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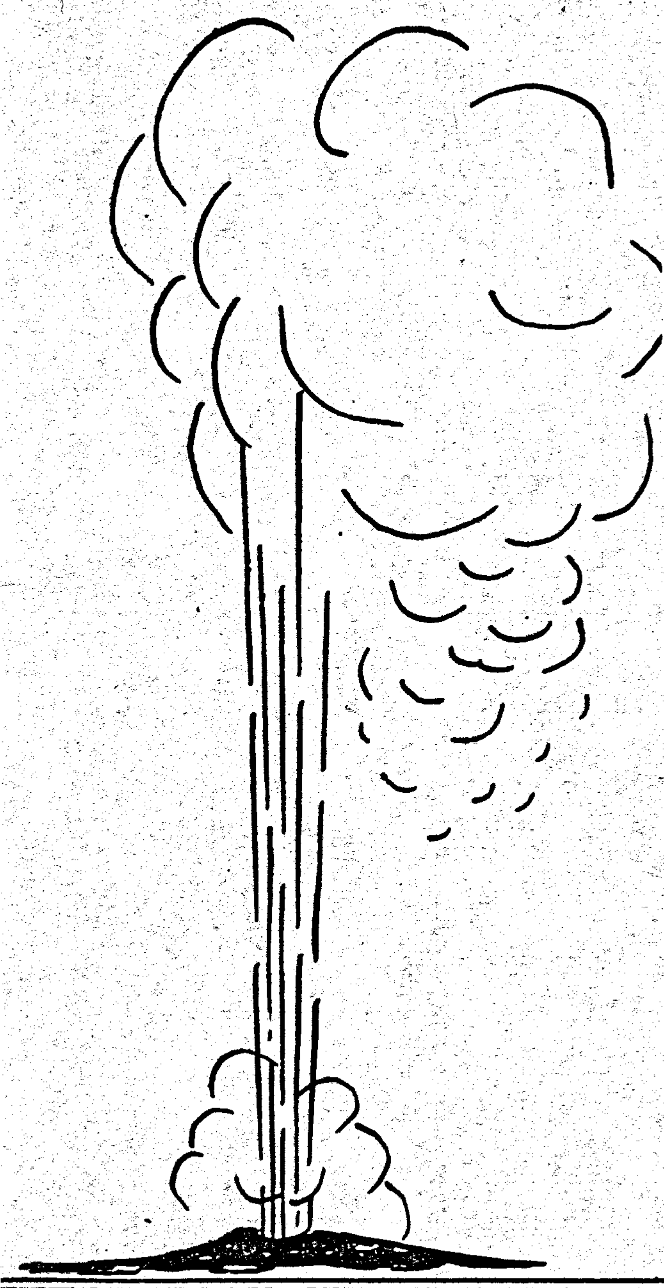

INDUSTRIAL FOOD PROCESSING AND SPACE HEATING WITH GEOTHERMAL HEAT

Final Report

February 16, 1979—August 31, 1982

August 1982

Prepared by

Energy Services, Inc.
Idaho Falls, Idaho

Under Subcontract to
Madison County, Idaho

For the
U.S. Department of Energy
Idaho Operations Office
Under Cooperative Agreement
No. DE-FC07-79ET27028

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INDUSTRIAL FOOD PROCESSING AND SPACE HEATING WITH GEOTHERMAL HEAT

by

Jay F. Kunze, and J. Kent Marlor

August 1982

Prepared by

ENERGY SERVICES, INC.
Two Airport Plaza, Skyline Drive
Idaho Falls, Idaho 83402

Under Subcontract to
Madison County
Madison County Courthouse
Rexburg, Idaho 83440

Sponsored by the
U.S. Department of Energy
Division of Geothermal and Hydropower Technologies
Washington, DC 20585
Under DOE-ID Cooperative Agreement DE-FC07-79ET27028

DISCLAIMER

ABSTRACT

In late 1978, a competitive award for a cost sharing program was made to Madison County, Idaho by the U.S. Department of Energy, to share in a program to develop moderate-to-low temperature geothermal energy for the heating of a large junior college, business building, public schools and other large buildings in Rexburg, Idaho.

In the summer of 1980, a 3,943 ft. deep well was drilled at the edge of Rexburg in a region that had been probed by some shallower test holes. Temperatures measured near the 4,000 ft depth were far below what was expected or needed, and drilling was abandoned at that depth. In 1981 attempts were made to restrict downward circulation into the well, but the results of this effort yielded no higher temperatures. The well is a prolific producer of 70°F water, and could be used as a domestic water well.

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ACKNOWLEDGEMENTS

The authors appreciate the significant efforts of Roger Stoker, geologist, and Ray Gould, drilling engineer for Energy Services, and Clayter Forsgren, the original project manager on the program. The assistance, technical and administrative support provided by the US Department of Energy, Idaho Operations Office and its contractor EG&G-Idaho. Principal personnel on this project from these organizations were Frank Childs, Susan Prestwich, John Griffith, and Kent Hastings. Mr.Dell Klingler, County Commissioner, was an enthusiastic supporter of the development of this resource for the citizens of Madison County, Idaho. Dr. Glenn F. Embree and Professor E. Williams of Ricks College provided considerable valuable advice in the initial analysis and interpretation of geology leading to selection of drill site. The typing and compilation of this report was the result of the diligence of Delma Bolkcom and Dennis Phetteplace.

PON FINAL REPORT FORMAT

This report follows a general outline which has been developed for PON project final reports. The intent of the outline is to provide general uniformity in reporting format and content. Since the scopes of the projects vary, some sections of the general outline may not be applicable. This accounts for gaps in the section numbering because consistent numbering has been maintained for each subject which is presented. A list of PON projects which are expected to use this final report format follows. The DOE report number will be of the format: DOE/ET/XXXXX-N, where the X's are the last five digits of the contract number (given below) and N is determined by the number of reports issued by the subject contract.

Contract Number	Project Name	Location	DOE Office
DE-FC07-78ET27054	Monroe	Monroe, Utah	ID
DE-FC07-78ET27080	Haakon School	Philip, South Dakota	ID
DE-FC07-78ET28419	Diamond Ring Ranch	Haakon County, South Dakota	ID
DE-AC07-78ET28424	Ore-Ida Foods	Ontario, Oregon	ID
DE-FC07-78ET28441	St. Mary's Hospital	Pierre, South Dakota	ID
DE-FC07-79ET27027	Utah State Prison	Draper, Utah	ID
DE-FC07-79ET27028	Madison County	Rexburg, Idaho	ID
DE-FC07-79ET27030	Pagosa Springs	Pagosa Springs, Colorado	ID
DE-AC07-79ET27033	Elko Heat Company	Elko, Nevada	ID
DE-FC07-79ET27053	Boise	Boise, Idaho	ID
DE-AC07-79ET27055	Warm Springs State Hospital	W.S.S.H., Montana	ID
DE-AC07-79ET27056	Utah Roses, Inc.	Sandy, Utah	ID
DE-AC03-78ET27154	Klamath Falls	Klamath Falls, Oregon	SAN
DE-AC03-79ET27029	Moana, Reno	Reno, Nevada	SAN
DE-AC03-79ET27040	Susanville	Susanville, California	SAN
DE-AC03-79ET27045	El Centro	El Centro, California	SAN
DE-AC03-79ET27047	Aquafarms	Dos Palmas Area, California	SAN
DE-AC08-78ET27059	T-H-S Hospital	Marlin, Texas	NV
DE-FC08-79ET27058	Navarro College	Corsicanna, Texas	NV

PROJECT REPORTS - MADISON COUNTY PON

1. Madison County Energy Commision, and Rogers Foods, Inc., Madison County Geothermal Project Proposal (2 Vol.), Report No. M.C.E.C.-78, July 1978 (41 and 53 pages).

*2. Energy Service,s Inc., Environmental Report for Madison County, Idaho Geothermal Project, Report No. DOE/ET/27028-1, Cooperative Agreement No. DE-FC07-79ET27028, September 1979 (106 pages).

3. Energy Services, Inc., Madison County Rogers Potato Geothermal Space/Process Heating Project, Semi-Annual Technical Report, February 1979 - August 1979, Report No. DOE/ET/27038-2, October 31, 1979 (32 pages).

*4. Energy Services, Inc., Evaluation of the Geothermal Potential Around Rexburg, Idaho, Report No. DOE/ET/27028-3, Cooperative Agreement No. DE-FC07-79ET27028, April 30, 1980 (154 pages).

*5. Energy Services, Inc., Madison County Geothermal Project, Preliminary Well Drilling Report, Report No. DOE/ET/27028-4, Cooperative Agreement No. DE-FC07-79ET27028, January 1981 (85 pages).

*6. Energy Service, Inc., Industrial Food Processing and Space Heating with Geothermal Heat, Final Report, Report No. DOE/ET/27028-6, Cooperative Agreement No. DE/FC07-79ET27028, August 1982.

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* Available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161

DOE Direct-Use Geothermal PON Project

1. Project Title: Industrial Food Processing and Space Heating with Geothermal Heat (Madison County).

Contract/Cooperative Agreement

2.	Number:	DE-FC07-79ET7028	
3.	Former No:	None	
4.	Period:	02/16/79 to 08/31/82	
5.	Value:	$3,368,285	
6.	DOE Share:	$1,650,900 49%	
7.	Participant Share:	$1,717,385 51%	(assumes $580,100 from AMPCO) (Incl. $14,785 Pre-award)

8. Project Application: Intercept faulting on eastern edge of Snake River Plain for district heating in Rexburg, ID and to provide 40% of potato processing heat at AMPCO plant. Need 1400 gpm of 250°F water. AMPCO will cascade 190°F water to the district heating system.

9. Project Location: Rexburg, Idaho; 25 miles NE of Idaho Falls, Idaho.

10. Well Name/Locaction: MCG-1/NW-1/4, NW-1/4, Sec 31, T6N, R40E

11.	Peak Heat Load:	85.0	Million Btu/hr
12.	Annual Heat Load:	630.0	Billion Btu/yr (load factor = 85%)
13.	Simple Payback (Cash):	1.7	Years (proposed value)

14. Project Status: MCG-1 drilled to 3,932 ft; tagged the expected fault at 3,000 ft, but the maximum temperature was only 72°F. Sluffing prevented logging below 2,400 ft. The hole was opened and deepened to 3,943 ft in May, 1981. A liner hung across the the influx zone, which was source of cold downward flow, leaked at the hanger packing. A sealing assembly placed across the liner hanger also leaked and was reworked. Currently the well head has a 10 inch, 3,000 lb flange with a 1/4 inch steel plate bolted to it. The surface temperature is 70°F. The well will remain in this condition until its disposition is determined by the city and county.

15.	Principal Investigator:	Dr. J. Kent Marlor, Chairman
16.	Firm:	Madison County Energy Commission
17.	Address:	Madison County Courthouse, Rexburg, ID 83440
18.	Phone:	208-356-3431

Other Participants:

19. Firm/Activity: Energy Services, Inc. Proj. Engr; Geo.; Drill Super.

20. Address: Two Airport Plaza, Skyline Drive, Idaho Falls, ID 83402

21. Phone/Contact: 208-529-3064/Dr. Jay Kunze; Ray W. Gould

22. Firm/Activity: CRC Colorado Well Service; Driller

23. Address: Rangely, Colorado 81648

24. Phone/Contact: 303-675-8281

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1.0 INTRODUCTION

The County seat for Madison County, Idaho is the town of Rexburg, with a population of 11,559 permanent residents and 7,000 college students who attend Ricks College, a two-year (junior) private college. See Figure 1, Location Map. The town attained a certain national prominence when, on June 5, 1976, it was inundated by the flood waters from the Teton Dam which collapsed, flooding the town with six ft of water except for the hill on which the college is located.

As a result of reconstruction efforts to rebuild the town and surrounding area, the county government established an Energy Commission, to help guide the area's future course of action in regard to effective utilization and development of various types of energy. In the summer of 1978, the Madison County Energy Commission made application to the U.S. Department of Energy's Division of Geothermal Energy for a cost shared field experiment project (Project Opportunity Notice, or PON) based upon the known geothermal anamolies along the boundaries of the Snake River Plain, certain temperature anamolies in Rexburg City wells and still higher temperatures in Newdale city wells, seven miles northeast. In April 1979, the Department of Energy made an award and signed a cooperative agreement with the Madison County Energy Commission, on an approximately equal cost sharing basis, with the federal government's share involved during most of the high risk portion of attempting to find the resource.

This award was given with the intent that the developed resource could be used for the local Rogers Foods processing plant and also for the space heating of the local college, county and school buildings. Also, it could have been possible to use the resource for heating of some of the local residences.

It was projected that after the successful drilling of one deep well, another would be feasible for further development. Since the highest temperature recorded was only 72°F in the first well, it was concluded that there was no usable geothermal resource at depths of less than 6000 ft in the vicinity of this well. The well could be an excellent re-injection well, however, and this sequence of events had been suggested in the original project plan. A second well was originally proposed. Before the data could be fully evaluated and a proposed second well site selected, federal budget constraints removed the remaining budgeted funds for this project. However, a high quality domestic water well exists and is expected to be used for future needs of the city or county as the area develops.

Unless otherwise noted, all footages in this report are from ground level.

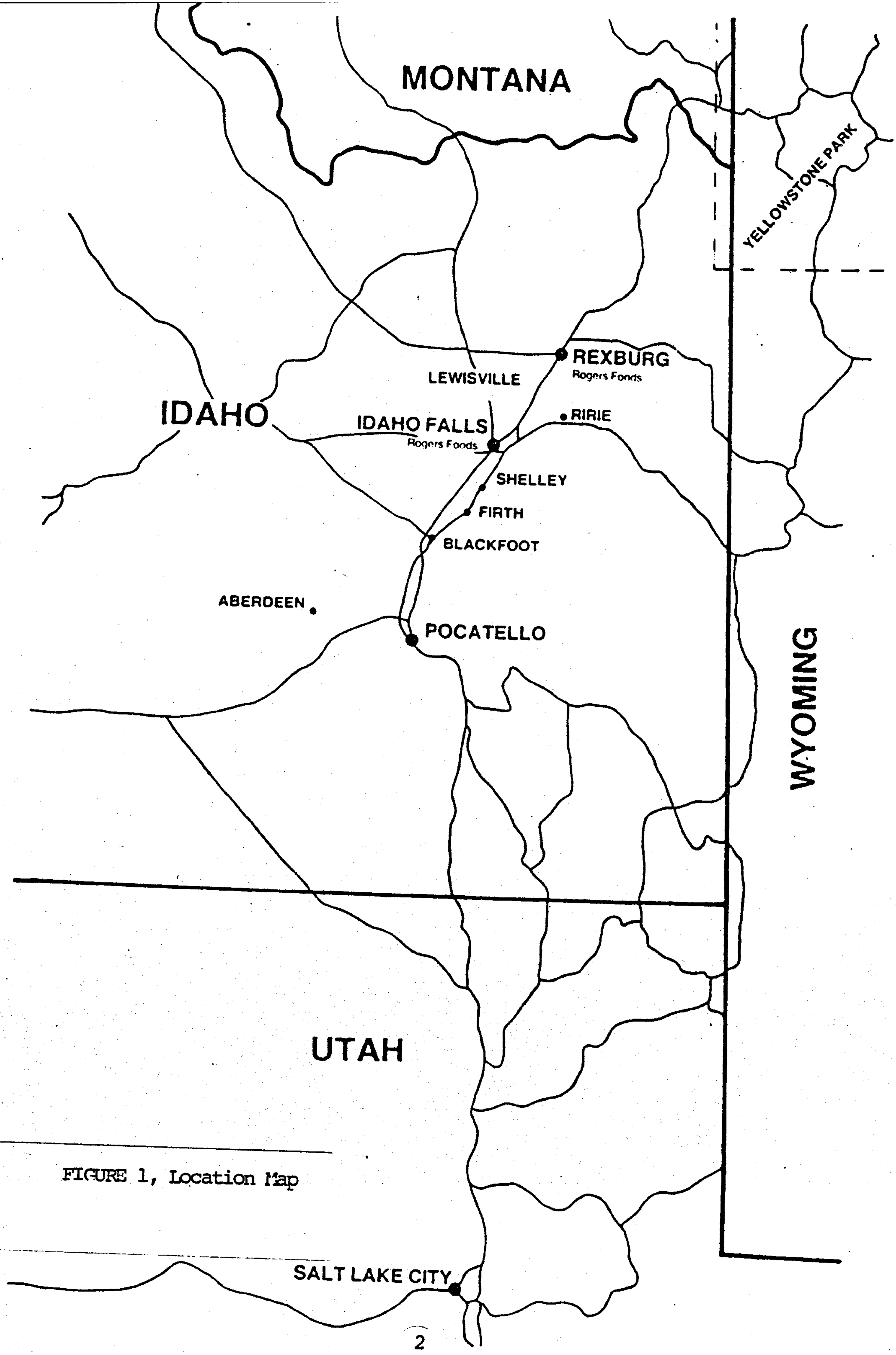


FIGURE 1, Location Map

1.1 Objectives

The principal project objectives were to demonstrate the feasibility of geothermal energy use in industry and space heating serving as a model to encourage interest from other industrial processors and towns in geothermal resource areas. This objective was to be realized by locating, tapping, and utilizing the suspected geothermal resource for food processing, space heating, and the heating of potable water.

1.1.1 Department of Energy Project Opportunity Notice Program

The use of geothermal energy for direct heat purposes by the private sector within the United States has been quite limited to date, yet there is a large potential market for thermal energy in such areas as industrial processing, agribusiness, and space/water heating of commercial and residential buildings. Technical and economic information is needed to assist in identifying prospective direct heat users and to match their energy needs to specific geothermal reservoirs. Technological uncertainties and associated economic risks have influenced potential user perception of profitability to the point of limiting private investment in geothermal direct heat applications.

In September 1977 and April 1978, the Department of Energy, Division of Geothermal Energy (now the Division of Geothermal and Hydropower Technologies), issued two Program Opportunity Notices. These solicitations were part of DOE's national geothermal energy program plan, which had as its goal the near-term research and development of hydrothermal resources by the private sector. Encouragement was given to municipalities and the private sector by DOE offering to share a portion of the front-end financial risk in a limited number of field experiment projects. After competitive evaluations, 23 PON projects were selected from the two Project Opportunity Notice (PON) solicitations. This is the final report for one of those PON projects.

1.1.2 Demonstration Project

Demonstration projects receiving financial support under the DOE's PON program must resolve a number of technical and institutional problems ranging from resource exploration to retrofit and operation of the plant on geothermal energy. The technology developed in these initial projects is being made available to the general public and to stimulate the development of geothermal energy.

Industrial application of geothermal energy is a relatively new concept, and carries significant potential in terms of market size and utilization factor. Utilization of geothermal energy in a process application, in comparison to space heating, has an inherent advantage in that it does not depend on climatic conditions, but rather on process load energy requirements. The industrial geothermal system can be used to its full capacity most of the time, while space heating is subject to seasonal drops.

Typically, in an industrial application, a large load is concentrated in a single facility. In contrast, a district heating system uses numerous, scattered, small loads. Thus, the energy unit cost of industrial application is lower.

Specifically, the Madison County Project was initiated to demonstrate the feasibility of exploring, testing, and developing a potential source of geothermal energy; retrofitting an existing gas and oil fired steam systems; and converting the systems to accommodate food processing and space heating. To ensure this program's value as a demonstration project for future evaluation and use, all phases of project development were closely monitored and documented.

2.0 SUMMARY

The Snake River Plain boundary passes through the southeast edge of Rexburg, and the site of Ricks College. It was in the vicinity of this fault that it was decided to drill the deep exploratory test well.

Prior to selecting this site, it was decided to further probe the area with two relatively inexpensive, small diameter, intermediate-depth test borings. One of these was drilled to a 1,200 ft depth at the edge of the plain. The other to a 1,500 ft depth some three miles from the plain, in the foothills, at an elevation 300 ft higher than the first test well. See Figure 2, Rexburg Area Geothermal Well Locations. The first of these showed the most promising temperature gradient, and it was decided to drill the deep well near this first well.

The deep well was targeted for hitting the fault at about the 3,000 foot depth, but the well was designed to go to as deep as 5,000 ft if necessary. The drilling budget was set at $450,000 and the drilling operation began on May 20, 1980. By July 4, a depth of 3,932 ft had been reached. Pure water was the drilling fluid below the casing (2,300 ft.).

During the open hole drilling, it was impossible to lift the drilling cuttings because of the numerous permeable strata. Cuttings would lodge in these strata, then fall back into the hole after circulation by the mud pumps was stopped. Logging of the hole revealed no temperatures higher than 72°F. The water level in the well was nominally 15 foot below the surface.

It was decided to use air to lift the water level and cause the well to flow, thus removing some of the cold water that had been used as the drilling fluid. Pipe for the air lift was inserted to a depth of 140 ft and air injected into the well bore to reduce the fluid density of the top 140 ft of water and cause the well to flow. After three days of pumping at about 600 gpm with a 600 SCFM compressor, there was still no change in the temperature profile in the well, and it was decided to terminate drilling. At that time, 90 percent of the allocated budget for the well had been spent. Deeper drilling would have required casing the well to greater depths than the 2,300 foot production casing. Use of mud to help to lift the drill cuttings would have been economically impractical because the many fractures and voids in the rhyolite and basalte flows would have caused excessive mud losses.

Several months after dismissing the drill rig, a temperature log showed no changes in maximum temperatures (72°F), but a flowmeter log revealed a very significant downward flow of cold water from just below the casing at 2,300 foot to the bottom of the well (3,943 foot). The flow rate was nominally 10 foot per min, or about 30 gallons per minute. This flow would continue to cool off the bottom of the well. After months of review by various project officials, installation of a solid liner to block this cold water flow was authorized.

In May 1981 using a workover rig, the well was cleaned out, deepened 10 ft to 3,942 ft. and a liner was installed. However, the packer in the liner hanger failed to close, allowing cold water to enter inside the hanger and continue to flow down the hole. An air lift flow test, in June 1981, produced about 250 gpm with a 300 scfm air compressor, with no significant temperature change. It was still not known if any water was being withdrawn from the lower part of well. It took several attempts with a custom made set of lead and rubber packers to seal around the failed packer. Various rubber and cement debre from prior attempts to seal the failed packer had to be removed. In October 1981, the leak in the packer was successfully sealed, however a log of the well showed an obstruction at 2,300 ft. An air lift flow test was run for one week with a 300 scfm compressor. The air lift produced 140 gpm and the surface temperatures never exceeded 70°F.

In November 1981, a cable tool rig unsuccessfully attempted to push the obstruction to the bottom of the well with a 600 lb hammer. On April 5, 1982 a rig with a heavier hammer, succeeded in pushing the obstruction to the bottom of the well. On October 6, 1982 a temperature log was taken. The log verified that the patching assembly had stopped the leakage. The bottom hole temperature was 72°F. From April 12 to April 16, a 53.5 hour air lift flow test with a 300 scfm air compressor produced 300 gpm water flow with a maximum temperature equal to the 72°F bottom hole temperature. From this testing, it was concluded that the fault that was penetrated by the drilling was either a recharge fault for the Snake River Aquifer, or that the massive Snake River Aquifier had successfully "killed" the geothermal potential in this region of the Snake River Plain Fault. It was agreed to wait until the next spring or summer to determine if any heating was occurring at the bottom of the well. A temperature log was taken on September 3, 1982, which gave the same results as five months earlier.

2.1 Project Development

This project was originally entered into jointly by Madison County, American Potato Company, and the Department of Energy for the purpose of demonstrating the feasibility of supplying geothermal energy for food processing and district heating.

This goal was never achieved due to the fact that the production drilling was terminated as an unsuccessful production well, the result of low temperature of the produced fluids (less than 72°F).

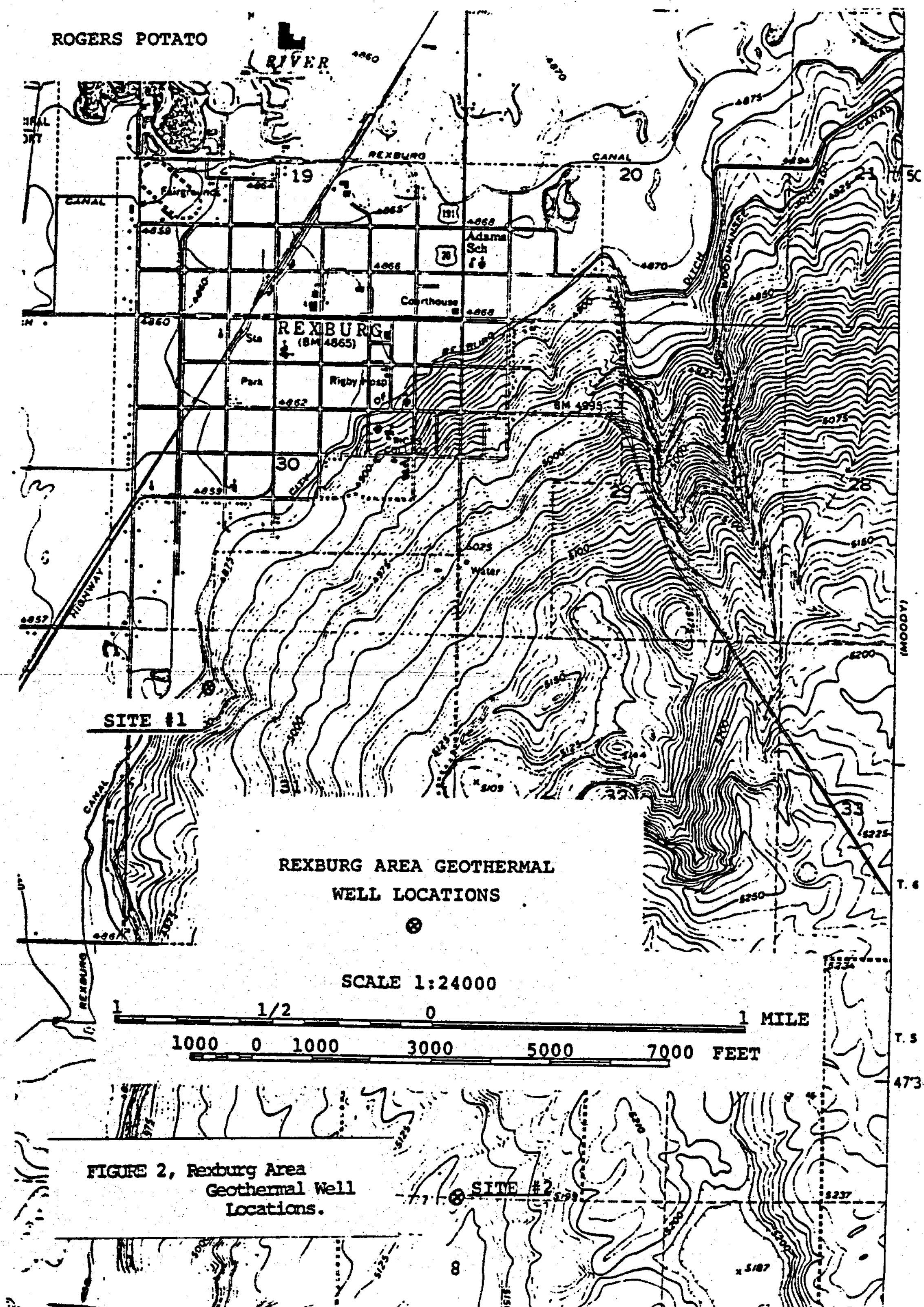


FIGURE 2, Rexburg Area Geothermal Well Locations.

2.2 Economic Result

The cost of the project to date has been approximately $895,000, with 90% of this by the U.S. Department of Energy, the remainder by Madison County. Of this total, 67% was spent on the deep well, including the remedial work. The two initial slim holes, the environmental report, and resource assessment report accounted for 25% of the expeditures. The remaining 8% of the expenditures were used for dissemination of information and various reporting functions to the Department of Energy.

