °F	108	108
<u>Individual Separator Conditions</u>		
Inlet brine flow, gpm	3,400	3,217
Exit brine flow, gpm	3,217	3,069
Flasher exit area, ft ²	3.56	6.26
Flasher exit inside diameter, in.	25.5	33.8
Separator, steam line exit diameter, in.	25.5	33.8
Brine discharge exit diameter, in.	25.5	33.8
Separator diameter, ft	6.38	8.47
Separator height, ft	24.5	32.47

Table I (Cont'd)

<u>Condenser Size</u>	<u>Flash #1</u>	<u>Flash #2</u>
Single condenser sized for discharge of both turbines		
Inlet diameter (equivalent), ft	11.2	
Body diameter, ft	17.9	
Height, ft	36	

condenser tank would be 18 ft in diameter by 36 ft in height. Approximately 30,000 gpm of cooling water at 24°C (75°F) (coolant towers) is required to condense the exhaust steam from the turbine but this requirement may be reduced by utilizing the 10°C (50°F) aquifer if required well depth and re-injection pressures prove feasible. Geological considerations call for the majority of the brine to be piped several miles (about 650 kW pump power) to re-injection wells where the brine is returned to the earth for recycling. Based on the known chemistry of Raft River geothermal water, no severe corrosion problems are envisioned which cannot be accommodated (with a few exceptions) by plant design and conventional materials like low carbon - low alloy steels and plastic.

4.1.2 Steam Plant Cost

The costs of the above system are shown in Table II. Only direct costs are itemized. Various indirect costs, as indicated, approximately double the power plant expense. Note, these costs are based on a conventional type of design, and were required for consideration for Congressional authorization to construct such an R&D facility. New design and material concepts for a plant operating under such low temperature and pressure conditions are expected to result in reduced costs, eventually. Such considerations are continuing, and testing programs to incorporate such innovations are being planned.

4.2 Binary Cycle Conceptual Design

4.2.1 Heat Exchanger Study

The best estimate for overall heat exchanger heat transfer coefficient at the present time is about 150 Btu/hr-ft² for both heaters and condensers. The overall coefficient for the heaters is limited by the brine fouling factor which at the present is unknown but estimated at 0.003 hr-ft²-°F/Btu. The overall coefficient for the condenser is limited by the organic fluid condensing coefficient due to the low thermal conductivity of the organic fluids. Multipass or series connected heat exchangers will be necessary to keep the exchanger length and tube flow velocities at acceptable values.

4.2.2 Working Fluid Review and Comments

Some partial parameters studies were made by hand calculations for six organic fluids (Freons-12, 22, 113, and 114, isobutane, and propylene). These studies indicate that isobutane is the better selection from the standpoint of thermodynamics (see Table III), but a more complete analysis is needed. Freon-114 looks favorable should the flammable or higher pressure systems prove to be too costly.

4.2.3 Effect of Condenser Cooling Water Temperature

A cooling water temperature study was made to determine the most economical cooling method between cooling towers 24°C (75°F) and cooling wells 10°C (50°F). The reduced cooling water temperature has obvious advantages but it is not clear that the advantages outweigh the additional pumping power requirements. This study indicates a significant net power gain can be obtained in comparison to towers for a binary cycle even when total pumping head of 400 to 600 ft is required. The advantage is greatest for the boiling cycle as opposed to the supercritical cycle. (See Figure 3)

4.2.4 Component Size and Rough Costs

Preliminary design and cost estimates of plants operating from 150°C (302°F) geothermal water indicate that a binary cycle power plant utilizing the boiling Freon-113 cycle will cost approximately \$4 million more than the steam plant while producing 25% less net power than the steam plant. This cost estimate probably does not reflect the best economic comparison since subsequent studies indicate that it is unlikely that Freon-113 is the best selection. Heat exchangers are large units (Table III), constituting a major part of the power plant cost, being estimated at \$10/square ft of area. A single flow turbine for the Freon-113 cycle was sized at 64 and 95 in. for inlet and outlet diameters, respectively, with 58 in. long rotor blades. Steam turbine-generator sets of about this size are estimated at around \$125/kW which could probably be considered a minimum for the Freon-113 turbine. Turbines for higher pressure cycles such as isobutane are sized considerably smaller and have diameters on the order of 2-3 ft.

Table II

Dual Flash Steam Plant Cost Summary

Land Aquisition	0
Deep Well Drilling*	
5 production wells	\$ 1,625,000
2 re-injection wells	400,000
Buildings and structures	792,000
Power Plant Equipment	
Turbine-generator and controls	1,852,000
Condensers	484,000
Steam separators	320,000
Other (pumps, valves, piping, insulation, etc.)	1,863,000
Cooling Towers	400,000
Hot Water Supply System	1,550,000
Geothermal Re-injection Line	1,000,000
Control Instrumentation and Data System	1,276,000
Miscellaneous	1,082,000
System Testing	<u>150,000</u>
TOTAL DIRECT COST	\$12,644,000

Indirect Costs Estimated as:

Engineering, design, and inspection 20%, except lesser amounts for off-the-shelf items

Contingency: 25%

Escalation 10 to 20% per year for a total of 20 to 50%

* It is anticipated that two other wells (one production, one re-injection) will be available from the exploratory phases of this project.