The original estimate for the project was $3,368,285 with $1,650,900 (49%) furnished by the Department of Energy, and $1,717,825 (51%) by the participants. DOE's contribution was primarily for the resource assessment and the first two deep wells. A small portion of this high risk phase of the project was contributed by Madison County, primarily for the remedial work efforts on the well. It was projected that Madison County and American Potato Co. would be spending approximately $1.7 million to supply the water delivery and utilization systems, and the disposal facilities. Of course, funds were expended for those purposes.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Technical

The deep well fell far short of achieving the desired temperatures, with only 72°F water found near the bottom of the well (3,942 ft). Apparently, this region of the Snake River Plain fault is a recharge zone for waters at greater depth that are assumed to be geothermal aquifers. Specifically, the near-surface water is going down to depth rather than geothermal water rising along the fault.

The well did succeed in intercepting the fault at the target depth of about 3,000 ft, and the permeability and productivity of water for this well are outstanding. How much deeper one would have to drill to find hot water and case out the downward flowing cool water is not known. At the time the drilling was terminated, it was decided that at least an additional 2000 ft of depth (to a total depth of 6,000 ft) would be necessary to find water temperatures of the minimum usable level (120°F).

Drilling was terminated because of lack of sufficient budget for the first well to permit the installation of a second production string. The casing would have been the only means of drilling deeper. Without the casing, drill cuttings could not be brought to the surface because of lost circulation zones, which were temporarily capturing the cuttings during circulation, then releasing these cuttings into the hole when circulation was stopped. When the subject of adding funds to the budget for this well was considered, the poor showings of temperature prompted project management to decide to save as much of the project as possible for a second well. The Department of Energy agreed that no further monies should be spent on the well.

Neither the use of air drilling or of heavy muds to stop lost circulation were practical and the only feasible means to permit drilling to greater depths in this hole would have been the installation of a second string of production casing, probably 7 inch in diameter and hung from the 2,200 ft level. In retrospect, adequate contingency should have been alloted to the budget of this well. This was needed to allow for such problems as the casing of the well to eliminate the lost circulation problem which would have permitted drilling or exceeding the 5,000 ft target depth.

3.2 Institutional

1. State bonding requirements for geothermal wells appear to be unnecessary for governmental entities, such as counties. Such public organizations are permanent, and

are essentially chartered by the State as an extension of state government authority. The geothermal bonding requirements were specifically designed for private organizations whose permanence, presence, and involvement in geothermal activities at a particular location were likely to be temporary. The $10,000 bond is to assure that the well will be properly abandoned, if that action is required. Certainly the county government is as concerned as is the state government, that wells are not abandoned without proper completions.

2. Idaho counties are severly limited in their ability to develop capital projects, since State Constitutional requirements dictate that counties have a debt-free budget. The only mitigating factor to this dilemna rests with a county's ability to contract with the Idaho Department of water Resources for a State bond issue. Such an arrangement is never guaranteed and could be most complex.

3. The State's testing requirements for blow-out-preventors insist on the presence of a representative from the Idaho Dept, of Water Resources (IDWR). In this case, only personnel in Boise were deemed qualified by the State, and much time and expense was lost awaiting the arrival of this representative. Even though the State was most cooperative in trying to minimize the lost time, it would seem that this requirement could be modified, such as permitting the witnessing of the test by an independent, qualified engineer or local representative of the IDWR.

3.3 Economic

Although this project failed to produce a useable geothermal resource, it needs to be recognized that the search for a natural resource underground is a risk, and that unsuccessful attempts will occur.

It is not known for certain at what depth or how much additional cost would have been required to tap the hot water of the desired temperature (hotter than 120^{o}F). Nor is it known if there would have been a more promising drilling site near Rexburg, one that would not have been plagued by the downward flow of cool water.

The original budgetary plan called for two wells, recognizing that an unsuccessful attempt at a production well might result from the first drilling, and yet this well could be a useful injection well. The latter is indeed the case, for the well would make an ideal injection well in its present condition, readily able to accept up to 1,000 gallons per minute with a reasonable pumping head. Drilling was terminated at the advice of the drilling engineers and the

Madison County program manager, based on fiscal prudence and the desire to save as many project funds as possible for the second well.

This well was, in retrospect, perhaps was not properly budgeted to allow for adequate contingency conditions. Compared to the costs of other wells targeted for 5,000 ft depth, a $500,000 budget was too slim.

Though only 50% of the budgeted US Department of Energy cost share funds had been expended on this project, budget reductions by the Office of Management and Budget dictated that no further funds could be spent on this project, thus eliminating the chance to proceed with the second well. Had a larger drilling budget been originally proposed for the first well, a larger surplus of authorized funds would have remained at the time the decision was made to stop drilling. Subsequent decisions on use of the remaining budget by Department of Energy officials might have had a different outcome.

As to the present economic outcome of the project - he well is a prolific producer of drinking water, and could be inexpensively modified to to produce even more. Thus it has value in the future when the City of Rexburg needs an additional well for its water system. A new water well would cost the City approximately $100,000 to drill. It is currently planned to leave the well capped until such time that it is needed, and to request the State to release the bond since the well is not considered a geothermal well.

4.0 PROJECT DESCRIPTION

4.1 Task Breakdown

The following lists the various phases and tasks for the work, along with the original schedules for completion. Modification of tasks in the project occurred generally in Phase One, with the decisions to drill two heat-flow test wells. At the completion of Phase Two, Project Management Decision Point Two, the decision was made to terminate the project.

Critical schedule elements included the following:

Phase 0.

Contract and Award Negotiations - Required and actual completion date, June 30, 1979.

Phase 1.

A. Environment Assessment and Review - Project completion August 15, 1979, actual completion date September 30, 1979.

B. Additional Leases & Permits from State - Projected completion August 15, 1979, actual completion date September 30, 1979.

C. Geology and Chemistry, Existing Wells - Projected completion May 31, 1979, actual completion date June 30, 1979.

D. Data Analysis & Drilling Decision, Intermediate Heat Temperature Wells - Projected completion August 15, 1979, actual completion date August 15, 1979.

E. Project Management Decision Point No. 1 - Type and depth of first intermediate depth well. Projected completion August 15, 1979, actual completion date, August 31, 1979.

F. Drill Intermediate Depth Heat Temperature Wells - Projected completion September 30, 1979, actual completion date November 30, 1979.

Phase 2.

A. Well Design - Projected completion October 30, 1979, actual completion date, January 31, 1980.

B. Driller Selection & Contract - Projected completion November 30, 1979, actual completion date April 30, 1980.

C. Drill 5,000 foot Well - Projectd completion July 15, 1980, actual completion date July 4, 1980 (It should be noted that drilling terminated at the 3,932 foot level. The well was deepened to 3,943 ft. and further testing took place in the periods May-July, 1981; September, 1981; and April, 1982).

Phase 3. Second Well.

Phase 4. Design of Utilization Systems.

Phase 5. Construction of Utilization System.

Phase 6. Operational Start-up.

THE ABOVE FOUR PHASES WERE NEVER IMPLEMENTED.

Phase 7. Reporting and Dissemination of Information - Included monthly reports and DOE conferences.

Final Report - Projected completion April 30, 1982, Actual completion date July 31, 1982 (Draft Report).

4.2 Organization and Participants

At Project inception, the principal owner-users were Madison County and Rogers Foods. The organization finally adopted for project accomplishment is shown on Table 1, Organization and Participants.

Rogers Foods Participation

The original project (Reference 1 - Madison County Geothermal Project Proposal Volume II) proposed that the teaming of Rogers Foods and Madison County would facilitate geothermal resource development on Rogers Foods properties north of Rexburg. However, geological studies indicated that alternative sites closer to faults zones and somewhat more removed from the Snake River Plain would probably hold greater geothermal resource potential.

Once the decision was made to explore for geothermal resources off the Rogers Foods property, the Company became a somewhat more reluctant participant in the project. Rogers officials were concerned that if the wells were located off their properties they would not have ultimate control over the costs of energy delivered to them.

Shortly after the start of the project, Rogers Foods was purchased by American Potato Company. Meetings between Madison County and American Potato provided a potential solution to the problem through a proposed contractual agreement between the two participants. Although the contract was drafted and appeared acceptable to both parties, American Potato chose not to conclude the agreement.

Interest and participation on the part of American Potato significantly decreased by December 1, 1979, with the completion of the two heat test holes south of Rexburg. By June, 1980 with the drilling of Madison County Production Well #1, Rogers Foods had ceased to function as a partner in the project. Without doubt, the American Potato Company purchase of Rogers Foods and the Accompanying change of company personnel assigned to represent Rogers Foods, had a critical impact. Throughout the life of the project, Rexburg City and Ricks College were active in supporting the project.

Decision of Drilling

Site location for the two heat test wells and the production well was determined only after careful evaluation of available data and meetings with technical experts. In August, 1979, Madison Energy Commission met with representatives of the U.S. Department of Energy and its contractor EG&G Idaho, Inc., U.S. Geological Survey, Ricks College Geology Department, and Energy Services, Inc. to determine location of the two heat test wells. Again, following the drilling of the test wells and the careful evaluation of data from the holes, Madison County Energy Commission met with the same group. A concensus recommendation was made to the Commission from the group as to the location of Production Well, Madison County Geothermal No. 1 (MCG-1).

It should be noted that American Potato/Rogers Foods, although invited to participate in both meetings, was not represented.

4.3 Cost Breakdown

The project was jointly funded by Madison County and The Department of Energy under its PON program. Rogers Foods, which was purchased by American Potato (of AMPCO) as the project began, contributed $6,700 to Phase 0. No other monies were contributed by other organizations during the life of the project.

The estimated total project cost was $3,368,285. Madison County's share of the project cost was to have been $1,130,585 and The Department of Energy's commitment was for $1,650,900 and AMPCO was to have provided $586,800 of which $3,600 was to have been contributed during Phase 1, but was never received.

The major portion of The Department of Energy's cost share was to take place during the early phases of the project. The Madison County and AMPCO shares were to be heaviest during the latter phases of the project.

Actual project costs totaled Madison County, $88,567; Department of Energy, $797,000; AMPCO, $3,600. A project breakdown by task is provided in Table 2, Madison County Geothermal Well Cost Summary.

TABLE 1

Organization and
Participants.

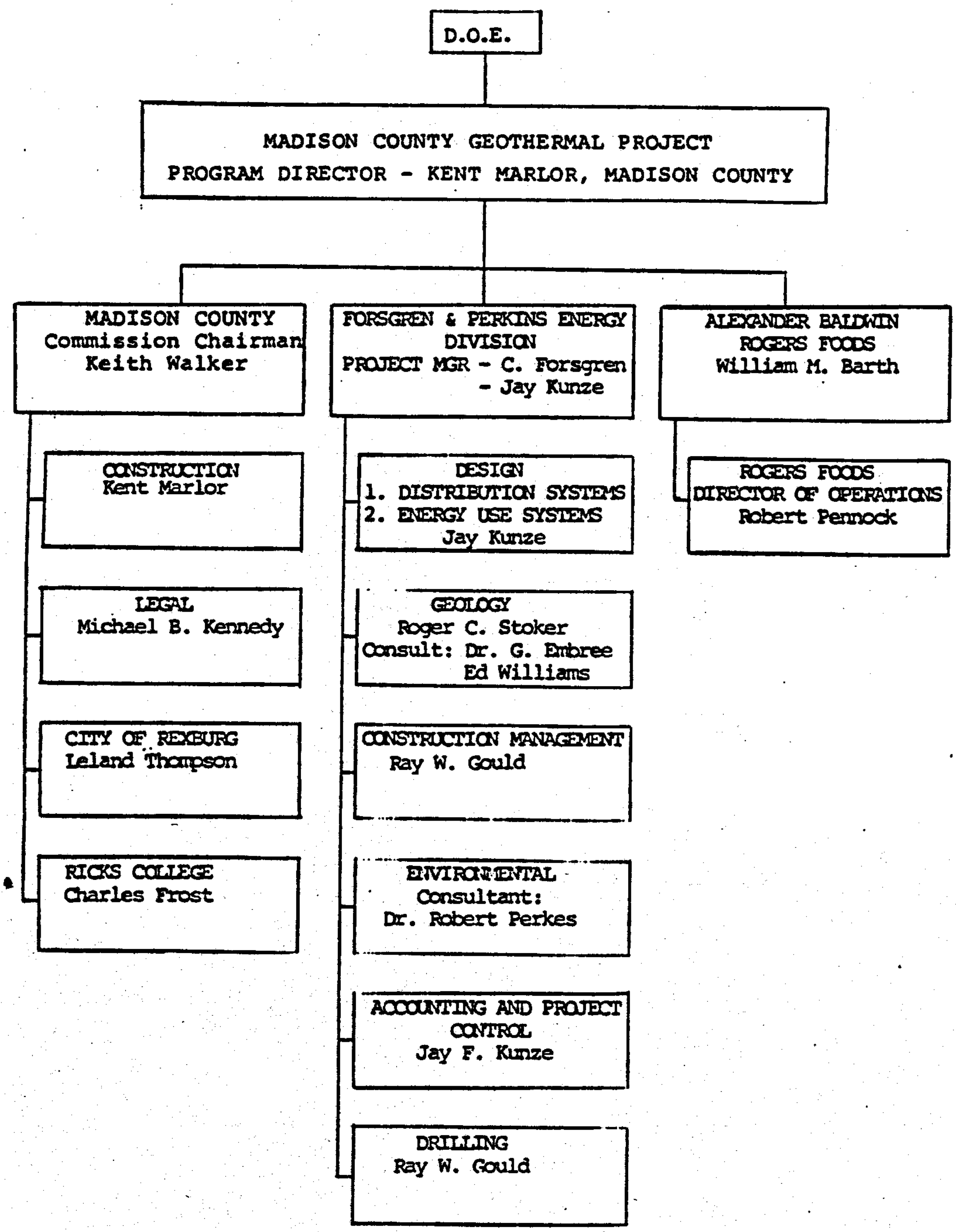


TABLE 2

MADISON COUNTY GEOTHERMAL WELL

COST SUMMARY

		US DOE	MADISON COUNTY	ROGERS FOOD
PHASE 0	Proposal to DOE	-	$ 8,085	$ 3,600
PHASE 1	Drilling Preparation	$ 3,000	1,400	-
	Environmental Report	7,500		
	Explorational Test Wells	178,522	600	-
	Project Management	14,500	10,522	-
PHASE 2	First Exploratory Well			
	Design, bid, selection	4,500	1,000	-
	Drilling	455,600	3,000	-
	Logging	11,000	4,000	-
	Remedial Work	32,500	42,760	-
	Testing & Analysis	29,600	1,000	-
	Project Management	12,800	10,900	-
PHASE 3 to 6	Never Activated	-0-	-0-	-
PHASE 7	Reporting	34,000	3,000	
PHASE 8	Public Information	12,900	2,300	
	TOTAL	$797,000	$88,567	$ 3,600

5.0 RESOURCE ASSESSMENT

5.1 Pre-Project Assessment

The area around Rexburg had several features that indicated excellent geothermal resource potential. Natural hot springs in the area discharged water up to 120°F at the surface. Some irrigation wells had above normal temperatures (i.e., above 50°F). Figure 3, Rexburg Area Subsurface Temperature. Geochemistry reports predict temperatures for the geothermal aquifer that could range from 160°F to 400°F. See Table 3, Rexburg Area Warm Springs and Wells. Additional information regarding Rexburg area water wells can be found in Appendix A, Rexburg Area Water Well Profiles.

5.2 Pre-Drilling Assessment

The distribution of hot water in the area appeared to be concentrated along the major late cenozoic linear and arcuate fault zones. Maps showing contoured reservoir temperatures calculated from the water chemistry also showed a possible concordance with major structures. Other intersections of major structures may have had geothermal potential, despite the lack of shallow indications of hot water.

The most promising area for geothermal exploration on the Rexburg bench was determined to be where two calderas overlap, resulting in a maximum depth of fill and intersecting fracture or fault system. See Figure 4, Geologic Structures and Faults Around Rexburg, Idaho.

The northeast normal faults opposite the Snake River Plain may have had special geothermal significance because they interrupted plainward migration of ground water and provided channelways for water to descend to hot depths.

The geological structure indicated Rexburg was situated on the edge of a huge rift (known as the Snake River Plain) and within the influence of a young complex caldera feature. See Figure 5, Rexburg Caldera Complex Sketch Map. Local high angle normal faults were located in the immediate area which appeared to influence the warm water occurrence.

It was decided to initally probe the area with at least two moderately deep, small diameter test holes. There were two areas considered as likely regions to probe. The one was a small graben intersecting the Snake River Plain fault at nearly a right angle near the extreme eastern edge of the city. The other area of interest was the bench area in the region directly south of the city. The latter area was eventually selected as the area to probe, primarily because geological evidence and interpretation indicated that this area had numerous fault intersections and was more closely centered in one of the calderas.

Prior to selecting the site location for these small diameter test holes, an electromagnetic wave detector tuned to submarine signals from Seattle was used to scan the area for low resistivity regions indicative of near surface faults. The instrument (known as EM-16) had a sensitivity of nominally 500 ft depth, and obtained the results shown in Figure 6, Geophysical Survey Lines and Well Locations.

Two moderately deep, small diameter exploratory wells were drilled after reviewing the available geological evidence. The 1,200 ft deep (HTW-1) and 1,500 ft deep (HTW-2) exploratory wells indicated that extensive fracturing and voids existed and which provide excellent porosity and permeability.

5.3 Drill Site Selection

5.3.1 Site Location

Based on data gathered from these two small diameter exploratory wells, it was considered feasible to proceed with a deep drilling geothermal program near the site of the HTW-1 well. That well showed a significant increase in temperature gradient over the last 500 ft of its depth, whereas the HTW-2 well, some three miles to the south, indicated a temperature reversal over the last 300 ft of its depth.

The site was recommended following a review of available data by geologists and hydrologists from the Department of Energy, U.S. Geological Survey, EG&G Idaho, Ricks College, and Energy Services. The site was offset approximately 400 ft west of the suspected surface trace of the 82°F dipping Snake River Plain Fault, so as to intersect this fault at a depth of approximately 3,000 ft.

It was determined that the deep well would be a minimum depth of 3,000 ft with a target total depth of 5,000 ft. This was based on the "normal" high temperature gradient (3.25°F/100 ft) that generally existed in the area and in particular was found in the bottom of HTW-1. The location of the well was targeted to intersect the major Snake River Plain Fault at about the 3,000 ft depth, and a minor fault trending NNW-SSE from the area of the bench south of Rexburg. A more complete discussion leading to the selection of this drill site is contained in Reference 2, Evaluation of the Geothermal Potential Around Rexburg, Idaho (DOE ET/27028-3).

5.3.2 Selection Criteria

The primary selection criteria was geological, based on the evidence of faults and of the temperature gradients measured in the moderately deep exploratory holes. There was little question about the presence of water in these faulted systems, but there was concern about possible overwhelming influence of cold water flooding from the Snake River Plain. This was one of the reasons that the graben area at the eastern edge of Rexburg was not chosen for further probing by the test exploratory holes. There was obviously concern as to why the HTW-2 well (some three miles to the south of the deep drill hole site) had shown such a dramatic reversal in temperature over its bottom 500 ft of depth. It was assumed that there was cold water intrusion occurring at that location from runoff from the mountains to the southeast. See Figure 7, HTW-1 Temperature Log and Figure 8, HTW-2 Temperature Log.

Another major criteria for drill site selection was the proximity of the well to the ultimate users in Rexburg. To put the well more than about two miles from these users would result in a pipeline cost which would be approximately equal to the well cost.

Land ownership was not an issue. Madison County had the cooperation of most all land owners in the likely drill site location regions, and had leases or options for geothermal leases on some 3,000 acres of land.

5.4 Post Drilling Assessment

The drilling of the deep well reached a final depth of only 3,942 before it was decided to terminate drilling based on disappointing showings of temperature. Subsequent measurements of a large volume of water entering the well just below the casing (at about 2,300 ft) and flowing down the well bore led to remedial efforts to case off this flow. Even after this effort was accomplished, temperatures in the bottom of the well were only in the range of 75°F, far below what would be expected from the normal temperature gradients in the area, or in the Snake River Plain aquifer.

The only logical conclusion drawn to date is that this portion of the Snake River plain fault is one where cold near surface water is traveling downward, perhaps recharging the geothermal reservoir(s) that must exist somewhere nearby. It is expected that this may be the condition in general along this portion of the Snake River Plain Fault within a few miles of Rexburg, though of course, this conclusion is only based on inference. See Figure 9, Surface Waters Rexburg City Area, which shows the abundance of surface streams near the Snake Plain Fault in the region of Rexburg. As a result of the low temperatures resulting from the apparent huge convective flows, project engineers and geologists are not of unanimity in proposing (after the fact) where a better drilling location would have been.

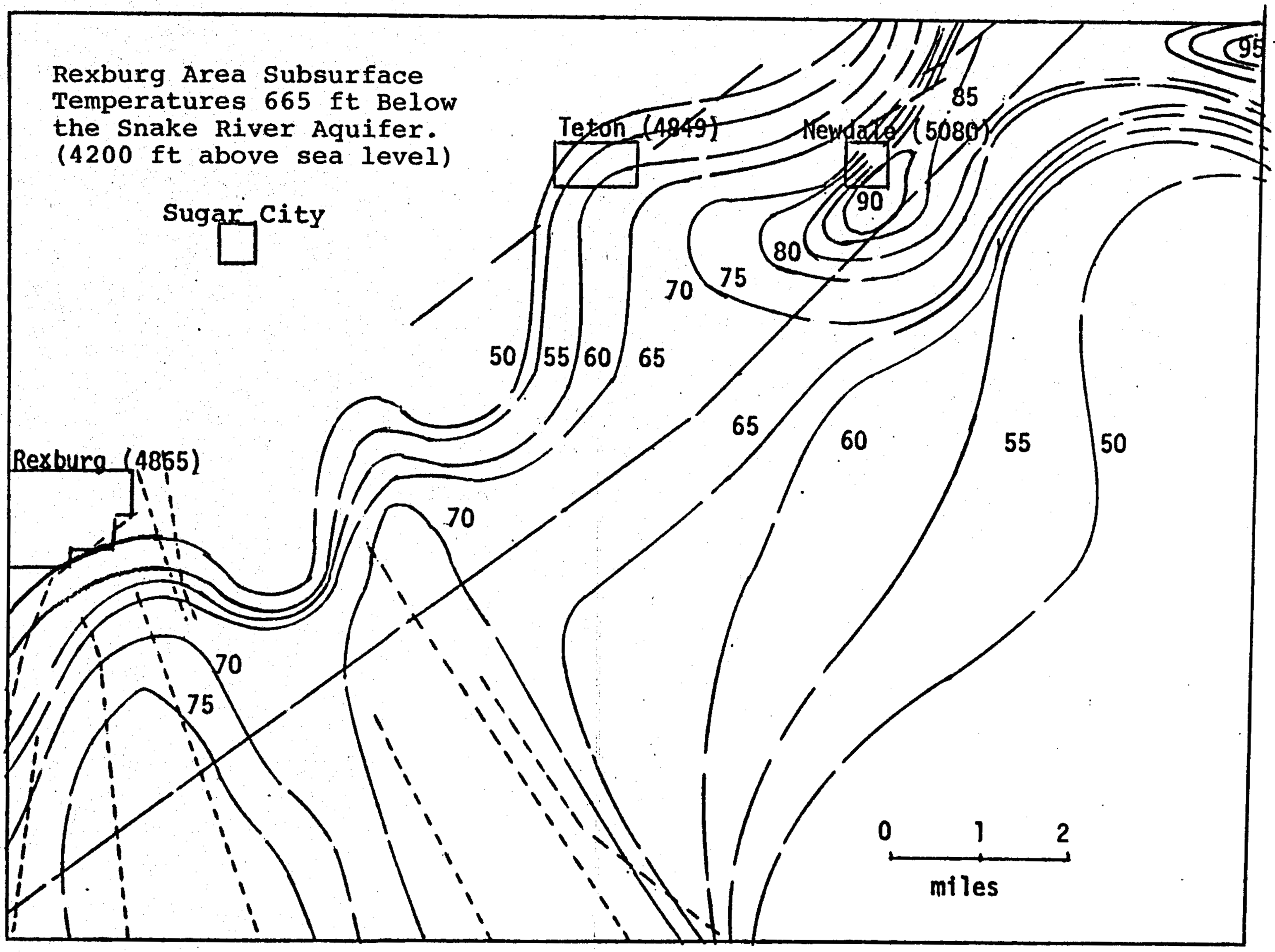


Figure 3 Rexburg Area Subsurface Temperatures

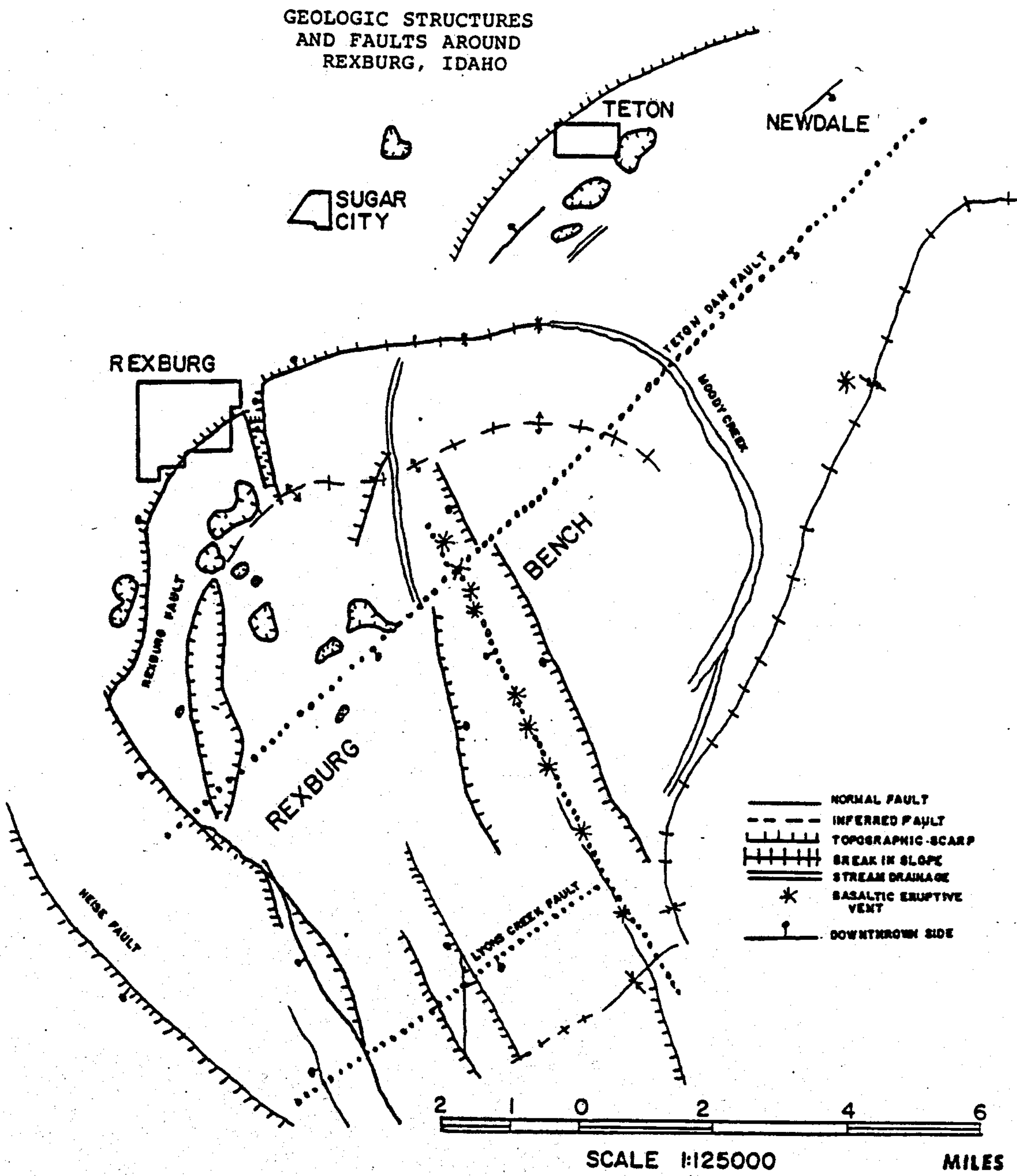
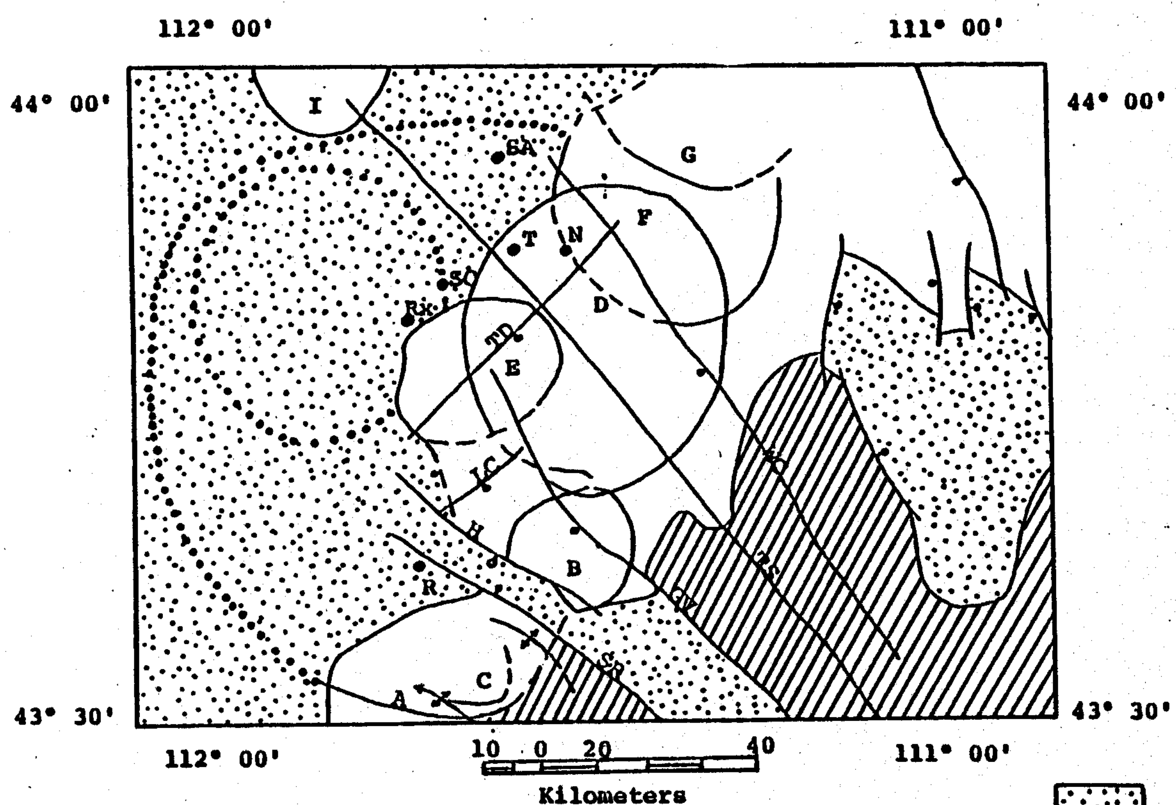


FIGURE 4, Geologic Structures and Faults Around Rexburg, Idaho



Sketch map showing the location of postulated calderas within the Rexburg caldera complex.
(From USGS Open - File Report 78-1009)

FIGURE 5, Rexburg Caldera Complex Sketch Map

Table 3
REXBURG AREA WARM
SPRINGS AND WELL*

	Distance from Rexburg	Surface Temperature	Predicted Reservoir Temperatures	
			Geothermometer Silica **	Geothermometer Na-K-Ca **
Green Canyon Hot Springs	17	111°F	158°F	41°F
Ashton Warm Springs	29	106°F	293°F	194°F
Big Springs	62	54°F	203°F	149°F
Lily Pad Lake Springs	49	63°F	95°F	68°F
Newdale Well	9	97°F	248°F	185°F
Heise Hot Springs	19	120°F	176°F	401°F

* Table compiled from Idaho Department of Water Resources Bulletin No. 30

** Silica and Na-K-Ca geothermometer indication of temperatures are less reliable at the lower temperatures. None of the predicted temperatures were made using the anthalpy-chemical dilution correlation model, which would give higher results than shown here.

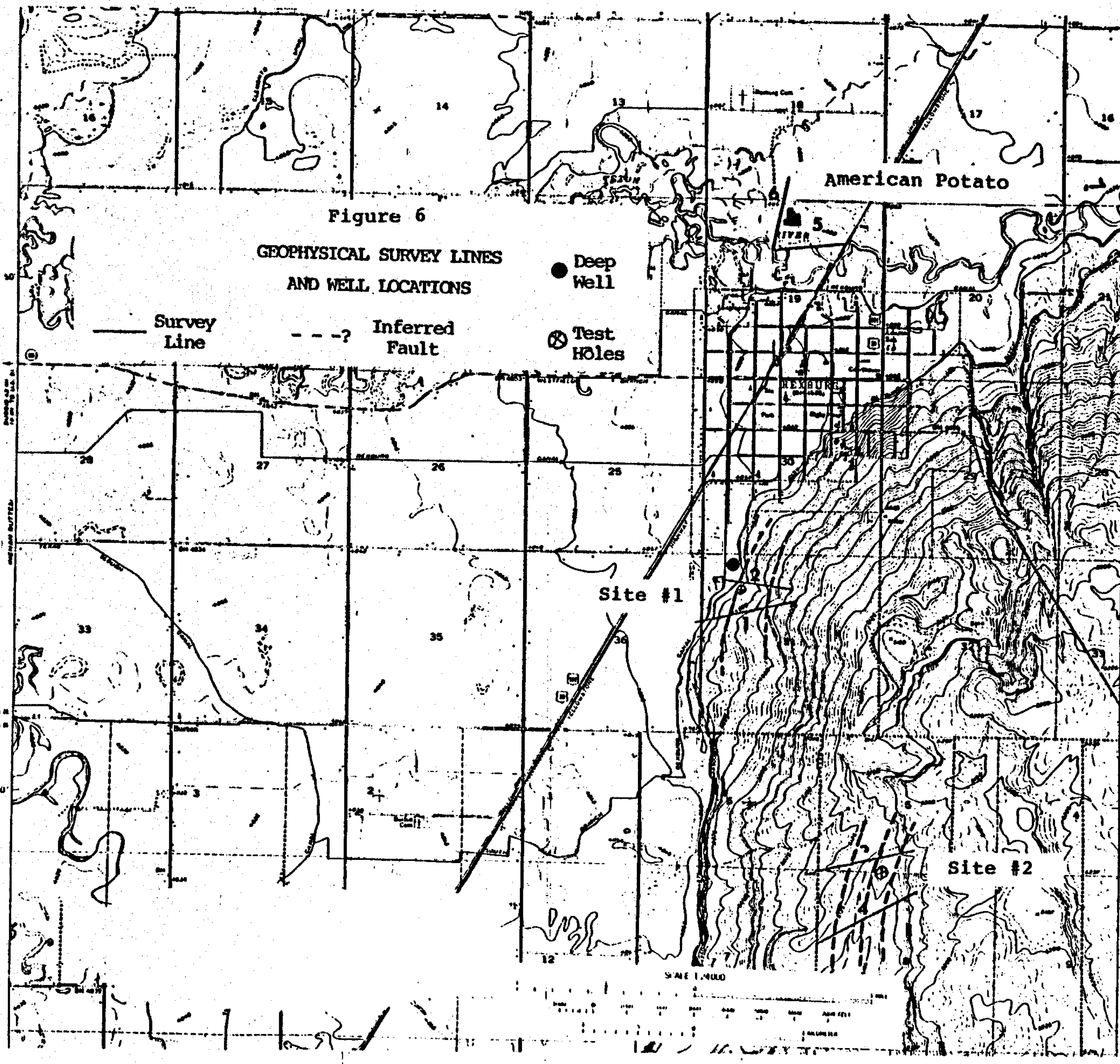


Figure 6
GEOPHYSICAL SURVEY LINES
AND WELL LOCATIONS
Survey Line
- - -? Inferred Fault
Deep Well
Test Holes
American Potato
Site #1
Site #2

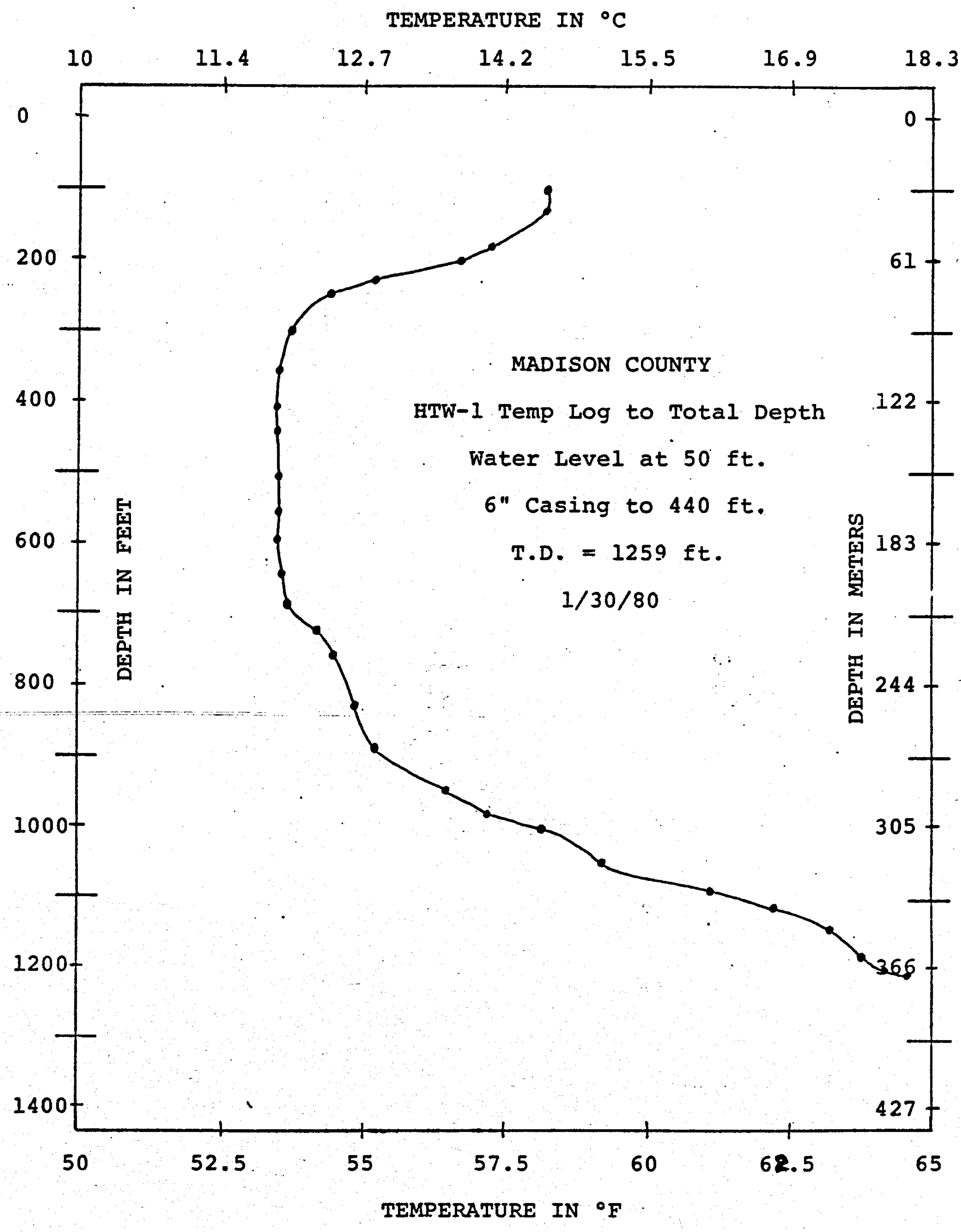


FIGURE 7, HTW-1 Temperature Log

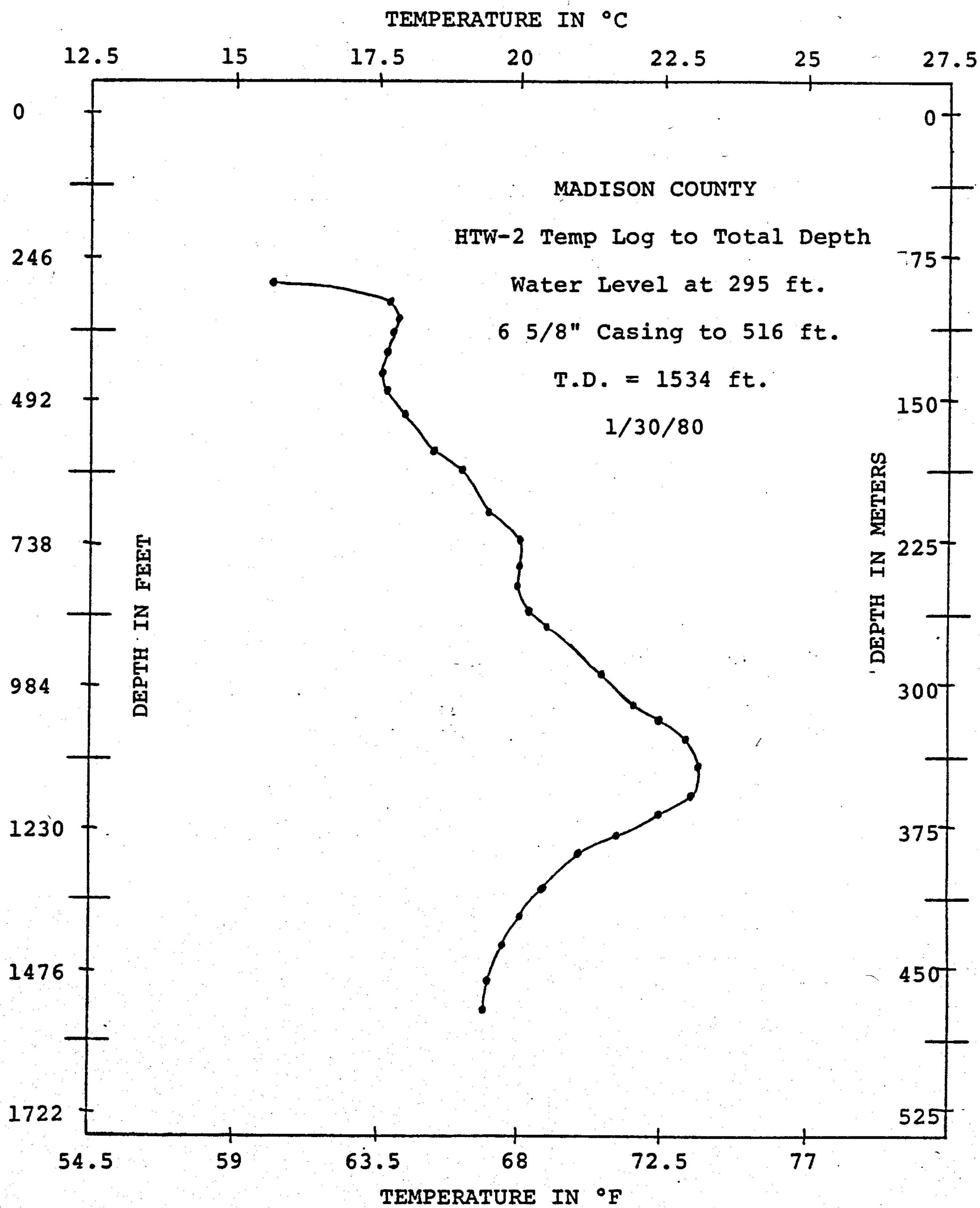


FIGURE 8, HTW-2 Temperature Log

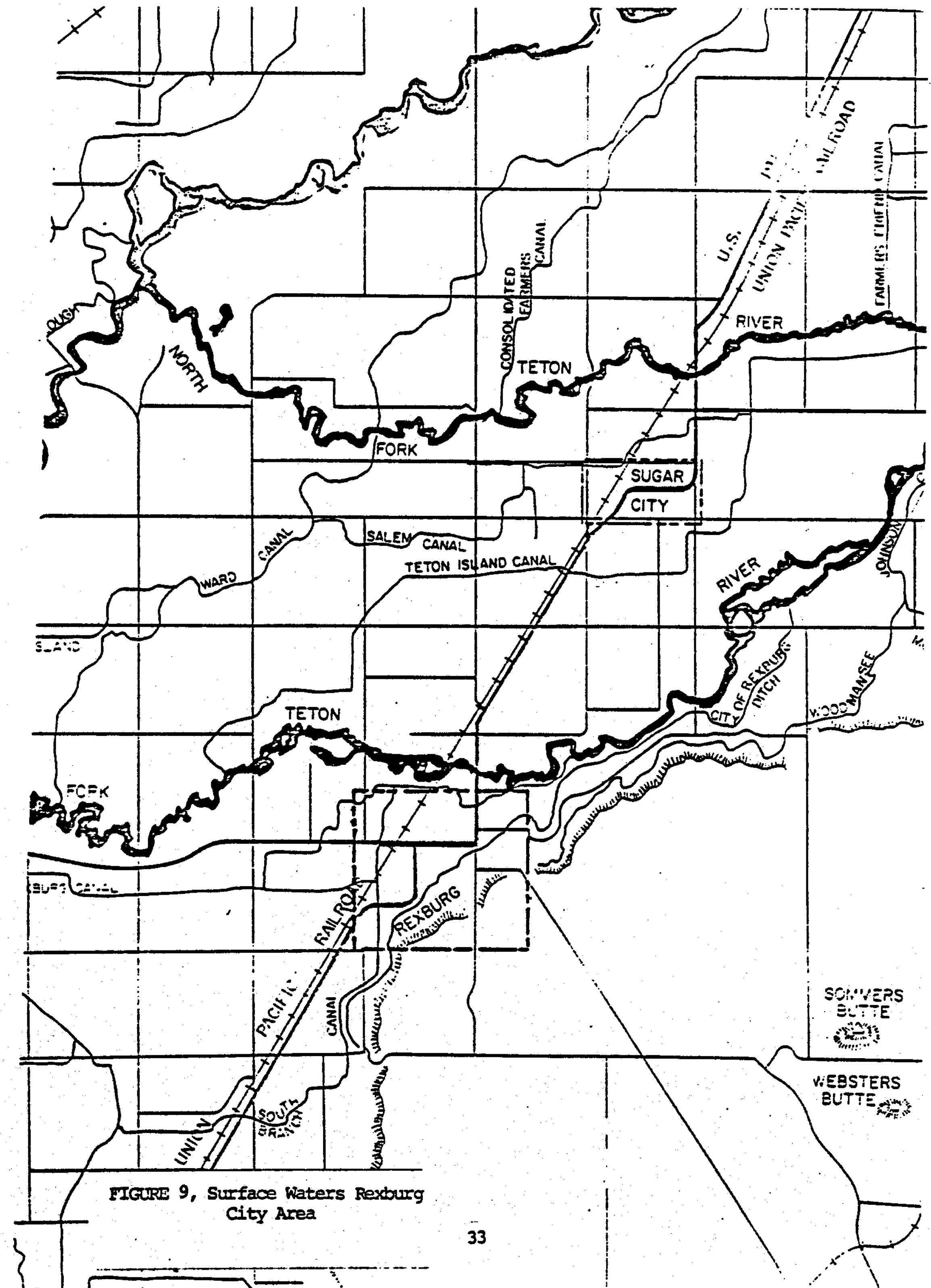


FIGURE 9, Surface Waters Rexburg City Area

6.0 ENVIRONMENTAL ISSUES

The drilling of the Madison County geothermal well addressed several areas regarding its environmental impact to the area. Both biological and human aspects were considered, and were evaluated in Reference 3, Environmental Report for Madison County Geothermal Project, which was the first phase undertaken in the project.

The primary environmental concern was in containing the fluids from the producing well until the water quality and production capability were determined. Once the well was successful and utilization of the fluids was planned, there was concern over the question of disposal. It was not known if injection of the cooled fluid would be necessary. That decision was dependent upon the fluid evaluation. No other major environmental problems were anticipated.

6.1 Pre-Drilling

Environmental degradation, resulting from setting-up and drilling the geothermal well, was temporary and relatively insignificant because the drilling was to occur on presently unused farm land. Some of the minor conditions of concern were as follows.

Flora and fauna existing near the drill site were of the common variety, and hence no irreparable damage would result. The drilling area consists of cultivated ground which will be leveled and restored to pasture or agricultural crop production at the completion of the project.

The drilling site is located in a semi-residential region just outside of the city limits. No threatened or endangered species reside in the area.

Due to the relatively insignificant impact of the single deep geothermal well, no increased occurrence of microseismic events should be expected.

Subsidence is sometimes of concern whenever large quantities of fluids are withdrawn from unconsolidated sediments or when declining reservoir pressures reduce the overburden support. However, water level decline has never been detected in any area within the Snake River Plain, and the abundant supply of recharge water led to the conclusion that subsidence should never be a problem in this project.

Contamination of domestic and agricultural water aquifers with geothermal fluids or contaminated drilling fluids was not to be permitted. The project plans and the drilling permit from the State required that the well be cased and cemented through the shallow ground water aquifer to reduce chances of contamination.

No long-term impact was anticipated on employment levels, housing, or income. Additional employment was available to the local labor market for a short period of time during drilling.

The equipment on location at the drill site presented a temporary undesirable aesthetic condition including an increased noise level. These conditions were insignificant and of a temporary nature.

The impact on air quality was anticipated to be minimal and probably undetectable above the existing environment. Particle concentrations were slightly increased during site preparation work as a result of wind-blown dust.

The entire drilling operation was supervised by qualified personnel and conformed to all state regulations. Since a usable resource was not encountered, the hole will:

1. Be plugged in accordance with Idaho Department of Water Resources standards for well abandonment;

   or

2. Will be left capped and in a standby condition awaiting eventual use by the City as a domestic well for its water system.

Upon completion or abandonment of the project, the reserve pit will be backfilled. The disturbed site will be graded, reseeded and all equipment, structures, and waste materials will be removed.

6.2 Post-drill

Since the completion of the drilling operations, no artesian flow has developed. The fluid level is approximately 15 ft below the ground surface at a temperature of 68°F. Water chemistry evaluation indicated fluids in the well were of equal quality (as measured by the total dissolved solids of approximately 270 ppm)* of that water presently being used in the Rexburg water system. Therefore, the well could serve very well as a suppplement to the water system, and might eventually be the source of water (72°F) for water-to-air heat pumps. This application would be the extraction of geothermal heat from ground water.

Presently the well head has a 10 inch, 3,000 lb flange with a 1/4 inch steel plate bolted to it, and it will remain in this condition until disposition of the well is determined by the City and the County.

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* Specific conductivity averaged 405 umhos/cm. For comparison with other domestic/irrigation wells in the area, See Table 4, which also gives the chemical analysis of the HTW-1 test well 150 yards from the deep well.

Madison County has turned the backfilling of the reserve pit, site restoration and are a cleanup over to the property owner, Mr. Dick Davis. This was done at Mr. Davis's request.

TABLE 4
Water Sample

Chemical Analysis Results

HTW-1 and Area Wells

	HTW-1 Feb. 27, 1980	Area Well Averages *
Conductivity	390 mho/cm	393 mho/cm
Calcium (Ca)	105 mg/l (ppm)	40 mg/l (ppm)
Silica (SiO_2)	28.5 mg/l (ppm)	44 mg/l)ppm)
Fluoride (F)	1.92 mg/l (ppm)	1.6 mg/l (ppm)
Potassium (K)	2.85 mg/l (ppm)	4 mg/l (ppm)
Sodium (Na)	30.0 mg/l (ppm)	26 mg/l (ppm)

* Reference: Table III, Madison County Evaluation of the Geothermal Potential Around Rexburg, Idaho. Dated April 30, 1980.

7.0 INSTITUTIONAL ISSUES AND PERMITS

7.1 Private

At the beginning of the project, while the environmental and resource assessment studies were underway, the areas of critical interest were identified and options to obtain a geothermal lease were signed with a number of property owners. Over 3,000 acres were optioned in this manner.

Once the deep drilling site had been selected, a drilling site lease was entered into with property owner Dick Davis.

7.2 City

Rexburg City was associated with the project and thus, a right-of-way agreement for the distribution system with the City was unnecessary. The drilling site was outside of city limits.

7.3 County

Since Madison County owned rights-of-way corresponding to the County road system, no rights-of-way agreements for the distribution system within the County was necessary.

7.4 State

Application number 227283 to appropriate public water was approved November 7, 1978. A copy of the permit is in Appendix B, Permits.

Geothermal Application 22-GR-1 was approved by Idaho Department of Water Resources, June 5, 1980. A copy of the approved application and approval letter is included in Appendix B. Cost of the permit was $100.

Because of the problems encountered in downflow of water in the well, it became necessary to submit an application for a Permit to alter a geothermal well. This application was submitted on February 23, 1981 with a $100 fee, linked to a renewal of the Water Resources Permit. The permit to alter was granted to perform remedial work and install a liner in the well.

Without doubt, informal contacts with Idaho Department of Water Resource Staff, and the providing to them of weekly progress reports on the drilling, enhanced the permit application process.

Madison County provided an escrow, $10,000 savings account, in lieu of the $10,000 bond required by the Idaho Department of Water Resources on October 16, 1980. Reference Appendix B, Permits.

County officials were disappointed with State bond requirements which gave no recognition of the County's special relationship with the state as a legal sub-entity. County officials perceived that having such a legal status should have exempted them from a lengthy, cumbersome and unnecessary process for compliance with bonding requirements. Ordinary bonding companies, not having dealt with the County previously, and not having any other business (such as insurance business) with the County were reluctant (in fact refused) to bond the County on the well, for what in effect could be a bond in perpetuity. Reference Appendix B, Permits for additional information regarding issues and permits.

8.0 PRODUCTION DRILLING AND LOGGING

8.1 Summary

The original plan was for two wells to be drilled, the first one of considerable depth (nominally 7,000 ft), drilled into the heart of the Snake River Plain, approximately two miles from the edge of the boundary fault. The purpose was to intercept high temperatures, hopefully exceeding 300°F, for use in the Rogers Food Co. processing plant north of Rexburg. Discharge water from this plant would be piped to the city for use in space heating buildings in Rexburg.

Depending upon the relative success of and information learned from this well, it was then planned to drill either an injection well or another production well nearer to the City, probably near the boundary fault of the Snake River Plain.

However, between the time the original plan was established and the time to determine the site of the first well, Rogers Food Co. was purchased by the American Potato Co. The latter company felt that it did not want to participate in any of the wells, but would consider participating as a user in the project. As a result of the partial withdrawal of American Potato Co. from the project, the only guaranteed users were the public buildings in Rexburg.

A second development that caused the drilling plans on the Madison County well to be altered was the drilling of one moderately deep and one very deep well by the US Department of Energy into the Snake River Plain. The moderatley deep well (2,200 ft) was drilled 3-miles north (at Sugar City) of the intended site of the Rogers Food Co. well. The very deep well was drilled into the heart of the plain, 50 miles to the east on the Idaho National Engineering Site reservation. This latter well was 10,000 ft deep. Neither well gave encouraging results. The Sugar City well found disappointing temperatures, and the deep INEL well apparently did not encounter permeable formations at depth, though high temperatures were found (in excess of 300°F).