Table III
Binary Cycle Parameters

<u>Fluid</u>	<u>Boiler Pressure (psia)</u>	<u>Thermal Efficiency (%)</u>	<u>Turbine Enthalpy Drop (Btu/LBM)</u>	<u>Organic Flow Rate (LBM/hr)</u>	<u>Brine Flow Rate (LBM/hr)</u>	<u>Total Heat Exchanger Area (ft²)</u>
Freon-12	700	11.8	9.8	6.88×10^6	4.08×10^6	282,000
Freon-22	700	9.8	9.4	6.88	5.23	278,000
Freon-113	81	11.1	9.0	5.97	5.56	155,000
Freon-114	275	11.7	8.8	6.46	3.92	225,000
Isobutane	550	13.2	24.8	2.54	3.81	197,000
Propylene	800	10.1	20.0	3.69	3.83	240,000
Water	17	11.0	118.3	0.44	6.14	108,000

Note: These are roughly optimized cycles based on 1) 10,000 kW(e) net power, 2) 400 ft deep cooling wells (w/o re-injection, and 3) 14,500 gpm of cooling water.

Fig. 3 Power gain by 50°F cooling water instead of 75°F cooling towers

5.0

NON-ELECTRIC USES OF GEOTHERMAL ENERGY

The AEC, in determining the need for R&D work on non-electrical uses of geothermal energy, has requested that an assessment be made of the possible impact of such resource utilization on the national energy requirements. The need for R&D to implement such utilization should be considered. Basic to the preparation of a national program plan for the utilization of geothermal energy for non-electric uses is a thorough library search and review of past and current activity in both the geothermal and related waste heat utilization fields. This has been accomplished and has resulted in a preliminary outline of a program plan.

It was early recognized that the National Reactor Testing Station personnel did not have all the expertise to fully explore the various fields of endeavor, consequently, research agreements were negotiated with specialists at several universities as well as in private industry to assist in developing the criteria for an integrated program plan.

Six areas of concern have been identified to study relative to the exploitation of geothermal energy for non-electric applications. These areas along with the assigned tasks of the specialists that have been engaged by ANC/AEC for assistance are as follows:

1. Data on Nationwide Availability of Geothermal Resources

Dr. Ken Hollenbaugh, and Dr. C. R. Nichols, Boise State University. Assimulate nationwide data on availability of known geothermal resource areas and present inferred data relative to water quality as well as quantity and indicated temperature.

2. Aquaculture

Mr. Paul Roberts, Fish Biologist. Investigate the potential use of geothermal energy in providing the various environmental requirements for fish culture.

3. Agriculture

Dr. Alvin Bishop, Utah State University. Investigate the potential utilization of geothermal water in both crop and animal raising. Particular emphasis will be placed on tolerance of various species to geothermal water contaminants.

4. Pharamacology

Dr. Dewitt Reed, Idaho State University. Determine the potential utilization of energy from geothermal waters in the preparation of various medical and cosmetic creams and liquids as well as active components of drugs.

5. Refrigeration

Dr. Merv Smith, Idaho State University. Determine the applicability of geothermal energy to the production of "cold Btu's" through the use of absorption refrigeration schemes.

6. Process Industries

Dr. S. R. Swanson, University of Utah. Survey the process industry fields, using the industries in the Salt Lake City area as examples for possible applications where heat from geothermal water could adequately supplant energy generated from other sources. Similar direct industry contacts are being made in the Idaho Falls and Pocatello, Idaho area by ANC personnel.

6.0 PLANS FOR SUBSEQUENT QUARTER

The next three month's activities will principally involve the following:

1. Completion of mid-depth core drilling, geology, and geophysics and determination of site (or sites) for deep test drilling.
2. Obtain well casing and other long lead items preparatory to drilling first deep test holes. Obtain drilling contract with a qualified drilling contractor for exploratory holes (one for production, one for re-injection).
3. Complete preliminary conceptual design on the power plant with dual flash power cycles. (Complete sufficiently to provide backup information to support the cost estimate in the construction data sheet).
4. Set up small corrosion, scaling and heat exchanger test program on existing hot water well. Run numerous materials and configurations using the available brine.
5. Execute a formalized agreement for the transfer of private utility funds toward the design and construction of the power plant.
6. Preparation of the Program Plan for non-electric utilization of geothermal energy.

REFERENCES

1. J. F. Kunze et al., "A Low Temperature Demonstration Geothermal Power Plant in the Raft River Valley," ANCR-1138 (February 1974, first issued July 1973).
2. Quarterly Report, ANCR-1155 (Dated March 18, 1974).