For these reasons, the geothermal drilling plan at Rexburg, in Madison County, was changed. The first well was to drill into a fault, or intersection of faults, that would likely produce good permeability and warm water. The minimum target temperature was 120°F, and the depth for intersection of the faults was targeted for about 3,000 ft so as to obtain these minimum temperatures. If this well was successful, appropriate considerations would be made concerning the second well - i.e., where should it be drilled, what were its objectives (production, injection, etc). Much would depend on the position of American Potato Co. at the time, and whether or not there was promise of temperatures in the range of 300^{o}+ F.

Because of these considerations, the two small diameters, intermediate-depth test holes were drilled into suspected fault intersections: HTW-1, on the Snake River Plain fault; and HTW-2, on the bench, 3 miles south of the major Snake River Plain fault. The former had a good temperature gradient over the bottom 500 ft, but the latter had a reversal in temperature over the bottom 300 ft. However, these temperature results did not make the decision "clean and easy", for geologistswho had studied the faults of the area. Don Mabey of the USGS and Glenn Embree of Ricks College preferred to probe deep into the bench area, which was suspected to be the edge of an ancient caldera. The sharp, and considerable temperature reversal from 1,200 ft to 1,500 ft depth in the test well on the bench, nevertheless, dictated against placing the deep drill hole in or near that location.

The selected deep drilling site was within 150 yards of HTW-1 target to intersect the Snake River Plain fault at a depth of 3,000 ft (assuming the fault dips about 82^{o}), and also at its intersection with a less distinct north-south trending fault emanating from the bench area. The latter fault was identified both with the EM-16 passive resistivity survey, and from certain geological evidence.

8.2 Organization

The Madison County Energy Commission was primarily responsible for the program, and delegated engineering and drilling direction responsibility to Energy Services. The Idaho operations Office of the US Department of Energy maintained approval and veto power over the drilling portion of the project. In February 1980, a budget of $465,000 was approved for the first well, to be drilled to intersect the fault and suspected warm water production zone at 3,000 ft, but with maximum drilling target depth of 5,000 ft (i.e., the drilling rig selected had to have the capability of drilling to the 5,000 ft depth.

8.3 Driller Bidding, Selection, and Contract

A bid specification was prepared and sent to 13 potential drilling contractors. Only two companies submitted bids: Holman Drilling of Spokane, WA; CRC Colorado Well of Rangely, CO.

Following a careful evaluation of the bids, CRC Colorado Well Service Co. was awarded the drilling contract. The rig that was used was CRC #75, a Cabot Model 750.

8.4 Drilling Summary

The well was located on a private 10 acres of ground, with drilling right and geothermal rights leased from Davis Construction Co. The location was in the NW 1/4, NW-1/4 of Section 31, Township 6N, Range 40 E. The elevation was 4,846 ft above sea level. The water table was approximately 20 ft below the surface in this area. Note: All depths stated in this report are from ground level.

The original plan for well design was as follows:

120 ft of 20-inch conductor pipe, cemented.

1,000 ft of 13-3/8 inch diameter surface pipe, cemented back to the surface.

1,600 ft of 9-5/8 inch diameter production pipe hung from the 900 ft level and cemented to bottom at 2,500 ft.

8-7/8 inch diameter open hole from 2,500 ft to total depth of 5,000 ft.

The actual casing program was slightly different, the result of unexpected problems caused by lost circulation, heavy gravels and caving. The final configuration is as follows:

110 ft of 20-inch conductor pipe, cemented. This pipe was drilled and set with a cable tool rig from Rocky Mountain Drilling Co. of Rexburg, Idaho.

735 ft of 13-3/8 inch surface casing, cemented back to the surface. Though the surface casing hole was drilled 17-1/2 inch in diameter to a depth of 989 ft,the surface casing could not be installed further than 735 ft.

2,289 ft of 9-5/8 inch production casing brought to the surface and cemented. The cost effectiveness of using a liner hanger vanished when the depth of the hanger moved up to the 700 ft level.

3,942 ft total depth of 8-7/8 inch hole. The fault was encountered as expected around 3,000 ft, but the target maximum depth of 5,000 ft could not be met because of lost circulation.

Figure10, Drilling Activities Chart, shows a graphical presentation of the daily drilling progress.

In May 1981, a workover rig was brought in to install a liner hanger and 5-1/2 inch liner for the purpose of sealing off flow that was entering the well at about the 2,300 ft level and flowing down the hole. The top of the hanger was set at 2,208 ft and the 5-1/2 inch, K-55, 15.5 lb/ft solid liner (casing) was hung from 2,215 ft to

MADISON COUNTY GEOTHERMAL WELL #1

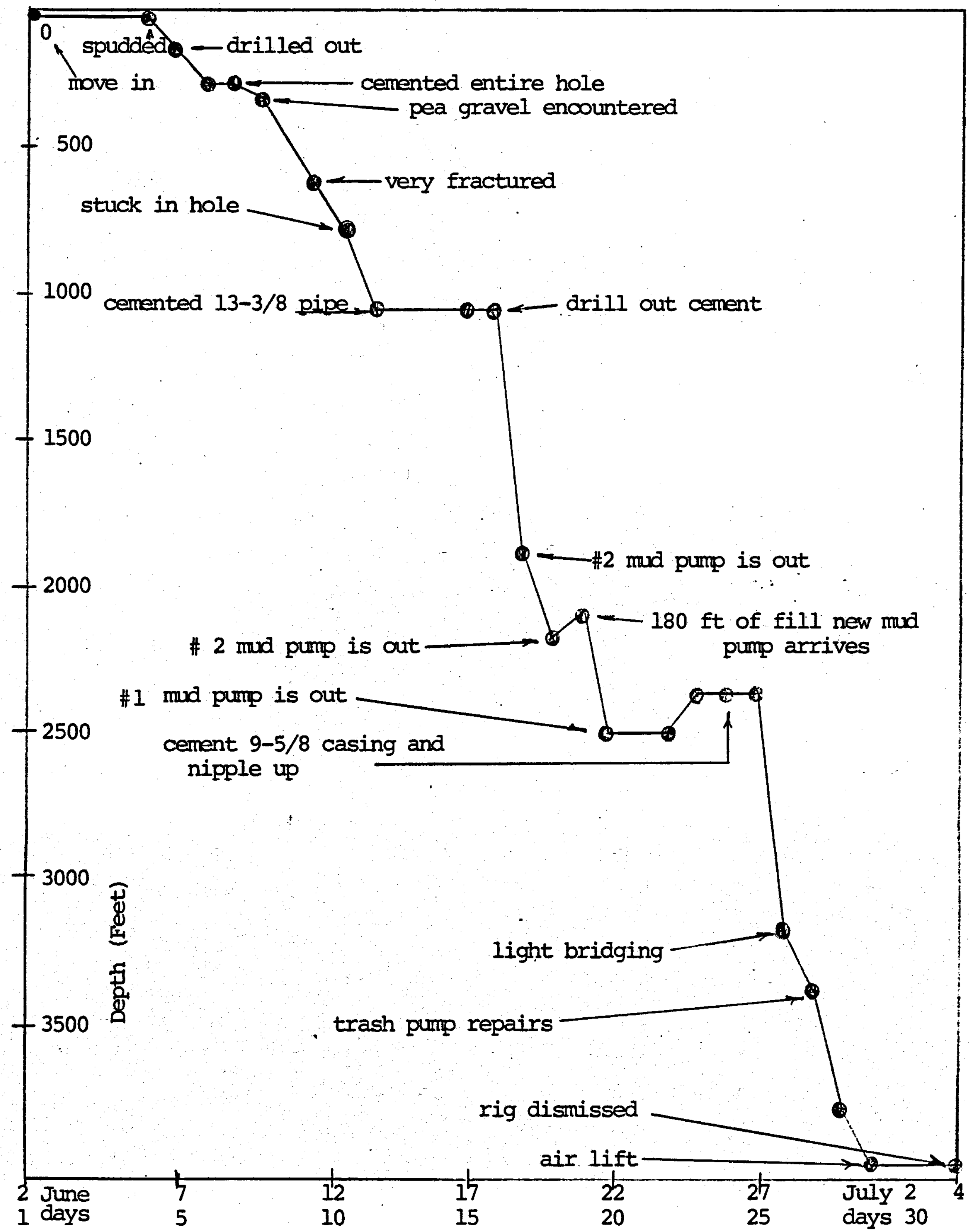


Figure 10, Drilling Activities Chart

3,540 ft. The liner hanger failed to close and seal the cementing ports. In October 1981, a lead packer double seal was installed inside the liner hanger to seal it and was successful. However, an obstruction was still present at the 2,300 ft level. In November 1981, a cable tool rig unsuccessfully tried to clear the well. On April 5, 1982 a cable tool rig with a heavier hammer was able to push the obstruction to the bottom of the well. It was determined at this time that the obstruction was various rubber and cement debre from various attempts to seal the packer. See Appendix D, Daily Drilling Summary, for more detailed information.

8.4.1 Well-Head Configuration

During the drilling below the production casing, a standard double ram (gate and pipe types) and a Hydril bag closure unit, all of 3,000 psi rating were installed on the 9-5/8 inch casing. This was installed on top of a standard 10-inch diameter casing head with two 2-inch nipples with gate valves installed below the flange of the head. See Figure 11, Well Head Drilling Configuration.

There was no need for the Blow-Out-Preventer before reaching the 2,300 ft depth. That depth was only 800 ft deeper than the total depth of the HTW-1 test holes 150 yds away, and temperatures in it were not even 70°F, and there was no artesian flow. However, it was decided to not drill to the original target of 2,500 ft for the production casing, because severe lost circulation created suspicion that the fault (originally targeted to be intersected at 3,000 ft) had already been encountered.

8.4.2 Final Well Head Configuration

Upon completion of the well, the blow-out-preventor was removed. The casing head was on the well, and a flat steel plate was covering the top of the well, bolted into place. See Figure 12, Final Well Head Configuration.

8.4.3 Drill Rig

The drill rig was a Cabot Model 750 with Cabot 2042 draw-works rated at 300,000 lbs capacity. The unit was equipped with two 375 HP engines. The rotary table had an opening 27.5 inch in diameter. The drill pipe was 4.5 inch diameter, 16.6 lb per ft. The substructure placed the Kelly bushing 14 ft above ground level. Reference Appendix C, Drill Rig #75 Equipment for a summary of the drilling equipment.

The unit came equipped with two mud pumps, both Gardner-Denver, one 700 HP the other 500 HP, models GXP16V71T.

For the drilling of the surface and production casing

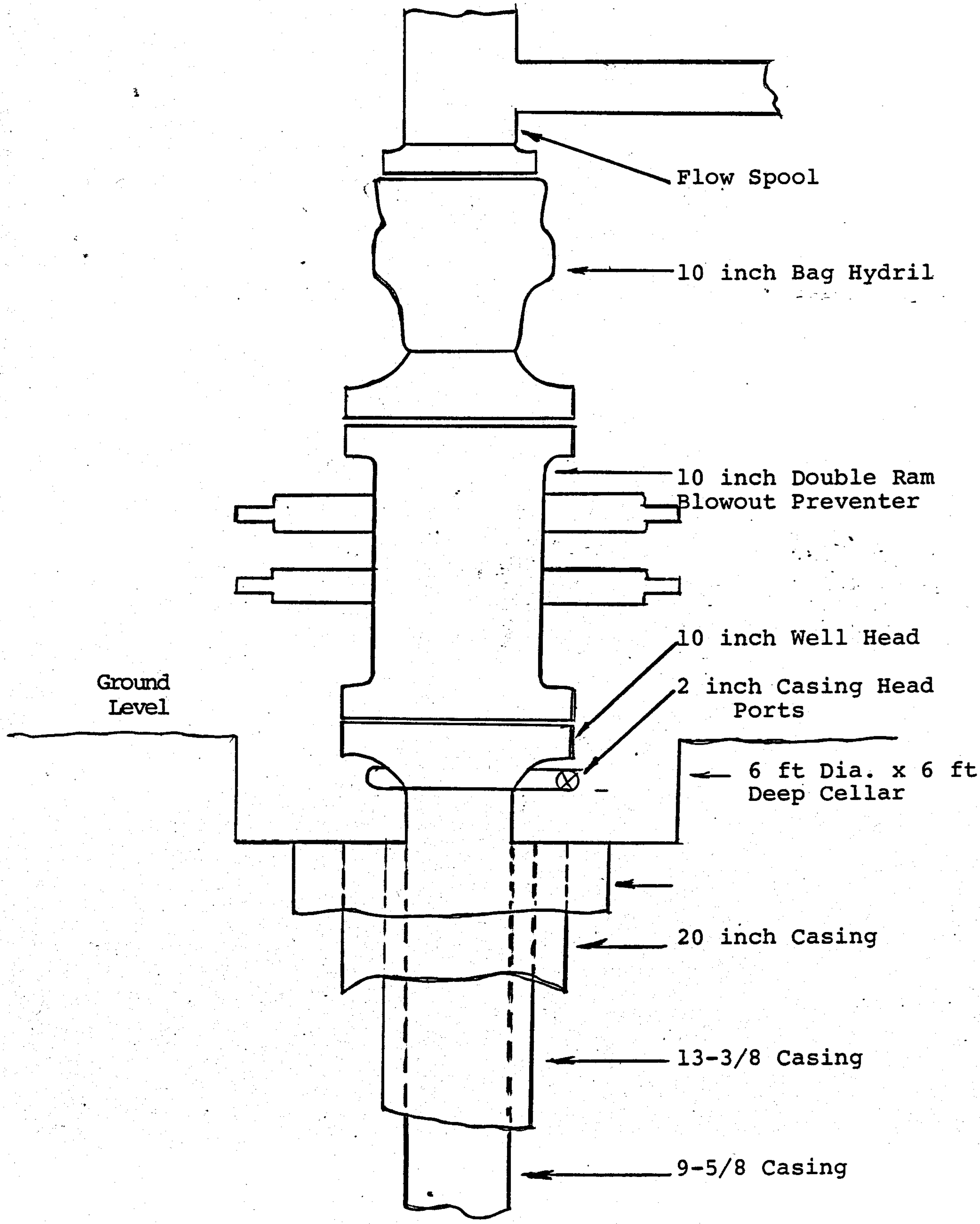


FIGURE 11, Well Head Drilling Configuration

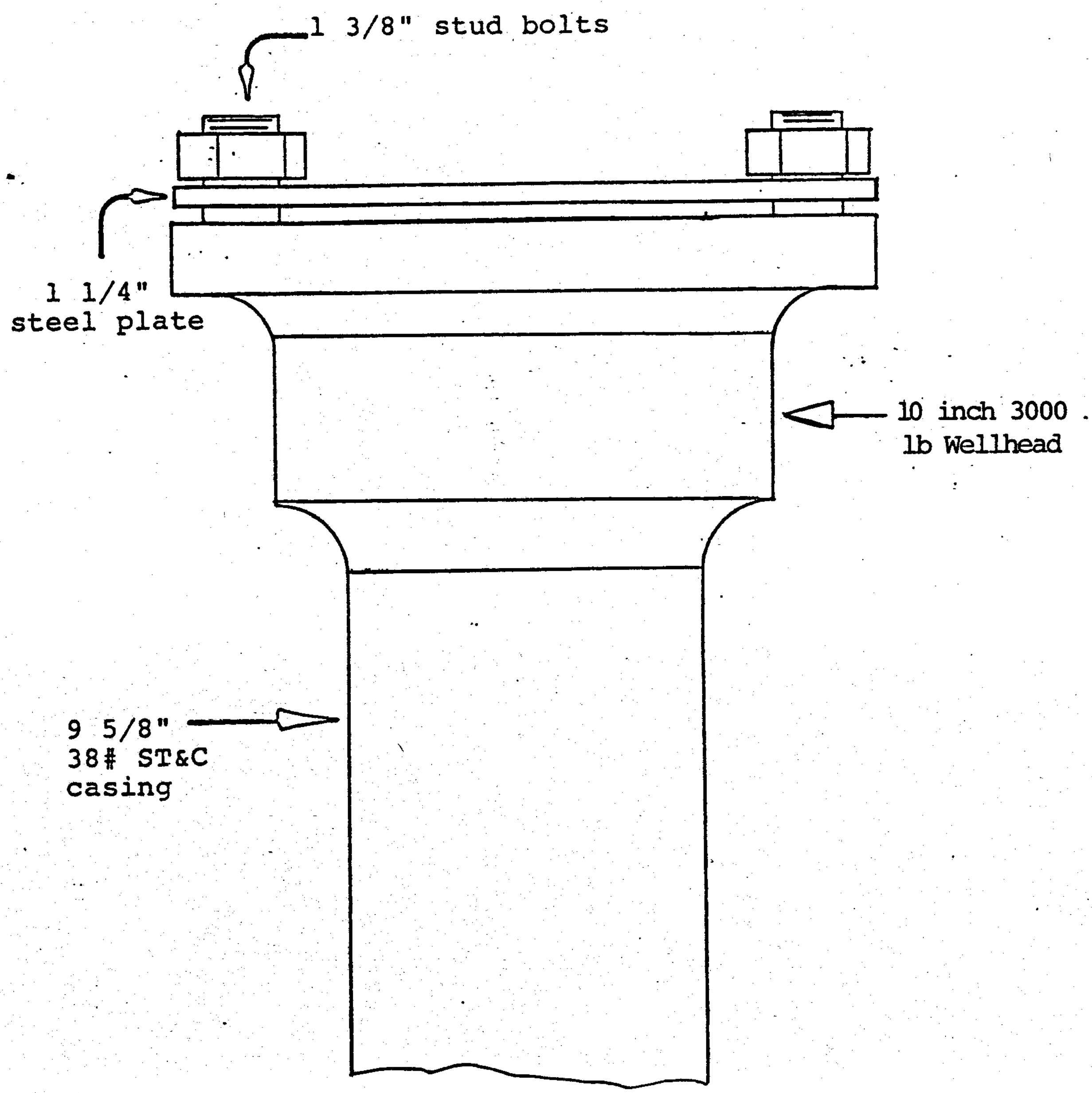


FIGURE 12, Final Well Head Configuration holes, both 8 inch and 6-1/4 inch diameter collars were used. Only the 6-1/4 inch collars were used for the open hole below 2,300 ft.

8.4.4 Drilling Fluids

A standard bentonite mud base was used for the surface hole (17-1/2 inch diameter to 1,006 ft depth KB). Henceforth, the drilling was carried out with pure water, except for an occasional "mud sweep" run at times when it was particularly difficult to bring the cuttings to the surface, and just before installing the production casing. These sweeps also contained some lost circulation material.

Total "mud" used was as follows:

Bentonite-base gel	579 sacks
Lime	39 sacks
Sodium Hydroxide	4 sacks
Mica	29 sacks
Fibre	14 sacks

8.4.5 Drill Bits

The drilling bit record is as follows:

17-1/2 inch	Reed S62J	80 to 1006 ft	174 total hours, drilling about 50% of the time
12-1/4 inch	Hughes J33	700 ft of cement 1006 to 1616 ft	45 hours
12-1/4 inch	Hughes J33	1616 to 2486 ft	44 hours
08-3/4 inch	Security H7SGJ	2486 to 3209 ft	25 hours
08-3/4 inch	Security M89F	3209 to 3793	28 hours
08-3/4 inch	Security M89F	3793 to 3948	12 hours

All depths are with respect to ground level.

The Security M89F bits were tungsten carbide bits. All others were mill tooth bits.

8.5 Completion Method

8.5.1 Conductor pipe

A 24" diameter hole was cut to a depth of 53 ft, using a cable tool rig, driving and drilling the casing simultaneously. This placed the bottom of the pipe below water level. Note: All depths referenced in this section are from ground level unless otherwise stated.

A 22 inch diameter hole was drilled with a cable tool rig from the 53 ft depth to 125 ft depth, and 20 inch diameter casing placed in the hole, but only to 110 ft (as far as it would go). This casing was cemented in place.

8.5.2 Surface Casing

A 17-1/2 inch diameter hole was drilled to a depth of 989 ft, using a mill-tooth bit followed by a reamer and two stabilizers (which were located 30 and 90 ft above the bit). At about the 200 ft level, significant amounts of gravel were encountered. As this gravel was removed to the surface, it tended to jam between the reamers and the basalt which had been drilled through nearer the surface. When the 245 ft level had been drilled, the reamers were removed. At that depth, a 10 cubic yard cement plug was installed in an attempt to stabilize the gravel. A total of $5,500 of mud was used in attempts to stabilize the gravels, and most of this was lost into the basalt formations. Drilling of the 17-1/2 inch hole terminated at the 989 ft level.

The 13-3/8 inch, K55, 68 pound per ft casing was installed. Installation could not go past the 735 ft level, despite efforts to flush (wash) the casing into the hole. Cementing was done with a 700 cubic ft of 50/50 Pos Mix, followed by 1059 cubic ft of Class G cement. This was 176% excess (276% of the required amount), to allow for the possibility of the cement going all the way to the bottom of the 989 ft hole. During the cementing procedure, the rubber plug between the cement and the displacing water became stuck in the cement head, and the cement set up in the pipe. Fortunately, the cement "turned around" just below the casing, and came back up the annulus, reaching the 225 ft level in the annulus. This top 225 ft portion was cemented from the ground through a 1-inch pipe, using 11 cubic yards. The cement within the 735 ft of surface casing had to be drilled out.

8.5.3 Production Casing

Below the surface casing, a 12-1/4 inch bit was used for the production casing hole. Three stabilizers were used, 30 ft apart on the drill string. The drilling fluid was water, except for an occasional mud sweep of 7 bags of bentonite to one bag of lime. These sweeps were needed to bring the cuttings to the surface when the hole became heavily laden with solids.

The production casing hole was drilled to 2,486 ft. Then 9-5/8 inch, K-55, 36 lbs per ft casing was installed to the 2,289 ft level, the deepest the casing could be pushed or washed. Cementing was with 1,338 cubic ft of Class G cement, with 2% calcium chloride accelerator and 6% cellophane flakes. This amount gave 100% excess cement. Nevertheless, the cement level did not get above the 350 ft level in the annulus between the 13-3/8 inch and 9-5/8 inch casing.

8.5.4 Blow-Out Preventor Installation

A 10-inch, 3000 lb, blow-out preventor unit consisting of a double gate (blind and pipe rams) and a bag hydril, was installed. An engineer from the Idaho Department of Water Resources was called to witness the test on the adequacy of the blow-out preventor.

8.5.5 Below the Production Casing

A 8-3/4 inch bit was used to drill below the production casing. No stabilizers were used. A shock sub was installed between the bit and 13, 6-1/4 inch drill collars. Drilling was sporadic when fault zones were encountered. Occasional rapid drilling may have indicated the presence of a lava ash strata, though no such evidence was ever found in the drill cuttings. The drilling in this part of the hole was with water, except for an occasional mud sweep to help remove cuttings from the hole.

At a depth of approximately 3,150 ft, there was considerable lost circulation, with no returns, and massive amounts of water being needed for makeup. This is believed to indicate the massive Snake River Plain fault. Though some returns were obtained below this level, makeup water had to be added throughout the remainder of the drilling. Two large "trash" pumps were used to supply water from the nearby canal.

Beyond the 3,700 ft level, cuttings were not being effectively removed. Apparently they were being lifted part way, then followed the lost circulation flow into the formation. When circulation in the drilling string was stopped, these cuttings would come out of the formation cracks and crevices, and fall back in the hole onto the top of the bit. At the 3,948 ft depth, the drill pipe became tightly stuck. After finally freeing the pipe, the decision was made to discontinue drilling, and logging and flow test the well. Based on those results, a decision concerning the casing of the hole or this discontinuance of the drilling would be made.

8.5.6 Liner

Ten months after the CRC Colorado Well Rig 75 (Cabot Model 750) was released, a small workover rig was brought in from CRC Colorado Well to install a 5-1/2 inch diameter liner (15.5 lb/ft casing) from the bottom of the production casing (2,200 ft, but the liner hanger was placed at 2,208 ft to allow for adequate overlap in case the hanger should slip. See Figure 13, Liner Hanger Details. The liner (casing) shoe was set on the fill, and raised 10 ft before being set in place. A small quantity of cement was then pumped into the bottom of the casing and out around it to anchor it in place and seal downward flow.

The bottom of the liner is at 3,540 ft. Just below the liner is a suspected fracture region with high production capability. This area was then drilled out with a 4-7/8 inch bit, removing the fill all the way to the previous total depth of 3,933 ft. Approximately 10 additional ft of hard rhyolitic rock were drilled with the fragile workover drill string. This additional drilling was quickly terminated because of slow drilling and danger of breaking off the drill string. Some return samples were obtained to identify the rock at that depth. (During the original drilling, no returns were obtained at that depth.) Total depth was established at this time at 3,942 ft.

The liner hanger did not seal, however, for subsequent logging with a flow meter showed nearly the same downward flow in the well as before the liner was installed. It was known at the time that the hanger was set that it had not closed and sealed, for apparently the shear pins which allowed the rubber packer to be compressed and expand radially to fill the hole, had not sheared.

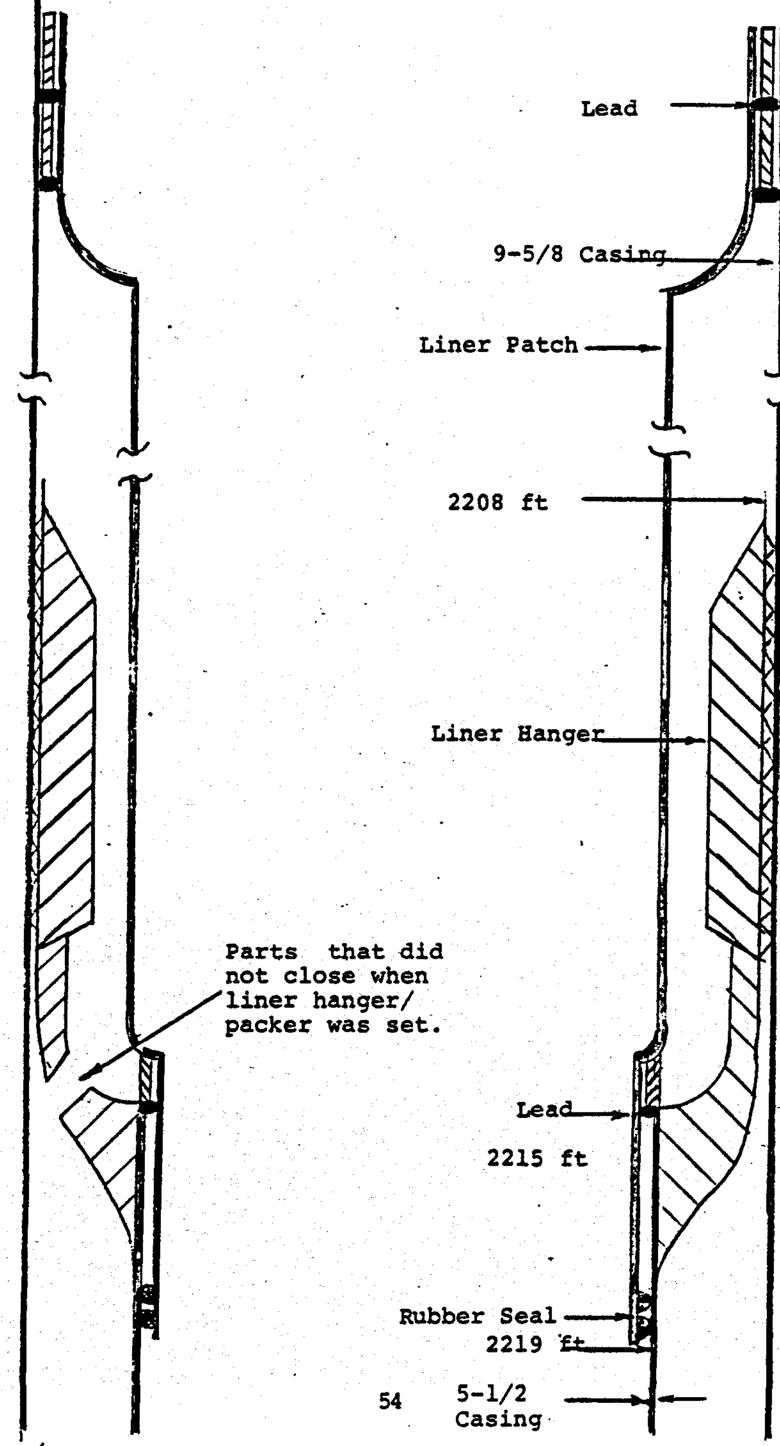
In August 1981 and October 1981, similar attempts were made to seal around the failed packer with two sets of lead packers, inserted and set using a cable tool rig (Rocky Mountain Drilling of Rexburg). On the second attempt the lead packers did the job intended, and sealed all measureable downflow in the well.

Figure 14, Well Casing Profile shows graphically the construction of the well.

NONE OF THE CASING HAS BEEN PERFORATED IN THIS WELL.

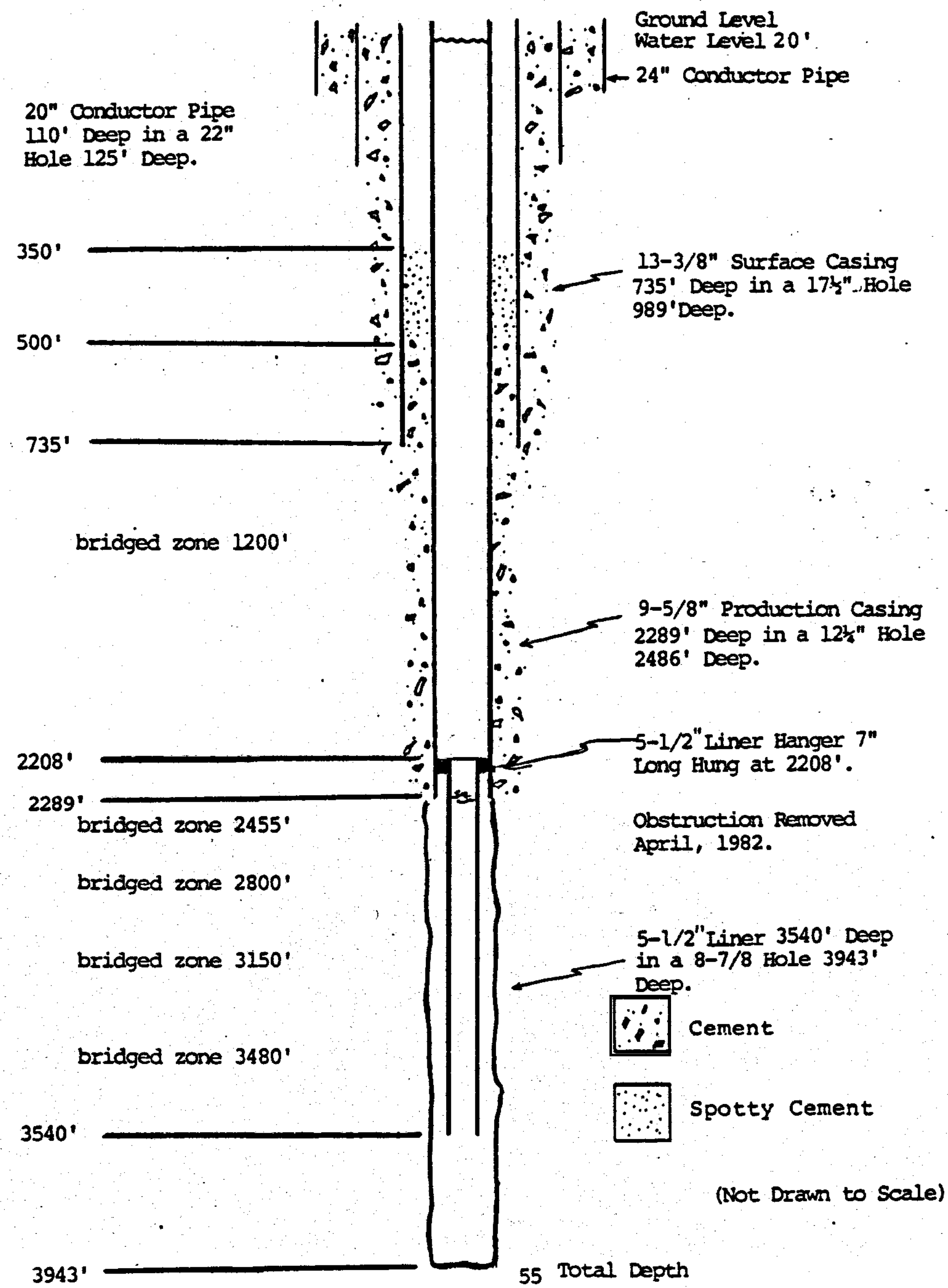
Figure 13

DETAILS OF THE LINER HANGER
AND PATCH TO REPAIR LEAKING PACKER



MADISON COUNTY WELL PROFILE
Figure 14
GEOTHERMAL WELL #1

All Levels Referenced to Ground Level



8.6 Stimulation Method

The well never received "stimulation" in the normal sense. Air was used to pump test the well, but the drawdown did not exceed approximately 20 ft, even when "pumping" at a rate of 600 gallons per minute.

8.6.1 Method and Equipment

The original air lift, with the drill rig still over the hole, was conducted with a 900 cfm, 125 psi compressor, injecting air at the 155 ft level through a 4.5 inch diameter drill pipe.

Subsequent air lifts, after the drill rig was off of the hole, used the same air compressor or a smaller 300 cfm unit. The pumping was done from the 140 ft level through a 2 inch pipe.

Total air lift pumping time was extensive to be certain that all cold drilling water was removed from the well and all downward flowing water entering from the 2,300 ft zone just below the casing, was partially removed from the well.

Pumping periods were as follows:

> Julyl through July 4,1980 - approximately 600 gpm with a 850 scfm compressor.
>
> April 12 through 16,1981 - approximately 600 gpm for a total of 55 hours of pumping.

After installing installation of the liner in May 1981.

> June 10,11, 18, 19, 1982 - 31 hours total,approximately250 gallons per minute with a 300 scfm compressor.

After finally sealing off the failed packer:

> October 20through 23, 1982 - approximately140 gallonsper minute for 76 hours with a 300 scfm compressor.
>
> April 12 through April 16, 1982 - approximately 300 gpm for 62 hrs with a 300 scfm compressor.

The well was logged after most of these air lifts (pumping) and in no case were temperatures above 72°F found, even at the bottom of the well. Near the surface, the water temperatures were a constant 53°F. Static water levels varied, throughout the two year period that these were monitored, from 12 to 18 ft below ground level. These were considered to be normal seasonal variations. See

Appendix F, Air Lift Testing for additional information.

The only time that activity in the well affected the water level was when the failed packer was finally sealed off on October 14, 1981. Then the water level dropped approximately 1 ft.

The results indicate that the formations are a prolific producer of cool water. Production rates from the bottom of the liner(below 3,540 ft) were a bit less than from higher levels, such as the extremely high productive zone near the 2,300 ft level. The difference is believed to be largely the result of pressure drop in the 5-1/2 inch liner, rather than being indicative of different prodictivity potential between these zones.

8.7 Well Logging Summary

All geophysical logging at the Madison County wells, both the small diameter test wells and the deep exploratory well, was done by Energy Services and the US Geological Survey (the group at the Idaho National Engineering Laboratory).

The USGS had considerable interest in the deep well, particularly because of the downward flow between the 2,300 and 3,600 ft depths. The USGS team at the INEL is assigned the responsibility of investigating (and monitoring) the aquifer, particularly around the waste disposal operations at the INEL. Data from the deep well near Rexburg gave information on the vertical movement (or tendency for movement) of the water within the aquifer.

Interpretation of the drill cuttings was done by geologists at Energy Services and Ricks College. Samples were collected at least every 30 ft of drilling.

8.7.1 Logs Run

Numerous temperature logs were run on the well. In addition, a flow meter log was run once below the production casing (2,300 ft on down) and several times within the liner hanger near the top of the production casing.

In addition, drilling fluid return samples were measured for conductivity and certain key dissolved chemicals. The latter gave no real clues about permeability (the result of water entry into the well) because the fluids in the well differed little from the run-off water that was used for the drilling fluids.

Table 5 is a composite list of all of the temperature logs run on the well. These logs are displayed in Appendix E.

TABLE 5
WELL LOGGING SUMMARY

Appendix E Figure No	Type of Log	Depth ft. (m)	Date	Comments
E01	Temp.	1210 (369)	6-22-80	Bridged
E02	Temp.	1210 (369)	6-22-80	Bridged
E03	Temp.	2165 (660)	6-25-80	Cement + 4 hr
E04	Temp.	656 (200)	6-26-80	Cement + 11hr
E05	Temp.	3149 (960)	6-28-80	Bridged
E06	Temp.	3332 (1016)	6-30-80	Bridged
E07	Temp.	3412 (1040)	7-30-80	Bridged
E08	Temp.	2844 (867)	7-04-80	Bridged
E09	Temp.	2525 (770)	7-05-80	Bridged
E10*	Gamma	2304 (702)	7-13-80	Bridged
E11*	Self.Pot./ Resistivity	2800 (853)	7-13-80	Bridged
E12*	Temp./ Fluid Resistivity	2400 (732)	7-13-80	Bridged
E13*	Caliper	2846 (867)	7-13-80	Bridged
E14*	Flowmeter	2800 (853)	7-13-80	Bridged
E15	Temp.	3950 (1204)	6-02-81	Liner set
	Temp.	3660 (1116)	6-11-81	After test
E16*	Gamma	3900 (1189)	6-04-81	Liner set

(Between July and October,1981, a number of flowmeter and temperature logs were made in the limited area between 2150 ft and 2300 ft, to determine if attempts to seal the failed packer had been successful.)

E17	Temp.	3900 (1189)	4-06-82	
	Temp.	3946 (1200)	9-03-82	

* These logs were run by the US Geological Survey logging truck from the Idaho National Engineering Laboratory.

All other logs were run by Energy Services.

8.7.2 Lithology Logs

Drill cuttings were obtained every 30 ft, bagged into three sets and labeled. These were distributed, by the engineer (Energy Services), to Ricks College, and to the University of Utah Research Institute. Independent analyses of these cuttings were made by Dr. Glen Embree of Ricks College and by Roger Stoker of Energy Services. A composite of their interpretations is shown in Figure 15, Lithology Log.

In the upper portion of the hole, there was much gravel, and considerable basalt. Below the 900 ft level, the formations were primarily basalt with some lava ash or other fine and soft material appearing in thin strata.

8.7.3 Porosity and Geophysical Logs

The USGS logging truck took natural gamma, overall resistivity, fluid resistivity, self-potential, and flow meter logs. These are displayed in the 18 figures of Appendix E. There was an occasional location were an indicated change in lithology did not concur with the log interpretations from the drill cuttings. However, this situation should not be unexpected, for there was mixing of the drill cuttings from various levels during much of the drilling operation.

8.7.4 Temperature

The numerous temperature logs that were taken were largely in the hope of receiving some clue that cold fluids, used in drilling or flowing down the hole from the 2,300 ft level, were eventually being removed and that geothermally heated water of significant temperatures was on its way into the well bore. The anticipated signals never came, however. The temperature logging tools of both the USGS and Energy Services had an absolute accuracy of approximately 1°F, but relative accuracy and sensitivity of 0.02°F. Figures displaying these temperature logs are in Appendix E.

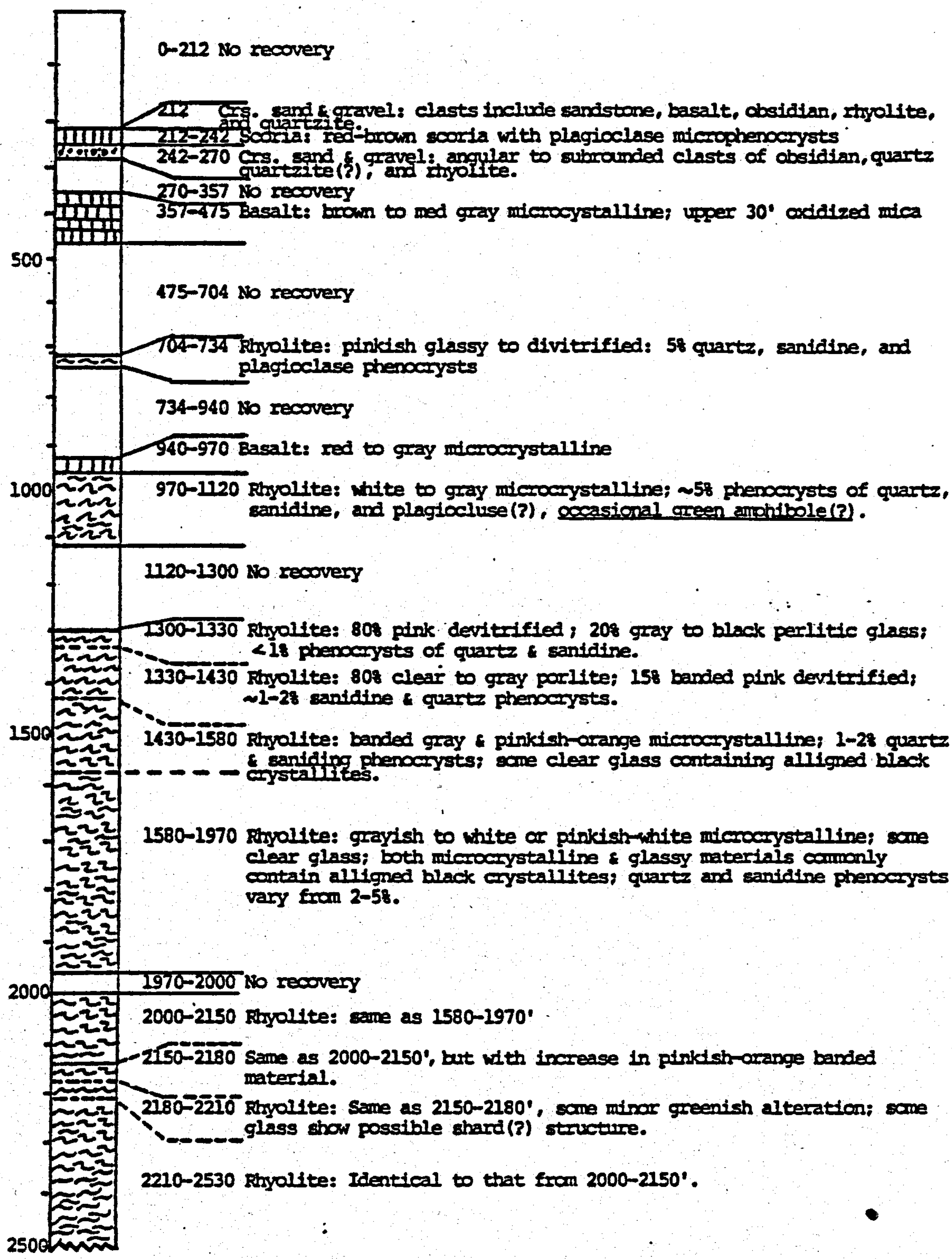
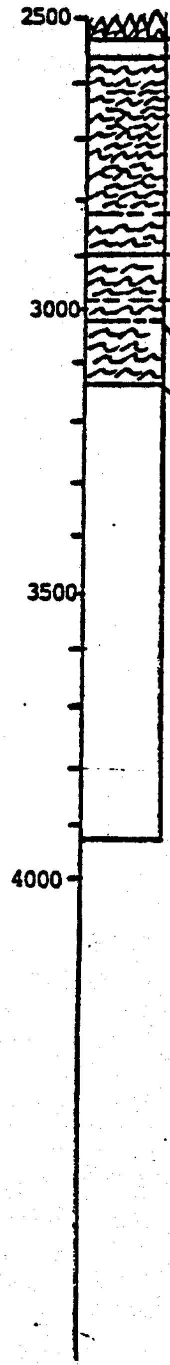


Figure 15 Lithology Log



2530-2550 No recovery

2550-2840 Rhyolite: Identical to that from 2000-2150'

2840-2900 Rhyolite: Same as above except ~20% gray to black banded perlitic glass

2900-2930 Rhyolite: green, altered, microcrystalline, porous, and sucrosic; much vapor phase crystalization.

2930-3020 Rhyolite: orange devitrified and black obsidian; ~5% quartz, and sanidine phenocrysts.

3020-3140 Rhyolite: maroon and reddish-brown microcrystallinge; glass and orange devitrified fractions; some white clay alteration; ~5% quartz and sanidine phenocrysts

3140-3933 No recovery

3933 T.D.

Rhyolite 1300-2900': Thickness, lack of convincing hard structure in glass, alignment of crystallites, banding and zonation, and consistency of phenocryst content suggest that this is a single rhyolite flow.

Rhyolite 2900-3140': This appears to be a single unit with typical rhyolite flow zonation.

2180-2210': The change in lithology and presence of alteration in this zone along with the presence of rocks above and below, which are identical to each other, suggest that this may be a fault zone. It is therefore possible that part of the major rhyolite flow may be repeated in this section.

Figure 15 Lithology Log (continued)

9.0 RESOURCE TESTING

The testing of the resource was done by air lifting the fluids from the top of the well. These tests are described in detail in Section 8.6, Stimulating Methods.

It is not possible to accurately deduce a productivity index from this data, for air lifting does not permit the measurement of the static water level as one can do in a pumping operation. However, by quickly observing the recovery rate after pumping (using air) at the rate of 600 gallons per minute, it was concluded that drawdown never exceeded 20 ft. When the liner was installed, the productivity appeared to drop slightly. However, even with the liner requiring that fluids be drawn from below the 3,540 ft level, the well is still a very prolific producer of 70° F water. The specific productivity was in the range of 20 gallons per minute per foot of drawdown. These results imply that a pump set at a 100 ft depth (85 ft below the static water level) should be able to produce 600 gal per minute.

If the liner is cut out of the well and removed, or perforated around the 2,300 ft level, it is likely that the well could be pumped at over 1,000 gallons per minute, basically up to the limit of the largest size of pump that could be placed inside of the 8-7/8 inch diameter casing.

Section 8.6 describes the details of the air lifting testing, and these will not be repeated here.

Subsequent sections specified for the Department of Energy's PON final report deal with system design, construction and operation. Sincse the project was termi;nataed at the completion of the production well, these sections have no application to this report and will not be included.

MAD-REFE
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REFERENCES

1. Madison County Energy Commission, and Rogers Food, Inc., Madison County Geothermal Project Proposal (Vol. 2), Report No. M.C.E.C. - 78, July 1978. (53 Pages).

2. Energy Services, Inc., Evaluation of the Geothermal Potential Around Rexburg, Idaho, Report No. DOE/FC07/27028-3, Cooperative Agreement No. DE-FC07-79ET27078, April 30, 1980 (154 Pages).

3. Energy Services, Inc., Environmental Report for Madison County, Idaho Geothermal Project., Report No. DOE/ET/27028-1, Cooperative Agreement No. DE-FC07-79ET27028, September 1979 (106 Pages).

APPENDIX A
REXBURG AREA WATER WELL PROFILES

Well No.	Owner	Location			Well Depth (ft)	Static Water Level (ft)	Reported Temperature (°F)	Max. Down-hole Temp. Spring 77 (°F)
1	Myrtle Egbert	T7N	R40E	23dd	160	90	54	
2	Brad Ostermiller	T7N	R40E	23dd	136	75	54	
3	Meyers Brothers	T7N	R40E	23cd	153	70		
4	Miles Allen	T7N	R41E	27ac	245	181	50	58
5	Roland Schaat	T7N	R40E	33aa	187	129	53	
6	Bill Hollist	T7N	R40E	36dc	145	70	54	
7	D. P. Hathaway	T7N	R41E	32da	220	136	54	
8	Buck Hathaway	T7N	R41E	32dd	206	134	52	
9	City of Newdale	T7N	R41E	34dd	274	233	97	90
10	City of Newdale	T7N	R41E	34dd	385	300		81
11	Don Staker	T7N	R41E	35cd	400	285	87	70
12	Wallace Little	T7N	R41E	35dd	400	320		
13	Sugar City	T6N	R40E	4da	195	23	54	
14	Clair Robinson	T6N	R41E	2bc	250	271	96	
15	Val Schwendiman	T6N	R41E	2ab	300	300	78	53
16	Craig Wood	T6N	R41E	10bb	265	218		75
17	Don Staker	T6N	R41E	16dd	283	210	51	
18	John H. Smith	T6N	R40E	21db	650	248		
19	John H. Smith	T6N	R40E	21da	204	120		
20	Kim Summers	T6N	R40E	22da	250	200	53	53
21	Parkinson Brothers	T6N	R40E	23bb	249	155	52	
22	Ralph Huskinson	T6N	R40E	24ba	317	294	50	47
23	Summers Brothers	T6N	R40E	24ab	350	310		46
24	Huskinson Brothers	T6N	R41E	18db	312	198	54	
25	Huskinson Farms	T6N	R41E	19dc	222	165	53	52
26	Staker & Walters	T6N	R41E	22ac	435	335		
27	Staker & Walters	T6N	R41E	22ac	775	402		
28	Laird Robinson	T6N	R41E	23cb	545	440	56	

Appendix A
(CONTINUED)

Well No.	Owner	Location			Well Depth (ft)	Static Water Level (ft)	Reported Temperature (°F)	Max. Downhole Temp. Spring 77 (°F)
29	Wallace Robinson	T6N	R41E	14cc	751	480	53	
30	Wallace Robinson	T6N	R41E	14dd	915	571		
31	City of Rexburg	T6N	R40E	29ccb	305	203	56	
32	Bryon Harris	T6N	R40E	28bbb	320	285	53	
33	Dick Smith	T6N	R40E	28cc	450	355		60
34	Frank Sommers	T6N	R40E	27cd	475	314		58
35	Kelly Summers	T6N	R40E	27ad	342	260	54	56
36	Sommers Brothers	T6N	R40E	26ab	400	300	53	58
37	David Beesly	T6N	R41E	30bd	471	308	54	
38	Bowen and Thomasen	T6N	R40E	31da	360	328		
39	City of Rexburg	T6N	R40E	31dad	388	324		
40	Owen Slaugh	T6N	R40E	32aa	338	299	50	
41	Sommers	T6N	R40E	35bd	1300	400		58
42	Myron Lewis	T5N	R40E	4bbb	442	396	54	
43	Jim Howe	T5N	R40E	3db	430	380	59	55
44	Jim Howe	T5N	R40E	3ca	430	360	59	53
45	Jensen	T5N	R40E	1bc	750	440		55
46	Jensen	T5N	R40E	1bc	700			
47	Mark Ricks	T5N	R40E	7cc	125	86		
48	Mark Ricks	T5N	R40E	6dc	220	140		61
49	Mark Ricks	T5N	R40E	5bc	320	260		64
50	Brent Arnold	T5N	R40E	7dda	106	17	53	
51	Webster Brothers	T5N	R40E	9cc	460	401	53	70
52	Clint Hoopes	T5N	R40E	9bb	420	350	52	
53	Jensen Brothers	T5N	R40E	11dd	562	350	53	56
54	Jensen Brothers	T5N	R40E	12db	1000		68	
55	George Brown	T5N	R41E	8ac	863	500	53	70
56	Steve Wood	T5N	R41E	8ad	600	366	54	
57	City of Rexburg	T6N	R40E	20cc	160			
58	City of Rexburg	T6N	R40E	30bd	172			
59	City of Rexburg	T6N	R40E	29bb	155			
60	Ross Parkinson, Jr.	T6N	R41E	33cb	930			
61	Gary Ball	T5N	R40E	15aa	1180	430		63
62	Dick Smith	T6N	R40E	33cc	450			

Well No.	Owner	Location			Well Depth (ft)	Water Level (ft)	Reported Temperature (°F)	Max. Downhole Temp. Spring 77 (°F)
63	Barn Ward	T7N	R42E	32ca	820	500		97
64	Greg Wood	T6N	R41E	10db	455	280		80
65	Wallace Robinson	T6N	R41E	15ab	550	300		60
66	Wallace Robinson	T6N	R41E	14db	700	580		51
67	Garner Simmons	T7N	R41E	26ac	283	230		71
68	R. Pocock	T6N	R41E	7bc	106			48
69	H. B. Wilding	T7N	R41E	33cc	200	114		51
70	Teton City	T7N	R41E	31db	240			66
71	Dry	T6N	R41E	7dd	300			55
72	Graham	T7N	R40E	12cd	130			50
73	Blair Cook	T5N	R40E	4ba	500	320		53
74	Darrel Neville	T6N	R40E	29cd	450	300		57
75	Del Raybould	T5N	R40E	4aa	500	340		59
76	Jim Howe	T5N	R40E	2bb	500	380		61
77	Merrill Pincock	T6N	R41E	16dc	400	260		51
78	David Beasley	T6N	R41E	31ab	700	630		48
79	City of Rexburg	T6N	R40E	31da	640	620		63
80	Mark Ricks	T5N	R40E	8bc	580			69
81	Evans	T6N	R40E	16aa	~ 50			48
82		T6N	R41E	27da	620	500		53
83	Teton City	T7N	R41E	31da				
84	Rexburg Golf Course	T6N	R39E	24cd				
85	Blaine Cook	T6N	R40E	31da				

Appendix A

REXBURG AREA WELL TEMPERATURE DATA (°F)

WELL NO.	ELEV (ft) 4960	ELEV (ft) 4880	ELEV (ft) 4800	ELEV (ft) 4720	ELEV (ft) 4560	ELEV (ft) 4400	ELEV (ft) 4200
4			57.2				
9					90.0		
10			59.0	60.4	80.6		
11	66.4	68.0	69.3	69.6			
15	56.6	58.9	62.2	62.7			
16			75.2				
20	52.3						
22	46.0	45.8	48.2	46.8			
23		46.4	46.0				
25	45.9	51.4	51.9				
33	49.6	51.1	59.2	59.6			
34	50.2	52.6	57.6				
35			56.1				
36		52.2	53.8	58.1			
41	45.9	48.7	51.1	51.9	52.5	52.5	58.0
43	48.0	49.5	54.9	55.0			
44		51.4	52.1	52.7			
45	45.0	46.1	53.8	54.4			
48		51.8	61.1				
49	53.8	59.5	64.0	64.2			
51	63.9	66.0	70.3				
53	55.4	55.8					
55	53.3	57.2	62.8	63.7	68.9	69.5	
61	50.7	62.1	62.7				
63	61.5	69.4	76.1	82.6	85.4	94.5	96.8
64	63.0	62.9	79.3	79.7			
65	59.1	59.8	59.9	60.1			
66	52.5	52.3	52.2	51.4			
67	69.4	70.8	71.0	71.1			
68				66.0			
69			50.5				
70				48.0			
71		56.3	56.5	56.6			
72			50.0				
73	47.0	50.2	52.1	52.7			
74	49.6	53.2	55.2	56.2	56.5		
75	43.7	47.5	55.0	58.6			
76	50.2	51.2	54.9	58.3	60.8		
77	41.4	45.1	48.9	50.0	50.9		
78		46.4	46.8	46.8	46.9	47.5	
79		49.4	60.1	60.8	62.8		
80			68.9				
81			48.0				
82	51.7	51.0	52.7				

NOTE: Temperature below well depth approximated by assuming geothermal gradient of 1.5°F/100 ft. added to bottom hole temperature.

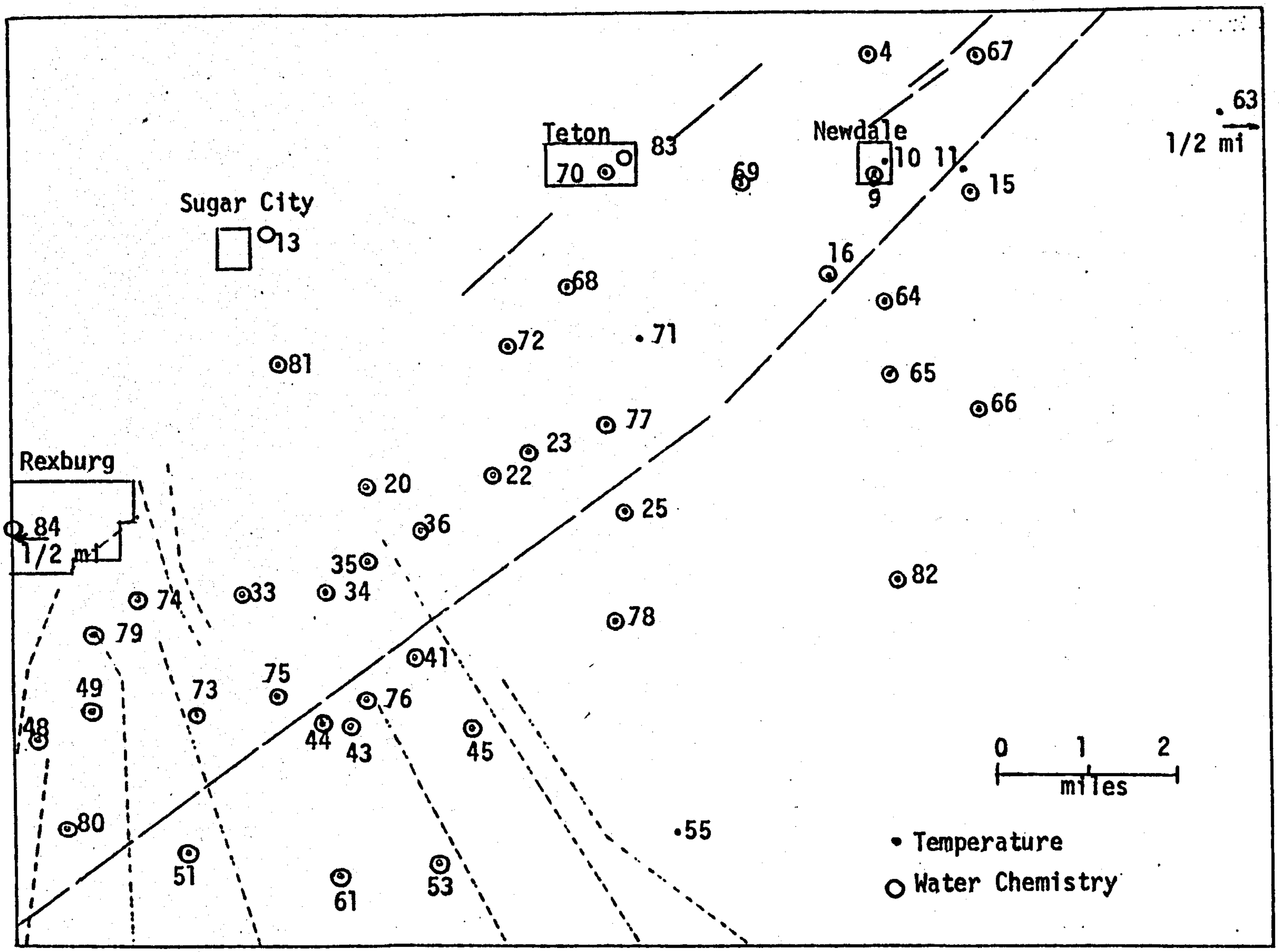

Figure Al Rexburg Area Water Well Locations

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FORSGREN, PERKINS & ASSOC., INC.
350 N. 2nd E.—Rexburg, Idaho 83440

Appendix B

Identification No. 22-7283
Application No.

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES
APPLICATION FOR PERMIT

APPROVED

To Appropriate the Public Waters of the State of Idaho
(TYPE OR PRINT IN INK)

1. Name of applicant Madison County Phone:
post office address Court House Rexburg, Idaho
2. Source of water supply Ground Water which is a tributary of
3. a. Location of point of diversion is NW ¼ of SE ¼ of Section 20 Township 6 N
Range 40 E B.M. Madison County; additional points of diversion if any:

b. If water is not consumed, it will be discharged into Well at a point in NW ¼
of SE ¼ of Section 20 Township 6 N Range 40E B.M.
4. Water will be used for the following purposes:
Amount 2 (cfs or acre-feet per annum) for space heating purpose from Jan. 1 to Dec. 31 (both dates inclusive)
Amount (cfs or acre-feet per annum) for purpose from to (both dates inclusive)
Amount (cfs or acre-feet per annum) for purpose from Jan. 1 to Dec. 31 (both dates inclusive)
5. Total quantity to be appropriated:
a. 2 cubic feet per second and/or
b. acre feet per annum.
6. Proposed diverting works:
a. Description of ditches, flumes, pumps, headgates, etc. 12" Well, Pump and Motor adequate for 2 CFS or Less and Pipelines (supply and return)

b Height of storage dam feet, active reservoir capacity acre feet; total reservoir capacity acre feet, materials used in storage dam:
Period of year during which storage will occur (Mo. Day) to (Mo. Day) inclusive.
c. Proposed well diameter is 12 inches; proposed depth of well is 2,990 feet.
7 a. Time required for the completion of the works and application of the water to the proposed beneficial use is 5 years.
b Estimated construction cost is $ 80,000
8 Description of proposed uses:
a. If water is not for irrigation: See item 8 b.
(1) Give the place of use of water: ¼ of ¼ of Section Township
Range B.M.
(2) Amount of power to be generated: hp under feet of head.
(3) List number of each kind of livestock to be watered

(4) Name of municipality to be served Rexburg or number of families to be supplied with domestic water
(5) If water is to be used for other purposes describe: Space Heating

b. ~~Where it is for irrigation,~~ Refer to item 8 a. indicate acreage in each subdivision in the tabulation below:

TWP.	RANGE	SEC.	NE¼ NE¼	NE¼ NW¼	NE¼ SW¼	NE¼ SE¼	NW¼ NE¼	NW¼ NW¼	NW¼ SW¼	NW¼ SE¼	SW¼ NE¼	SW¼ NW¼	SW¼ SW¼	SW¼ SE¼	SE¼ NE¼	SE¼ NW¼	SE¼ SW¼	SE¼ SE¼	TOTALS
6N	40E	19									X	X	X	X	X	X	X	X	
		20									X	X	X	X					
		29					X	X	X	X	X	X	X	X					
		30	X	X	X	X	X	X	X	X	X	X	X	X	X	X			

Total number of acres to be irrigated

c. Describe any other water rights used for the same purposes as described above

9. a. Who owns the property at the point of diversion Gene W. Palmer & Clara Ann D. Palmer

b. Who owns the land to be irrigated or place of use City of Rexburg

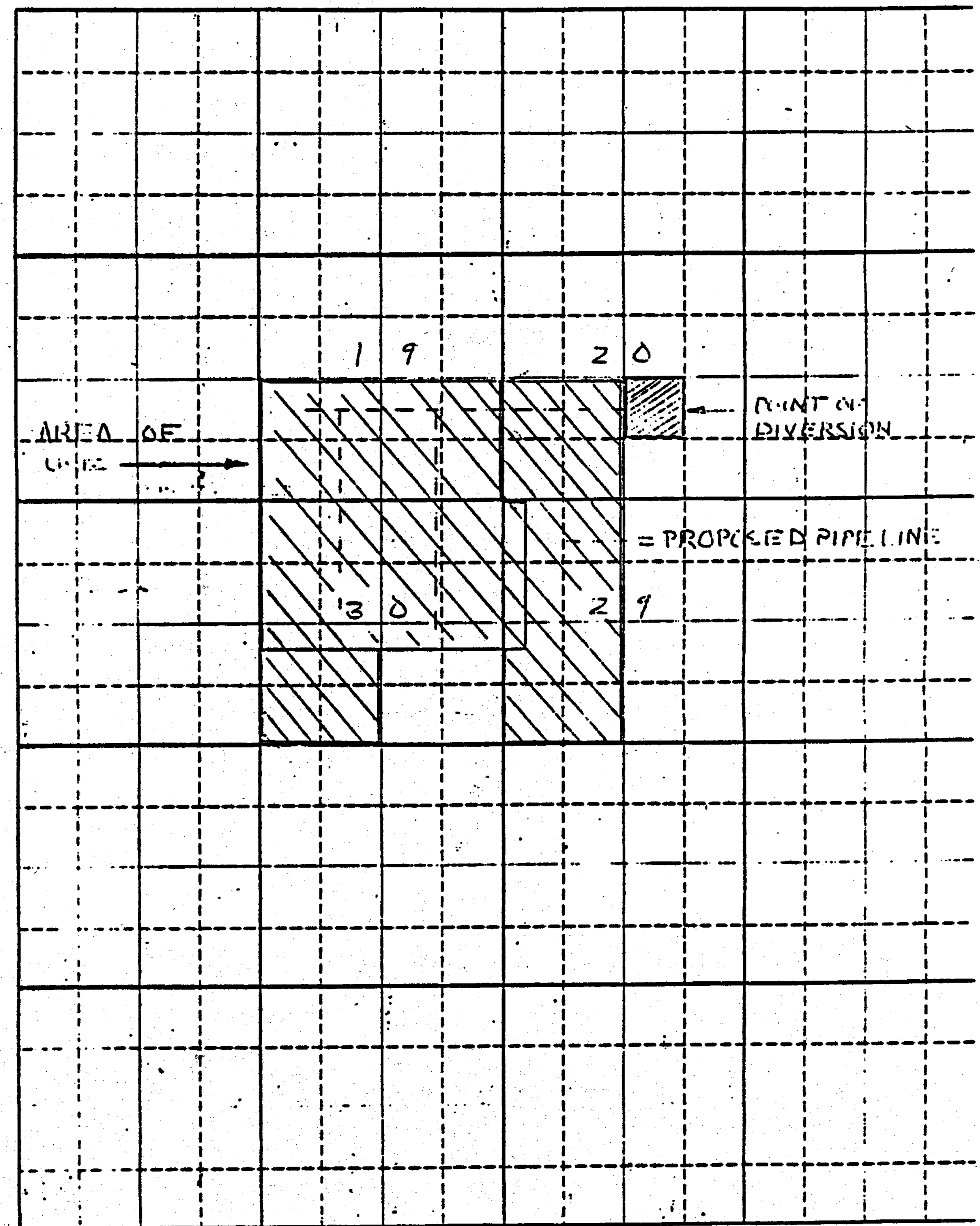
c. If the property is owned by a person other than the applicant, describe the arrangement enabling the applicant to make this filing Geothermal Hot Water Lease Agreement

10. Remarks Hot water from this well is to be used for space heating in Rexburg. Indications from hydrology and geology are that temperatures of approximately 150°F exist at 2,500 to 3,000 ft. The suspected layering of sediments and basaltic or tuff at that depth would yield reasonably permeable rock reservoirs. The drilling of the well is considered somewhat exploratory, but the well is being designed for conversion into a useful production well, with pump, if the desired resource is found. The applicant is also applying for a cost-sharing grant from the U.S. Department of Energy so as to minimize the financial risk to this local government body. That application is being filed under U.S. Department of Energy RFP EG-78-N-03-2047, and must be submitted by July 18, 1978.

The well will probably be designed with 20 inch conductor pipe, then 13 3/8 surface casing through the loose gravels and domestic aquifer(to about 500 ft.) Drilling beyond this point would proceed as if it were exploratory. If successful, the well would be finished with 9 5/8 inch casing to pump setting depth, and smaller diameter casing below as needed.

Appendix B

11 Map of proposed project: show clearly the proposed point of diversion, place of use, section number, township and range number.



Scale: 2 inches equal 1 mile

BE IT KNOWN that the undersigned hereby makes application for permit to appropriate the public waters of the State of Idaho as herein set forth.

(Applicant)

Chairman, Madison County Board of Commissioners

(7.4-A1)

Proposed Priority 7-28-78

Appendix B

7-28-78 11:30 A.M

Received by BP Date 6-30-78 Time 3:00 PM

Preliminary check by EMC Fee $35.00

Receipted by BP Date 6-30-78 # 11444

Publication prepared by CW Date 8-04-78

Published in Standard Journal

Publication dates Aug 10 & 17-1978

Publication approved D1 Date 9-15-78

Priority reduced to ________ Reason ________

Protests filed by: ________

Copies of protests forwarded by ________

Hearing held by ______ Date ________

Recommended for approval denial by EMC

ACTION OF THE DIRECTOR, DEPARTMENT OF WATER RESOURCES

This is to certify that I have examined Application for Permit to appropriate the public waters of the State of Idaho No. 22-7283, and said application is hereby APPROVED.

1. Approval of said application is subject to the following limitations and conditions:

   a. SUBJECT TO ALL PRIOR WATER RIGHTS.

   b. Proof of construction of works and application of water to beneficial use shall be submitted on or before November 1, 19 83.

   c. Other: SEE ATTACHMENT A

2. Denial of said application is for the following reasons: ________

Witness my hand this 7 day of November 19 78.

DIRECTOR

(7.4-A1)

CONDITIONS OF APPROVAL

Permit No. 22-7283
Attachment A

C-1 A well construction prospectus shall be submitted to the Department before drilling is started. The prospectus must describe specifically the proposed casing program and well construction including casing size, thickness, length of conductor, surface, and production pipes; proposed grouting procedures, safety devices, valving, and other measures designed to conserve and protect the groundwaters.

C-2 All well logs, including lithologic, shall be submitted to the Department.

C-3 A notice of intent to drill shall be submitted to this Department at least five (5) working days prior to the start of drilling.

C-4 Blow-out prevention equipment shall be installed in compliance with Rules and Regulations and Minimum Well Construction Standards for Geothermal Resources. The equipment shall be pressure tested when installed and the Department shall be notified five (5) days prior to the test.

C-5 If the well is to be abandoned, a notice of intent to abandon shall be submitted to this Department at least five (5) days prior to beginning abandonment procedures.

C-6 A $10,000 bond indemnifying the State of Idaho, conditioned upon the performance of the duties required by this permit and the proper abandonment of the well, shall be submitted to this Department prior to drilling.

C-7 Prior to the production of any waters, this Department shall be notified and be given complete information as to the method of disposal of these waters. Written approval of the disposal methods must be issued by this Department prior to this production. Any disposal of these waters by means of injection wells is subject to the geothermal injection well standards and to applicable filing requirements.

Form 4003-1
5/78

Appendix B

Geothermal Application No. 2-/ /.K-

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

MAR 31

APPLICATION FOR PERMIT TO DRILL FOR GEOTHERMAL RESOURCES

1. Name of applicant MADISON COUNTY ENERGY COMMISSION

Post office address P.O. BOX 396, MADISON COUNTY COURT HOUSE, REXBURG, ID 8344

If partnership, joint-venture, association, or unincorporated group, attach names and places of domicile of partners or persons. If corporation, attach list of corporate offices and their place of domicile, and the names and place of domicile of any person owning thirty percent (30%) or greater interest in the corporation. Also give:

a. Place of incorporation and date NA

b. Principal place of business MADISON COUNTY

c. Location of home office REXBURG, ID

d. Is applicant making application as an agent for another person, corporation or entity? If so, state name, address, and interest of your principal.

e. Designation of agent residing in the State of Idaho

2. Location of proposed well

NW ¼ NW ¼, Section 31, Township 6N, Range 40E, B.M.

Well number or well name Madison Geothermal #1

3. Type of well: ☒ Exploration ☒ Production ☐ Injection

4. Well construction:

Describe specifically or attach information pertinent to the proposed casing program, and well construction including casing size, thickness, length of conductor, surface and production pipes; proposed grouting procedures, safety devices, valving, and other measures designed to conserve and protect the geothermal resource and ground water of the state. 20 inch conductor pipe to approximately 60 feet, cemented. 13 3/8 inch oil field or 14 inch water-well surface casing to at least 500 feet, cemented if oil field, drill and drive if water well (but it will be cemented to conductor pipe leaving uncemented top 5 feet for possible cellar construction. 9 5/8 inch oil field casing to a nominal 2,500 foot depth, either brought back to surface or hung from surface casing with approximately 100 foot overlap.

5. If the proposed well is for exploration or production, explain the means by which you expect to contain and control the resource. (Use additional sheets if necessary.)

Well is adjacent to test hole to 1,200 feet, drilled in October, 1979. Bottom hole temperature is about 70°F, with encouraging gradient. Propose to drill open hole until drilling returns are in excess of 100°F or measured temperature in hole exceeds 120°F, at which time a standard (150lb) gate valve will be installed.

If returns exceed 120°F or measured temperature exceed 160°F, a "stripper" (hydril bag packer or other device of equivalent function) will be installed. If boiling water temperature are encountered, a full hydraulically actuated BOP (blind and pipe) ram will installed.

6. What is the character and composition of the material you expect to derive from the well? Include parameters such as phase, estimated temperatures, etc.

Hot water only is sought. Fluid will be used in liquid phase, even if it exceeds 212°F. Transmission through pipelines for space and process heating.

Partially explored. Results attached with other data and reference material.

7. Is this application a part of a program for exploration or development of an already explored geothermal resource?

Partially explored. Results attached with other data and reference material.

8. What is the estimated cost of the construction of the well and related uses? Provide a validated financial statement showing the applicant has sufficient financial resources to complete the project. * See #12

9. If the proposed development will involve the use of water for purposes other than geothermal uses, has the applicant applied for a permit to appropriate water as prescribed in Chapter 2, Title 42, Idaho Code?

Yes, Permit # 22-7283, granted in July,1978. ~~A change in location of diversion point is being requested in attachment.~~

10. List in detail the applicant's previous experience in geothermal resource development.

Applicants Engineer's Experience (Energy Services, Inc., subsidiary of Forsgren-Perkins Engineering, principals, Dr. Jay Kunze, P.E., Roger C. Stoker, P.G. and Ray W. Gould). 1. Raft River first 4 deep wells. 2.Boise Front wells ("Beard and Blot wells") . 3. Utah Roses 5,001 foot well at Sandy, UT 4. Bluffdale (Utah State Prison) 200°F geothermal well. 5. Newcastle, UT 500 foot, 200°F Water.

11. What does the applicant intend to do with waste products, brine or water from the well?

Reinject if not of adequate quality to dispose of on surface.

12. Idaho law requires that a bond be filed with the Department indemnifying the State of Idaho, conditional upon the performance of the duties required by the Idaho Geothermal Resources Act and the proper abandonment of any well covered by permit of not less than $10,000 per well, the actual amount set as a condition of the permit. Identify the company that will underwrite your bond and provide confirmation that they will issue such bond upon payment of the necessary fees.

* An agency of the Madison County Government will be the fiscally responsible party, working under U.S. DOE contract # FC07-79 ET 27028. Estimate $300,000 to 3,000', $430,000 to 5,000'.

[signature]
Signature for application

(7.4-A2)

State of Idaho) Appendix B
) ss.
County of Madison)

J. Kent Marlor being first duly sworn and on his (her) oath, deposes and says:

That he (she) is the applicant in the above matter; that he (she) has read the foregoing application and knows the contents thereof, and the facts therein contained are true as I verily believe.

Subscribed and sworn to before me this 19th day of March, 19 80.

Gloria G. Andrus
Notary Public for Idaho

Residence: Rexburg, ID

Commission expires: 10-8-82

FOR DEPARTMENT USE ONLY

Received 3/21/80 by WEJ

Fee received 3/24/80 by WEJ Receipt No. 16734

ACTION OF THE DIRECTOR, DEPARTMENT OF WATER RESOURCES

This application has been reviewed in accordance with Title 42, Chapter 40, Idaho Code and is hereby APPROVED, subject to the following limitations and conditions.

SUBJECT TO CONDITIONS ON ACCOMPANYING LETTER.

6 5 80
Date

Administrator-Resources/Administration Div.

Cut along this line *Cut along this line* *Cut along this line*

NOTICE OF INTENT TO DRILL

This portion of the permit must be returned to the Department of Water Resources at least five (5) working days prior to the commencement of drilling operations.

Name of applicant Madison County Energy Commission

Well number Madison Geothermal # 1

Location of well: NW ¼ NW ¼, Section 31, Township 6N, Range 40E, B.M.

Date drilling will begin June 7, 1980.

June 2, 1980
Date

Jay F. Kunze
Signature
General Mgr. Energy Services
(Engineer for Madison County)

(7.4-A2)

Form 4003-2
5/78

Appendix B

Geothermal Application No. 22-7283

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

APPLICATION FOR PERMIT TO ALTER A GEOTHERMAL WELL

Rexburg, Idaho February 23 (Month) (Day), 1981 (Year).

I, J. Kent Marlor [signature], do hereby give notice of intent to deepen or otherwise modify well number MCGW I located in NW ¼ NW ¼, Section 31, Township 6N, Range 40E, B.M., Madison County.

1. Present condition of the well:
   a. Total depth 3993
   b. Complete casing record, including plugs, liners, etc. 13 3/8" Surface Casing to 735' 9 5/8" Production Casing to 2,289' (G.L.) Conductor Pipe to 20" diameter installed to 115'.
   c. Last produced July 4, 1980 (Date) Production 1.25 million gallons of 69 water, Dissolved solids ~200 ppm.
2. The proposed work is as follows: Cleanout fill and bridges, with workover rig, to 3600'; Install 5" solid liner hung from the bottom of production casing (100 ft overlap), and spot a cement plug at bottom(3,600'). Drill-out plug and fill to present total depth and perhaps 50 to 100' further. Log and pump test.
   a. Date deepening or modification will begin May (Month) 1 (Day), 19 81 (Year).

Operator Madison County Energy Comm. Address Courthouse, Rexburg, ID 83440

Date February (Month) 23 (Day), 19 81 (Year). Telephone 356-3491

FOR DEPARTMENT USE ONLY

Date received ______ by ______

Fee received ______ by ______ Receipt No. ______

ACTION OF THE DIRECTOR, DEPARTMENT OF WATER RESOURCES

	Gross Wages	Fed. Soc. Sec.	Fed. Inc. Tax	State Inc. Tax	Retirement	Insurance	Advance	Tot. Ded.	Net Wages
Payroll									
OTHER			Renewal of permit			100.00			

MADISON COUNTY WARRANT

REXBURG, IDAHO

No. 765

PAY 100 and 00 cts $100.00

TO THE ORDER OF
Department of Water Resources
150 Shoup Avenue
Idaho Falls, Idaho 83401

Date 2/27/81 SERIES 1981

[signature]
COUNTY AUDITOR

By ______ DEPUTY

Payable Through
1ST SECURITY BANK OF IDAHO, N.A.
VALLEY BANK
IDAHO FIRST NATIONAL BANK

Appendix B

TO: Idaho First National Bank
(Bank or Savings and Loan Association)

Address: 77 East Main, Rexburg, Idaho

FOR VALUE RECEIVED, I, Jayne R. Green, Madison County Treasurer do hereby assign, set over and pledge to the Director, Idaho Department of Water Resources as a cash bond, or cash deposit the sum of $10,000.00 in a Savings Account carried in the name of Madison County being xx Certificate of Deposit ~~Savings Account No.~~ 378015, maturity date November 1, 1980

This pledge is given in lieu of Surety Bond in securing a license to drill a geothermal well (*) under Section 42-238 of the Idaho Code, and said assignment and pledge shall remain in full force and effect until the same has been released by the Director, Idaho Department of Water Resources.

The interest paid on the $10,000.00 hereby assigned and pledged shall be paid to account holder Madison County this assignment and pledge being only for the principal amount.

Dated at Rexburg, Idaho. this 16 day of October, 19 80.

Jayne R. Green, Treasurer
Account Holder

State of Idaho)ss
County of Madison)

On this 16 day of October, 19 80, personally appeared before me the signer of the above instrument, who duly acknowledged to me that he executed the same.

Patricia A. Carver
Notary Public residing at Rexburg, Id

My commission expires: 10-25-84

I, Tom Fulton (Name), MANAGER (Title) do hereby acknowledge that Madison County has on deposit $10,000.00 which has been assigned to the Director, Idaho Department of Water Resources which shall remain in force and effect until released by the Director, Idaho Department of Water Resources.

(Bank or Savings & Loan Official)

State of Idaho)ss
County of Madison)

Acknowledged on this 16 day of October, 19 80, before me:

Patricia A. Carver
Notary Public residing at Rexburg, Id

(*) The geothermal well "bonded" by this account is named Madison County #1, located in Section 31, Township 6 North, Range 40 East, Boise Meridian.

Appendix C

DRILL RIG #75 EQUIPMENT

Cabot 750 Series with 112' - 300,000# Pemco Derrick, Powered by 2-8V71T Detroit Engines (700HP). Mounted on six axle carrier. Self-propelled.

DRAWWORKS	Cabot 2042
SUBSTRUCTURE	12' High (clear) 400,000#
ROTARY TABLE	Oilwell 27½"
SWIVEL	Brewster - 6-5 X 220 ton
KELLY	40' X 4¼" Square
KELLYCOCK	TIW 3,000#
PUMP #1	Gardner-Denver GP-G X P 16V71T (700HP)
#2	Gardner-Denver GP-G X P 16V71 (500HP)
MUD TANKS	Steel (2) 500 Bbl total storage
SHAKER	Swaco Double
DESANDER	Swaco 8 Cone
MUD MIXING SYSTEM #1	6 X 8 Mission Magnum Centrifugal with 6V53 GMC
#2	5 X 6 Mission Magnum Centrifugal with 4V71 GMC
BLOCKS	Ideco 4 Sheave 160 ton
GENERATORS #1	40 KW with 471 GMC
#2	35 KW with 453 GMC
DRILL PIPE	4½" Full Hole Grade "E" 16.60#
DRILL COLLARS	16 - 6¼ X 2¼
WATER STORAGE	500 Bbl
FUEL STORAGE	2,000 Gallons
BOP'S	10" 3000 with pipe and CSO rams
CLOSING UNIT	ValvCon 40 Gallon
TONGS	BJ Type "B"

RIG #75 CONTINUED ON NEXT PAGE

Appendix C

5 VALVE CHOKE MANIFOLD WITH POSITIVE AND ADJUSTABLE CHOKE

BOILER OR HOT AIR HEATER IF NEEDED

ALLIED EQUIPMENT: Catwalk, pipe racks, dog house, change house, trailer house, wind breaks, recorder, drift indicator, reel and measuring line, safety valve, and handling tools for drill pipe and drill collars.

APPENDIX D

DAILY DRILLING SUMMARY

MADISON COUNTY GEOTHERMAL WELL #1

June 1, 1980	Set conductor pipe to 110 ft (Kingston Drilling)
June 2,	Rig mobilization to Rexburg (CRC Colorado Well Co.)
June 5,	Began drilling mouse and rat holes. Severe lost circulation areas developed. Water supply system breakdown.
June 6	10 p.m., completed mouse and rate holes
June 7	At 2 a.m., began drilling out of the 20 inch surface seal. Pipe with 17 1/2 inch bit at 125 ft level KB (110 ft ground level). (All future depth references are from KB.) KB = Kelly Bushing
June 8	At 4 a.m., Drilled to 245 ft; No returns; Had difficulty getting the tool out of the hole. Started cementing entire hole at 4 p.m. and completed the cementing at 8 p.m. The cement had not set-up at midnight.
June 9	Began drilling out cement at 1 a.m., cement had not set-up. Delayed drilling until 6 a.m.
June 10	Pea gravel encountered at the 300 ft level. Removed 17 1/2 inch reamer from behind 17 1/2 inch bit.
June 11	Considerable difficulty was encountered cleaning the pea gravel out of the hole. No returns. Very fractured formation. Presumed to be basalt.
June 12	Reached 600 ft. level.
June 13	The drill bit hung up in the hole at the 730 ft level. Ran quick mud sweep to free bit.
June 14	Reached 1006 ft with 17 1/2 inch bit at 8:45 a.m. Spotty returns. Ran mud sweep to condition hole and lost returns. Began tripping out to case at 1000 ft. Began casing at 12:15 p.m. Casing hit obstruction at about 730 ft at 2 p.m. Washed casing into the 750 ft level by 5 p.m. Could get it no further, and decided to cement at that point. Began cementing at 8:45 p.m. with 1,750 cu

ft total; first 700 cu.ft., a 50/50 pos mix, then followed by 1050 cu. ft. class G. All cement in pipe at 10:00 p.m. Plug wouldn't drop and couldn't displace remaining cement out of pipe. Abandoned operation at midnight. There was 813 cu. ft. inside 13 3/8 casing, and presumably 585 cu. ft. in the drilled space outside of casing. The remaining 350 cu. ft. is excess for voids. Obtained no returns at the surface.

June 15 — Waited on cement. Nippled up and started in hole at 7 p.m. Drilling started at 143 foot level.

June 16 — At 9:30 a.m. Drilled to 423 feet. At 11:40 a.m. the penetration rate was approximately 30 feet/hr. Drilled to 613 feet, tripped out and put the collars in. This was completed at 6 p.m. At 10:00 p.m. the bit plugged. Tripped five double stands and cleared the bit. Continued drilling.

June 17 — At 8:15 a.m. The bit plugged when making a connection. Tripped out to clear cross-over sub and 6.25 inch washed out collar. The sub was replaced and collar layed down. Both mud pumps were causing trouble. At 7:30 p.m. the pumps were repaired. Drilling continued at 8:30 at the of 1,132 foot level. Tripped to install float and sub to eliminate bit plugging.

June 18 — Continuous drilling with shutdowns to service the rig and pumps. Tripped out at 1,616 feet. The bit was then changed. The float was plugged with the vis/funnel. After the formation changed, the penetration rate was very slow.

June 19 — Continued drilling from 1700 to 1889 feet. Formation consisted of rhyolite and quartz. The penetration rate was very slow because the #2 mud pump was down. The hole could not be cleaned. Mixed 10-bag-pill (10 bags Bentonite and one bag lime) to run sweep and clean the hole.

June 20 — Continued drilling from 2,010 to 2,165 feet with a 12 1/4 inch bit. The drilling rate was very slow, due to #2 mud pump being out of service (re-welded). Continued drilling with #1 pump but couldn't clean hole. At 10:00 p.m., penetration rate zero, bit sticking in hole. Mixed 10-bags-pill to run sweep and see if penetration rate changes. No change, tripped and changed two jets to #12.

June 21 Trip in complete at 2:30 a.m. with 180 feet of fill. Drilling at with 90 rpm and 10,000 lbs. More weight doesn't help penetration rate even at low speed. New pump delivered at 3:00 p.m., and installed at 8:30 p.m. Tried various drilling rates. Decided best rate to be 12,000 lbs. and 40 rpm which is 12 feet per hour.

June 22 Reached 2,486 feet at 1:00 p.m. Began trip out of hole. Out of hole at 4:30 p.m. and began to temperature log. Could not get through bridge at 1,210 feet. Began to trip at 7:00 p.m. Broke through bridge with 35,000 lb. (1,210 feet). Encountered 400 feet of fill at bottom of hole. #1 mud pump bull wheel has all spokes broken. Pump inoperable. Shut drilling operation down at 10:00 p.m. Awaiting arrival of replacement mud pump. Pulled tools up inside 13 foot 3/8 inch casing.

June 23 No activity while waiting for mud pump.

June 24 No activity mud pump arrived at 3:00 p.m.

June 25 The mud pump was installed and drilling started again at 3:20 p.m. 50 bags of gel were ordered to condition the hole in preparation for running casing. At 4:11 p.m., the first sweep was pumped in the hole. At 6:00 p.m. started tripping out of the hole for temperature logging and to run casing. At 9:00 p.m. logging tool hit a bridge at 1,210 feet. The casing was in the hole at 1:30 to a depth of 2,304 feet.

June 26 Began waiting on cement tracks at 2:00 a.m. The cement trucks arrived at 4:30 a.m. and started pumping at 5:10 a.m. Finished at 7:05 a.m. 238 barrels were used during the cementing operation. Water was obtained in the returns but no cement. The cement was tagged between the 13-3/8 inch and 20 inch casing at 225 feet GL. The cement between 9-5/8 and 13-3/8 inch was tagged 350 feet KB. The water level in the annulus between 13-3/8 inch and 20 inch was 23 feet. Cement was pumped through the 1-1/2 inch pipe in between the 13-3/8 inch and 20 inch casing until the cement was at GL. This was completed at 8:30 p.m. The 20 inch, 13-3/8, and 9-5/8 inch casing was cut off to nipple up and install the BOP (Blow out preventer). Temperature logged from 11:00 p.m. to 1:00 a.m., and from 6:00 to 7:00 a.m.

June 27	Frank Sherman from the state witnessed the BOP pressure test. There was 810 psi on the blind rams for 1 hour and 850 psi on the pipe rams for 30 minutes. The test was terminated at 10:00 a.m. Drilled out float and shoes at 1:00 p.m. Only 35 feet to 40 feet of cement was encountered at the bottom of the casing. There was not much fill when the cement was drilled through. Drilled to 2,805 feet.
June 28	Continued drilling and lost circulation at 3,148 feet with no returns. Five feet fault zone encountered. Reached 3,209 feet, but bridged immediately between 3,150 and 3,100 feet. Lost one trash pump on the canal and the second pump couldn't keep up with lost circulation. Began tripping out of the hole at 7:35. Tripping was completed two hours later. Ran a temperature log until 11:30 p.m. Temperature probe hit a bridge at 3,150 feet. Tripped back in hole at 11:30 p.m.
June 29	On the way back in, hit a light bridge about 3,150 feet. Still no returns, 20 feet of light fill was encountered at the bottom of the hole. At 8:50 a.m. drilled to 3,369 feet. At 8:00 a.m. the total depth drilled was 3,350 feet. Problems with the trash pump and bit sticking in the hole. Pulled up four double stands, (240 feet) for trash pump repairs. Back on bottom at 11:50 a.m. bridge at 3,155 encountered. Continued drilling with no returns. Some fill encountered in bottom on each connection.
June 30	Continued drilling with no returns, at 10:30 a.m. tripped out to check bit and run temperature log. At 3:30 p.m., tripped back in and continued drilling; still no returns. At 7:00 p.m. started to stick in the hole. Three hundred feet of pipe was tripped out and circulated to clean hole.
July 01	Reached depth of 3,948 ft (KB) or 3,932 ft (G.L.) Tripped out of the hole due to sticking in the hole. A bailer was run to 3,700 feet to retrieve cuttings and then a deviation survey was run. The deviation was one degree. An air lift was started at 1:20 p.m., at a flow rate of 700 GPM.
July 02	Theair lift continued until noon at about 600 GPM. The drill pipe was tripped out to log the well. After the log was run, tripped in to clean out possible bridges.

July 03 Started air lift again at 2:40 p.m. and continued airlift all day.

July 04 Continued air lift until 8:00 a.m., then tripped out to run temperature log. Temperatures did not exceed 71°F (22°C).

From July 1 to July 4, the air lift was run 40 hours. The air lift removed approximately 1,600,000 gallons. Each time the air lift was stopped the water level was measured at the 30 foot level. It is estimated that no more than 1,250,000 gallons of cold canal-water drilling fluids had been pumped into the well during the drilling operation.

Tripped back in to clean hole and found 250 feet of fill. The decision was made that it was futile to attempt to remove this fill, and imposed a significant danger of sticking the drill pipe into the hole. D.O.E. officials were consulted and it was decided to release the rig.

Appendix D

DRILLING REPORT FOR
MADISON COUNTY GEOTHERMAL WELL
REMEDIAL WORK - MAY, 1981

May 5, Tuesday, 1981 - Arrived on location with water pump at 2:30 p.m. A load of drill pipe was the only equipmenton location (6.5 lb/ft, too light to use for drilling). Note: All depths are referenced from ground level.

May 6, Wednesday, 1981 - At 11:00 a.m. a new load of drill pipe arrived and was unloaded. Tripped into the hole with 8-3/4 inch bit. Hit a small bridged area at 2,824.6 ft which was pushed through with the weight of the drill string. At 3,265 ft, hit a solid bridge and hooked up power swivel for drilling. Continued drilling until 5:30 p.m., gaining approximately 10 ft. SDFN at 5:30 p.m. no returns so pulled back up into cased hole.

May 7, Thursday, 1981 - 8:00 p.m. Tripped out of the hole, the bit was chattering, one cone was locking up. Changed bit and tripped back in. Mixed mud and circulated. Drilling was very hard, penetration was very slow and it was assumed the drilling was on ledge and penetration was very slow at times, and fast at other times. Drilled to 3,511 ft by 5:30 p.m. No returns, pulled back up into cased hole SDFN.

May 8, Friday, 1981 - Mixed mud and tripped into the hole to continue drilling. At 8:15 a.m. anchor arm on power tongs broke, resulting in injury of two people and hospital treatment. One man treated and released for cut near eye and the other, Farnsworth kept overnight - severe laceration on chest. The rig was down for 4 hours for repairs. Through short handed, continued to clean hole. Started running casing at 5:30 p.m. and completed at 8:00 p.m. Hanger set and held at 2,208 ft, casing bottom at 3,540 ft. Set down heavy to set packer. SDFN.

May 9, Saturday, 1981 - Crew arrived at 7:00 a.m. along with the Blane Hendricks cement pumping unit. Four yards of washed sand and 9 bags cement/yd were mixed and delivered at 7:35 p.m. Pumping began at 8:50 p.m. After a delay to mate hoses from the pumping unit to the cement head. After pumping about 3 to 3-1/2 yards, the unit pressured up and the cement would not move. There should have been, at that time, about 2.1 yards in the drill pipe and about 1 yard in the casing. The cement truck left at 9:30 a.m., and it was not until 2:30 p.m. that all of the drill pipe was out of the hole and the cement cleaned out. The cement was not ordered with an accelerator (fortunately), and the last 5 sections of drill pipe had to be blown out with up to 3500 psig of water pressure. It was found that the top plug was jammed half way through the first piece of drill pipe, and that several large pieces of gravel were jammed in the bottom plug (in the liner packer). Several places along the drill pipe had sections of very dry, compacted, and nearly set-up cement. There was very serious trouble with the automatic slips, causing about 3 hours of delay in coming out from the hole.

The injured Mark Farnesworth was released from the hospital and flown home on the CRC plane.

May 11,Monday, 1981 - Crew arrived on location at 10:00 a.m. Repairing air slips, power swivel, and casing tongs from the accident on Friday. The crew brought new parts back with them this morning on the plane. At 1:30 p.m. tripped back in hole with 4-3/4 inch bit tagged cement at 3,400 ft in casing.

May 12,Tuesday, 1981 - Drilled out cement to depth of 3,600 ft, poor cement job. Tripped out of the hole to do remedial cement job, then tripped in hole to pump cement at 3,550 ft. (4 yards of sand and cement, 9 bag/yd mix) 4:00 p.m. Tripped out of hole to put bit on and wait on cement.

May 13,Wednesday, 1981 - Tripped in hole and tagged cement. Drilled down to 3,350 ft, no returns. Determined packer had not sealed at the liner hanger. Discussed problem with Baker people several times to try to determine solution. They recommended putting weight on the top, to see if shear pins could be broken, allowing the packer to seal under the weight.

Tripped out hole and put old 8-3/4 inch bit back on to be used to beat on the packer in an attempt to seal it. All attempts were unsuccessful, abandoned effort after repeated hammering caused concern that the liner hanger might break.

May 14,Thursday, 1981 - Tripped out of hole, and the Bakerline service hand was on location with displacement plug to seal off 5-1/2 inch casing in preparation for cementing to seal the packer and liner hanger. Pumped 1 yard of cement to plug the liner hanger and packer. Waited on cement for several hours.

Tried to fill hole with water but the hole would not hold water which indicated cement had not worked. Tripped in hole to tag cement, no cement could be found.

Tripped out of hole and removed bit. Then tripped back in hole with open end of drill pipe in preparation for pumping cement SDFN.

May 15,Friday, 1981 - Cement truck and pump were on location at 7:15 a.m. Pumped 2 yards of cement and completed at 8:15 a.m. Filled the hole with water after tripping out of hole with drill pipe.

May 15,Friday, 1981 - continued - Tripped in hole with 8-3/4 inch bit to drill down to top of liner hanger and packer. Drilled out cement to within 25 ft of the top of the liner hanger and packer.

Circulating in hole to clean out drilled cement. Tripped out of hole, to put 4-3/4 inch bit on to drill through the liner hanger and packer, tripped in hole and waited on cement.

May 16,Saturday, 1981 - Drilled cement plug out of packer and started to trip stands in to cement plug at bottom.

Stuck in hole at 2,021 ft. Hooked up circulating head and built pressure up to 3,000 psi with 35,000 lb pull. After it was freed, began to circulate for 1 hr at 300 psi. Ran stand of pipe to tag cement 3,376 ft and drill rate 30 ft/hr. SDFN at 5:00 p.m. and TD of 3,436 ft.

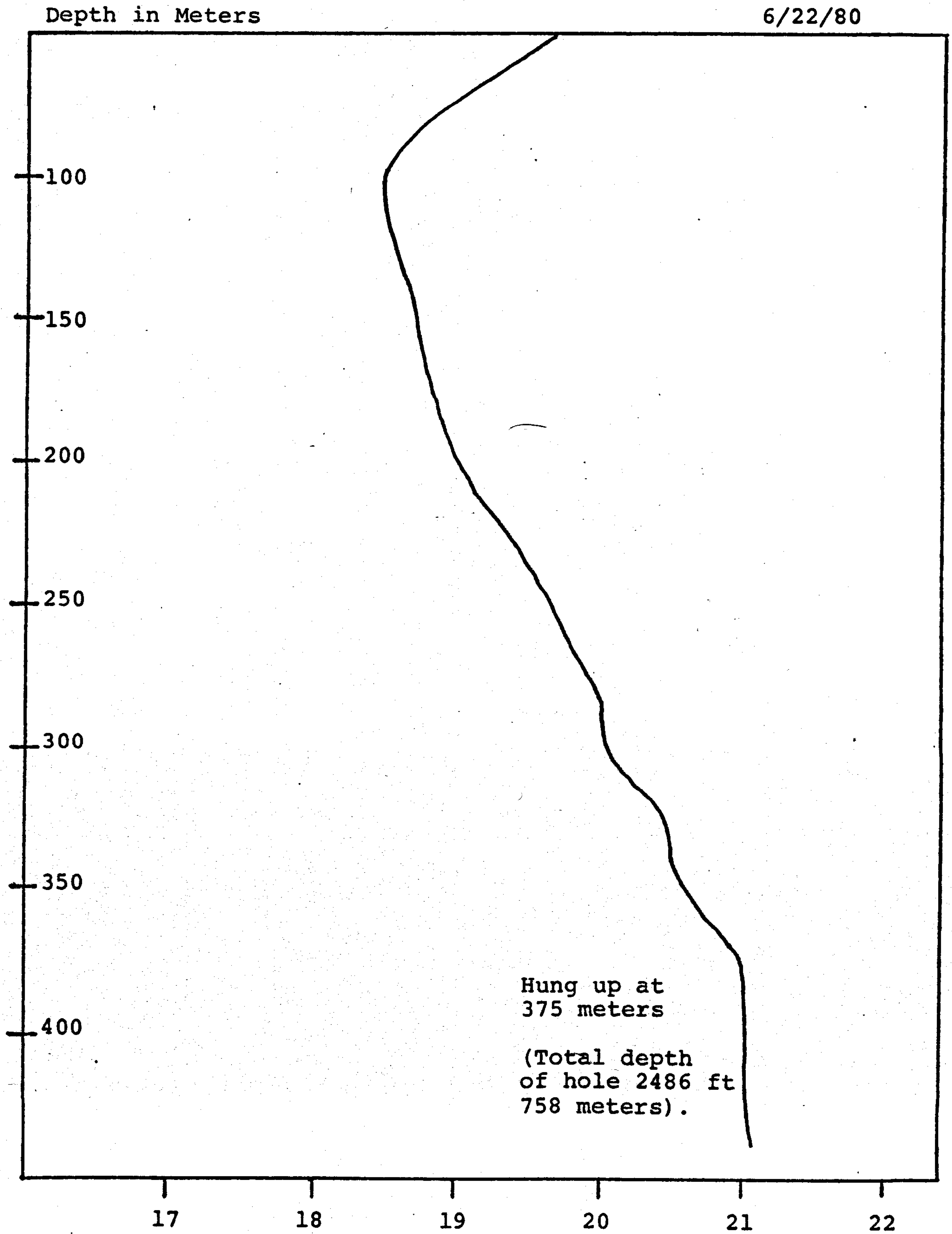
May 18,Monday, 1981 - Continued drilling cement plug out of 5-1/2 inch casing. Power swivel hose broke. Repaired hose and started drilling. Stiff arm on power swivel bent. Repaired arm and drilled down to 3,948,(bottom of previous hole). Drilling rate was slow beyond this point. Drilled to 3,958 ft, collected samples and pulled back into casing. SDFN.

May 19,Tuesday, 1981 - Tripped in hole and tagged 50 ft of fill. Continued drilling and circulating to clean hole until 11:00 a.m. Shut down to see how much fill we would have in hole. Tagged fill at 10 ft off the bottom at 1:00 p.m. It was decided that we would not be able to lift any more fill out of the hole with out using mud. Did not want to put mud in the hole so tripped out of the hole to laydown drill pipe and released the rig.

Rigged down and released the rig at 5:30 p.m.

Appendix E
Figure E1
MADISON COUNTY
WELL LOG

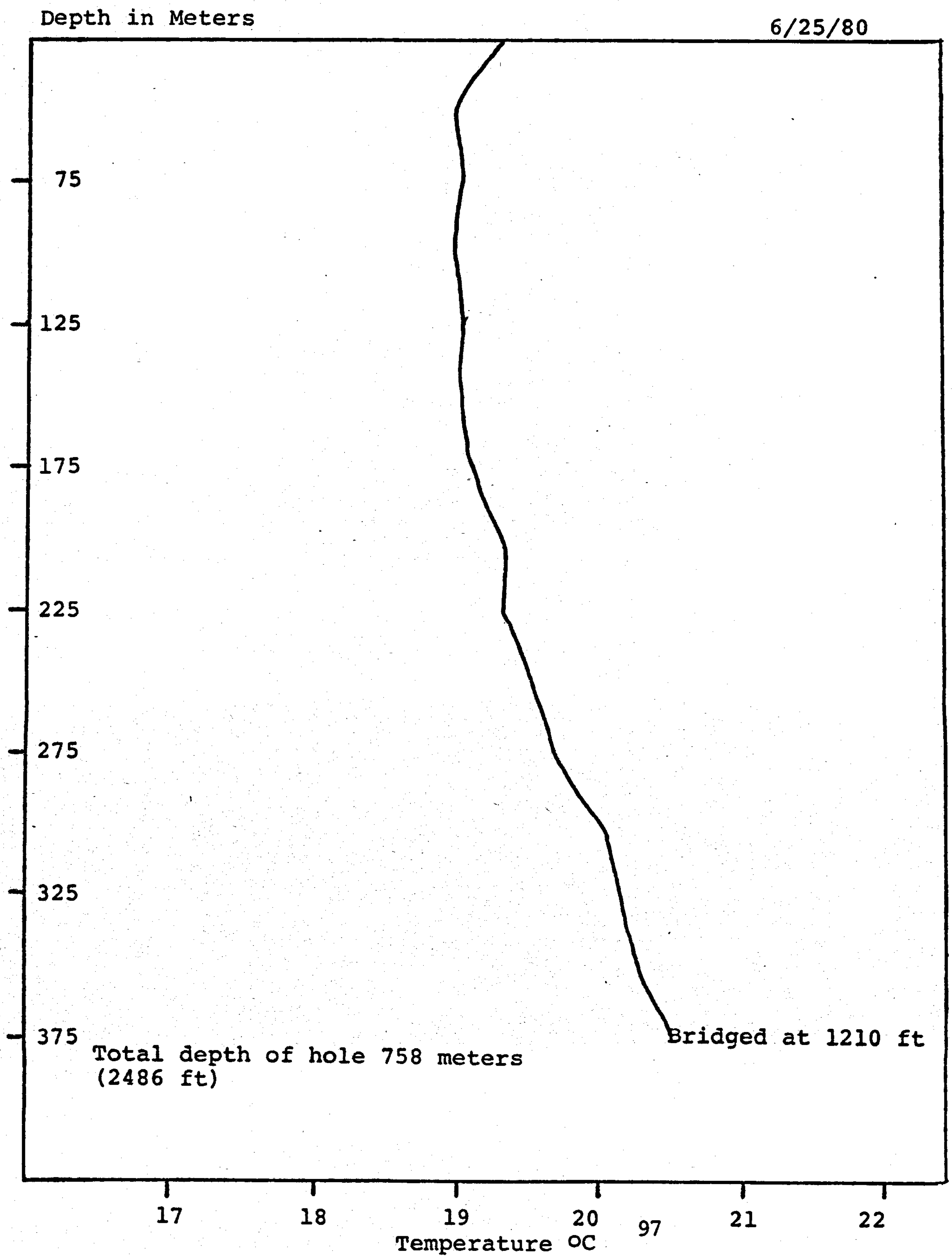
TEMPERATURE



Appendix E
Figure E2

MADISON COUNTY
WELL LOG

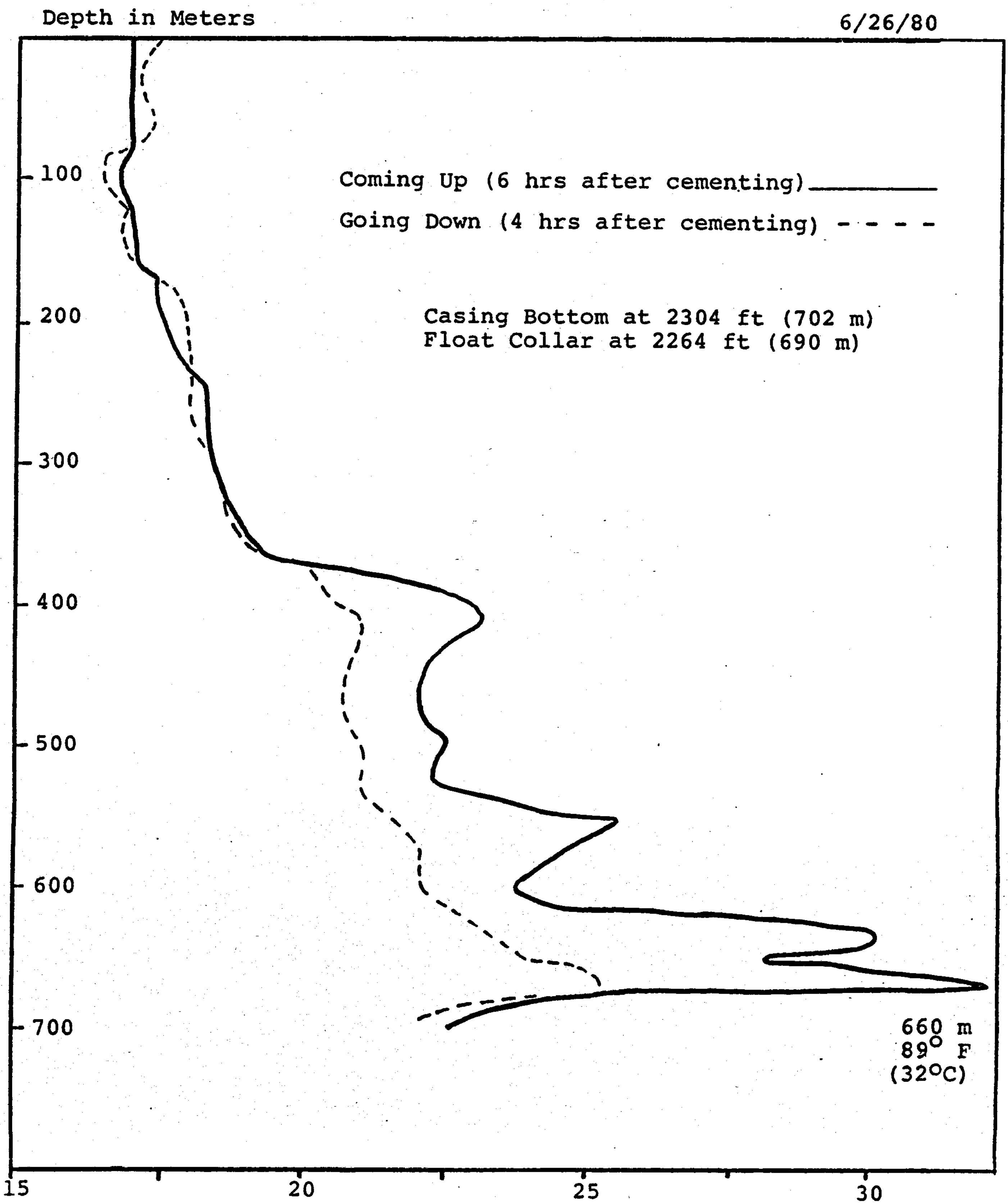
TEMPERATURE



Appendix E
Figure E3

MADISON COUNTY
WELL LOG

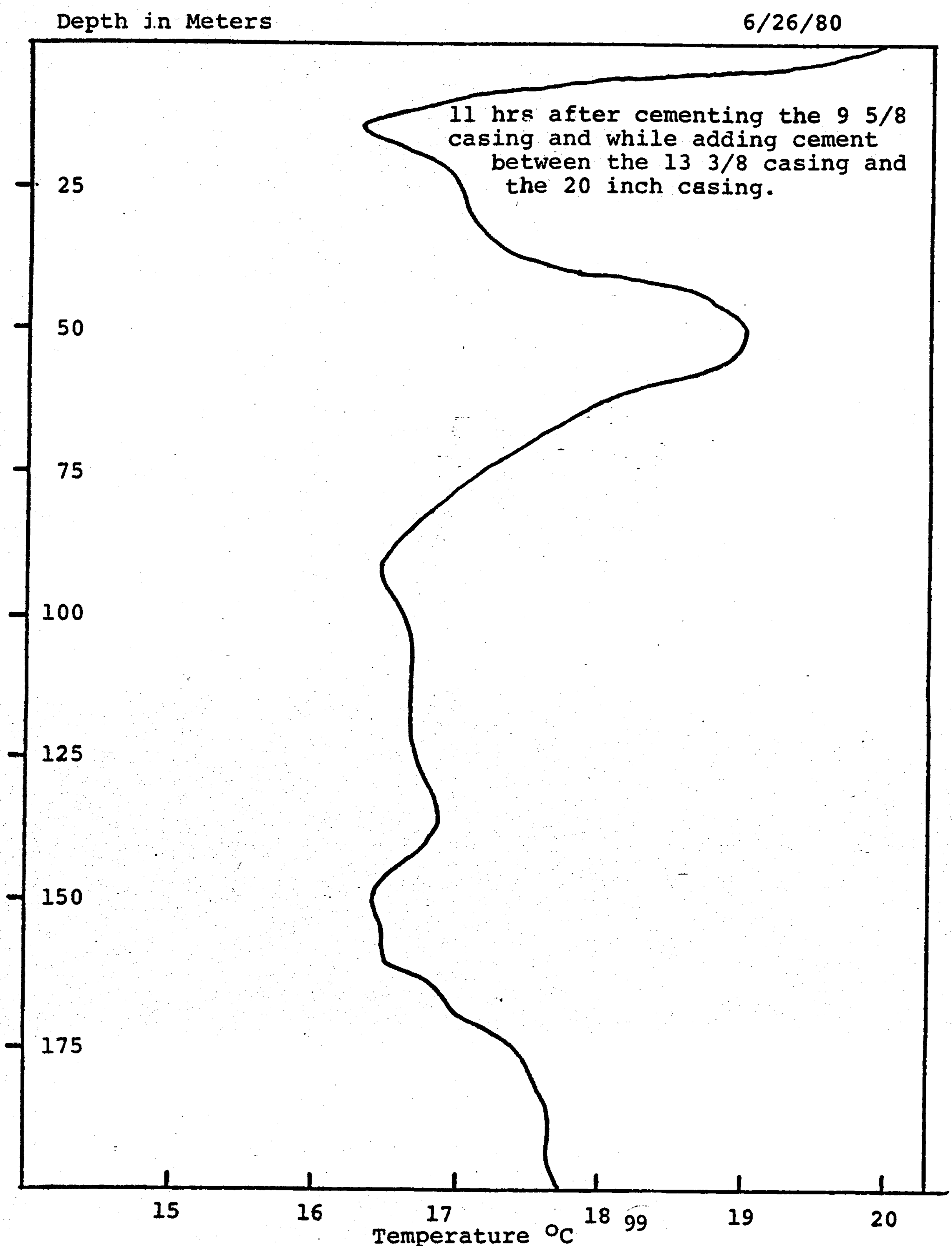
TEMPERATURE



Appendix E
Figure E4

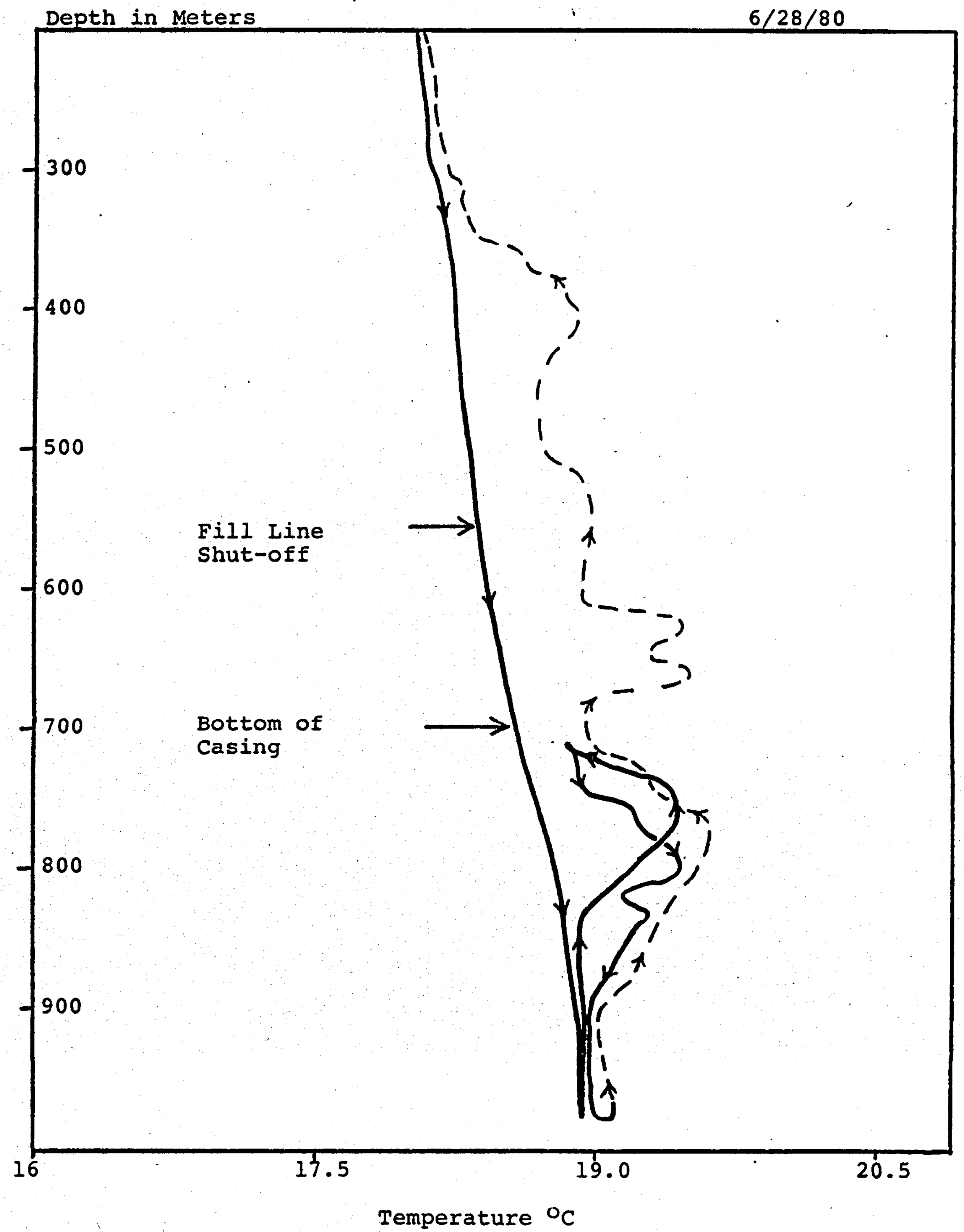
MADISON COUNTY
WELL LOG

TEMPERATURE

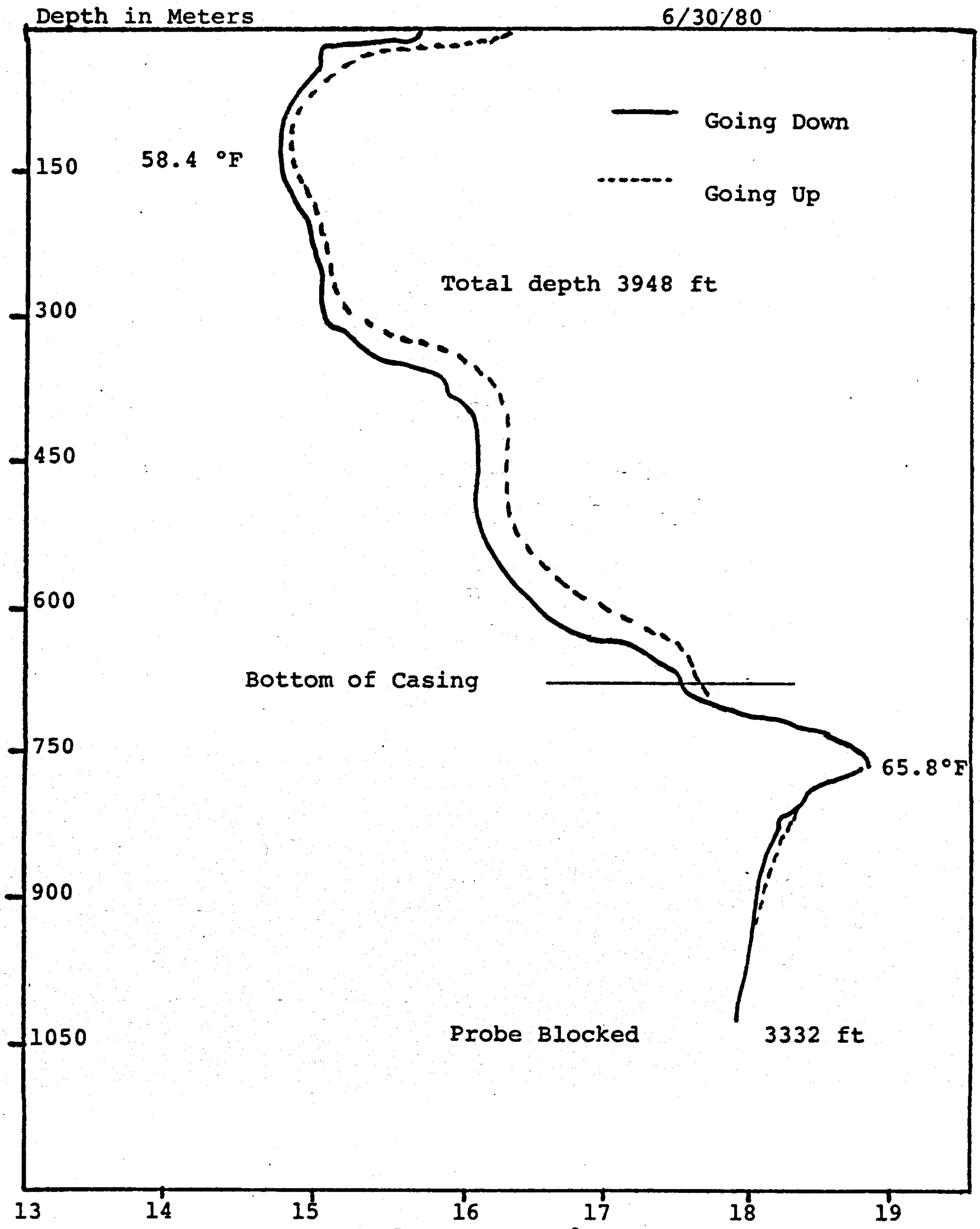


Appendix E
Figure E5
MADISON COUNTY
WELL LOG

TEMPERATURE

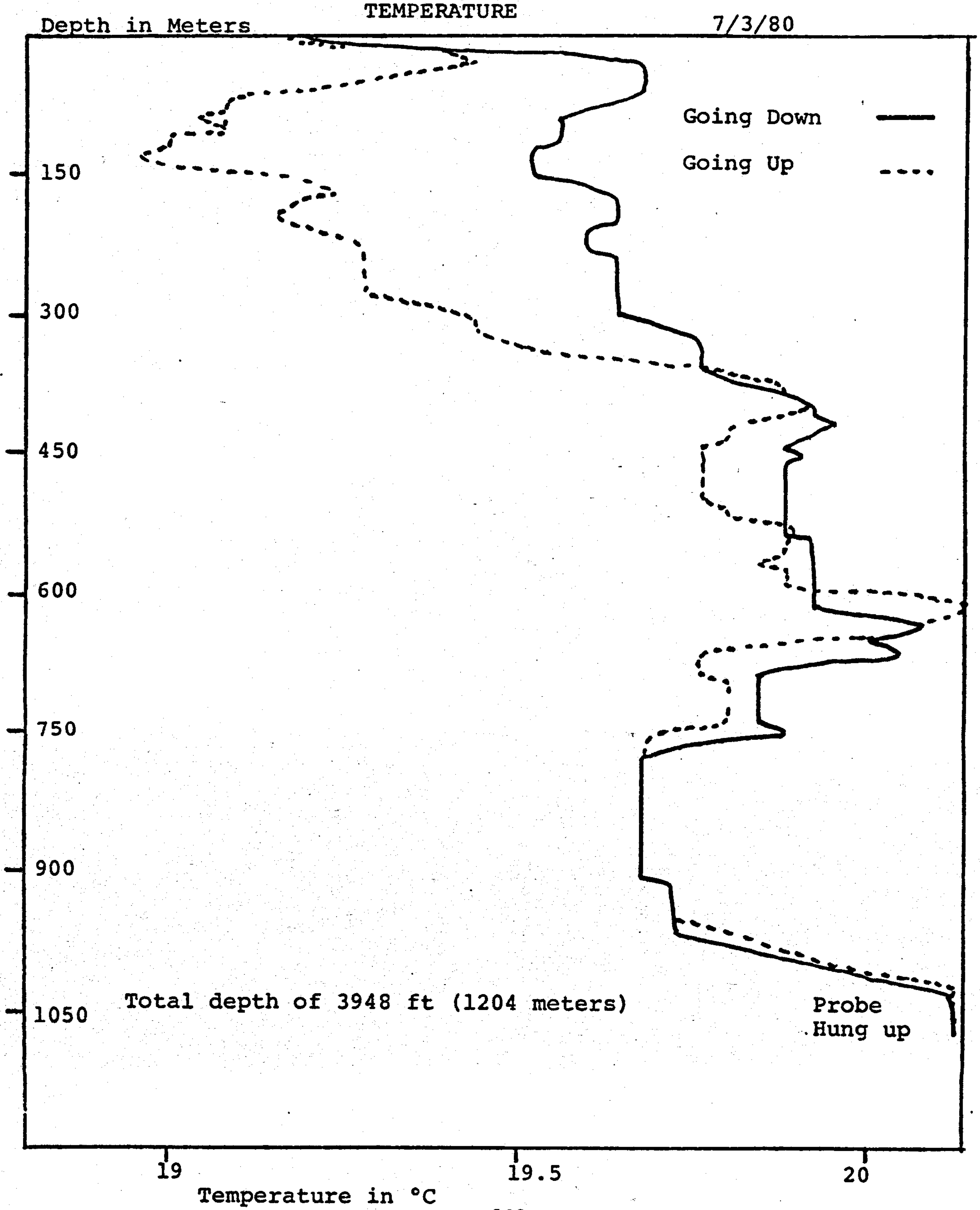


Appendix E
Figure E6
MADISON COUNTY
WELL LOG
TEMPERATURE



Appendix E
Figure E7

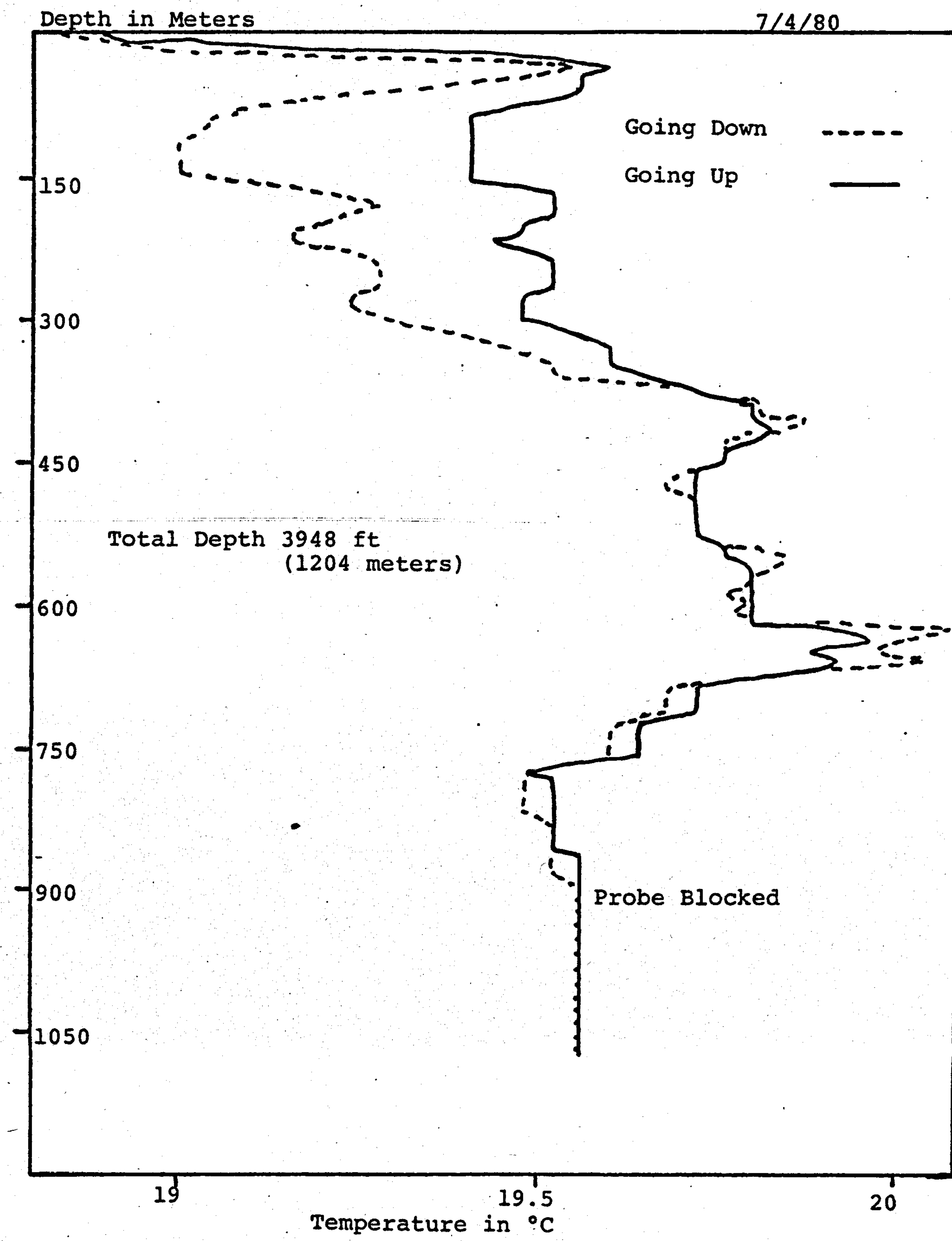
MADISON COUNTY
WELL LOG
TEMPERATURE



Appendix E
Figure E8

MADISON COUNTY
WELL LOG

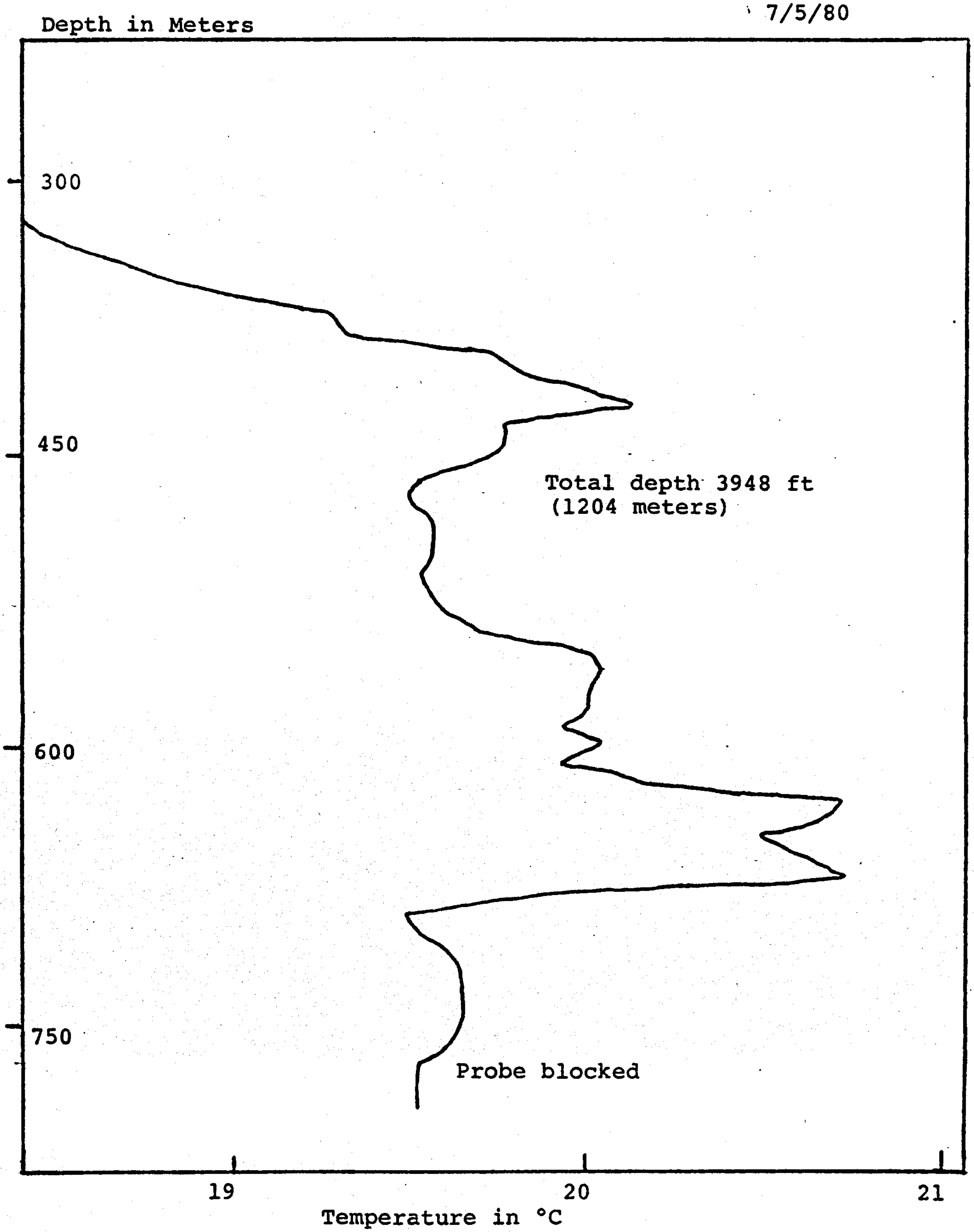
TEMPERATURE



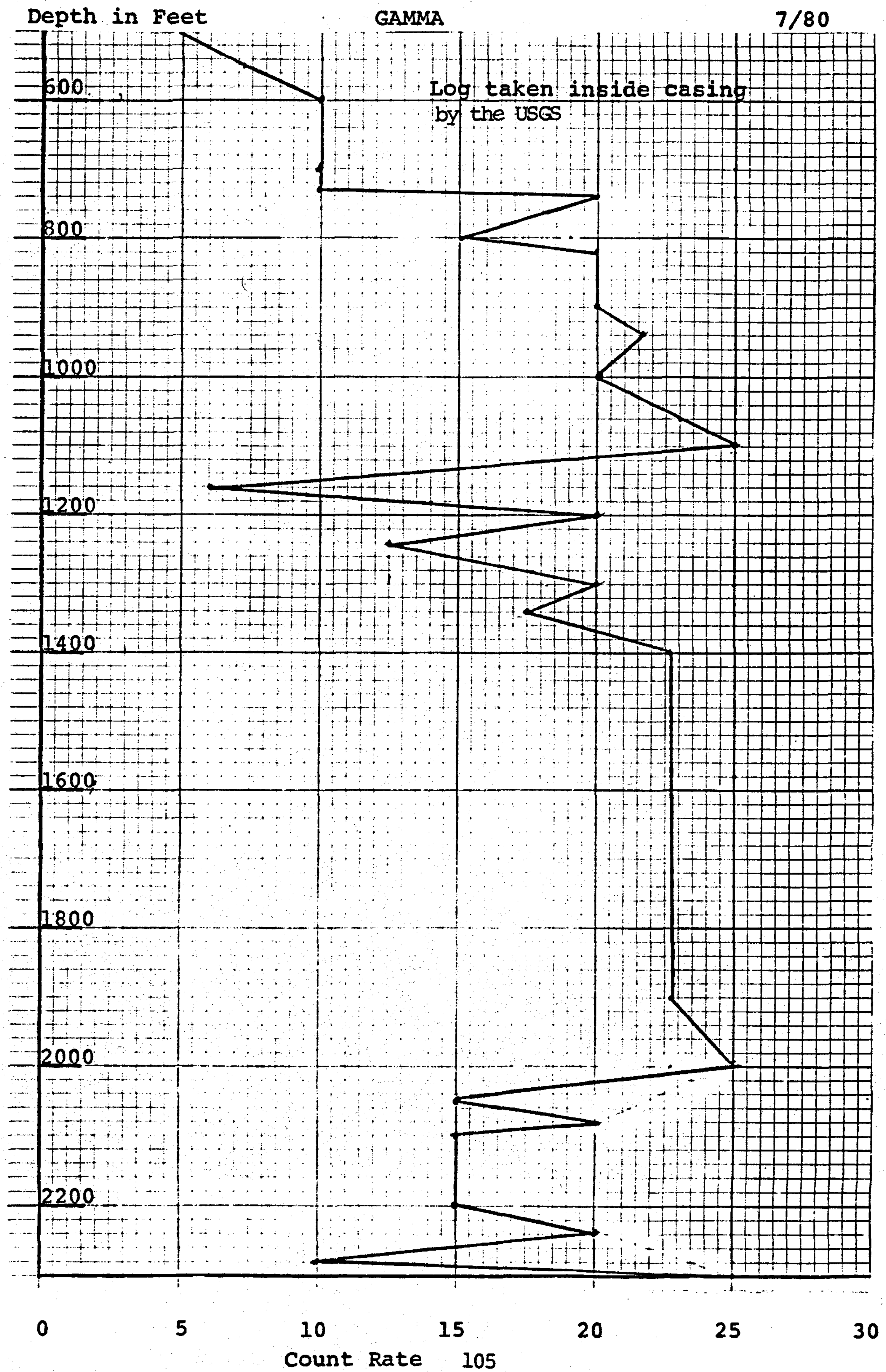
Appendix E
Figure E9

MADISON COUNTY
WELL LOG

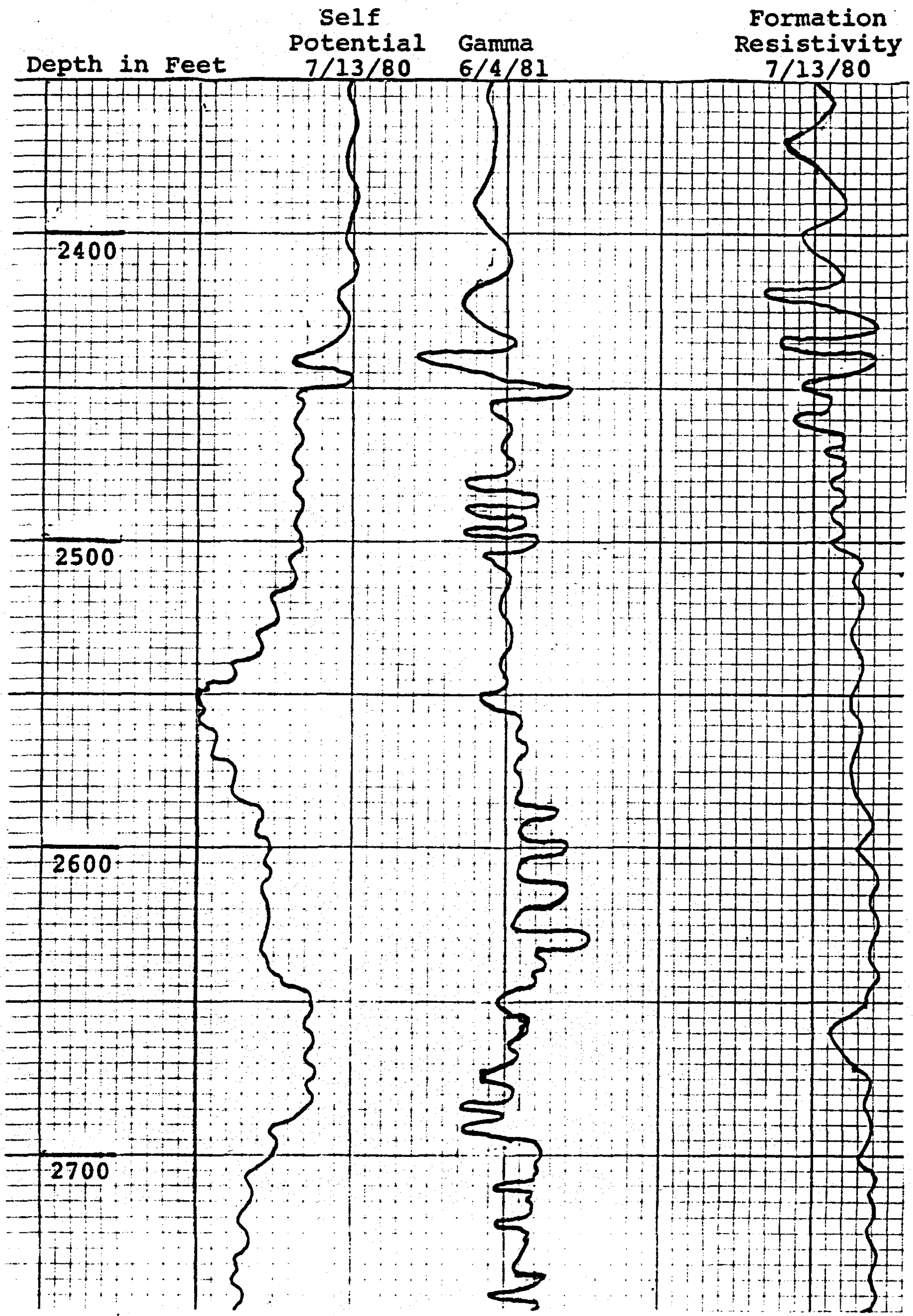
TEMPERATURE



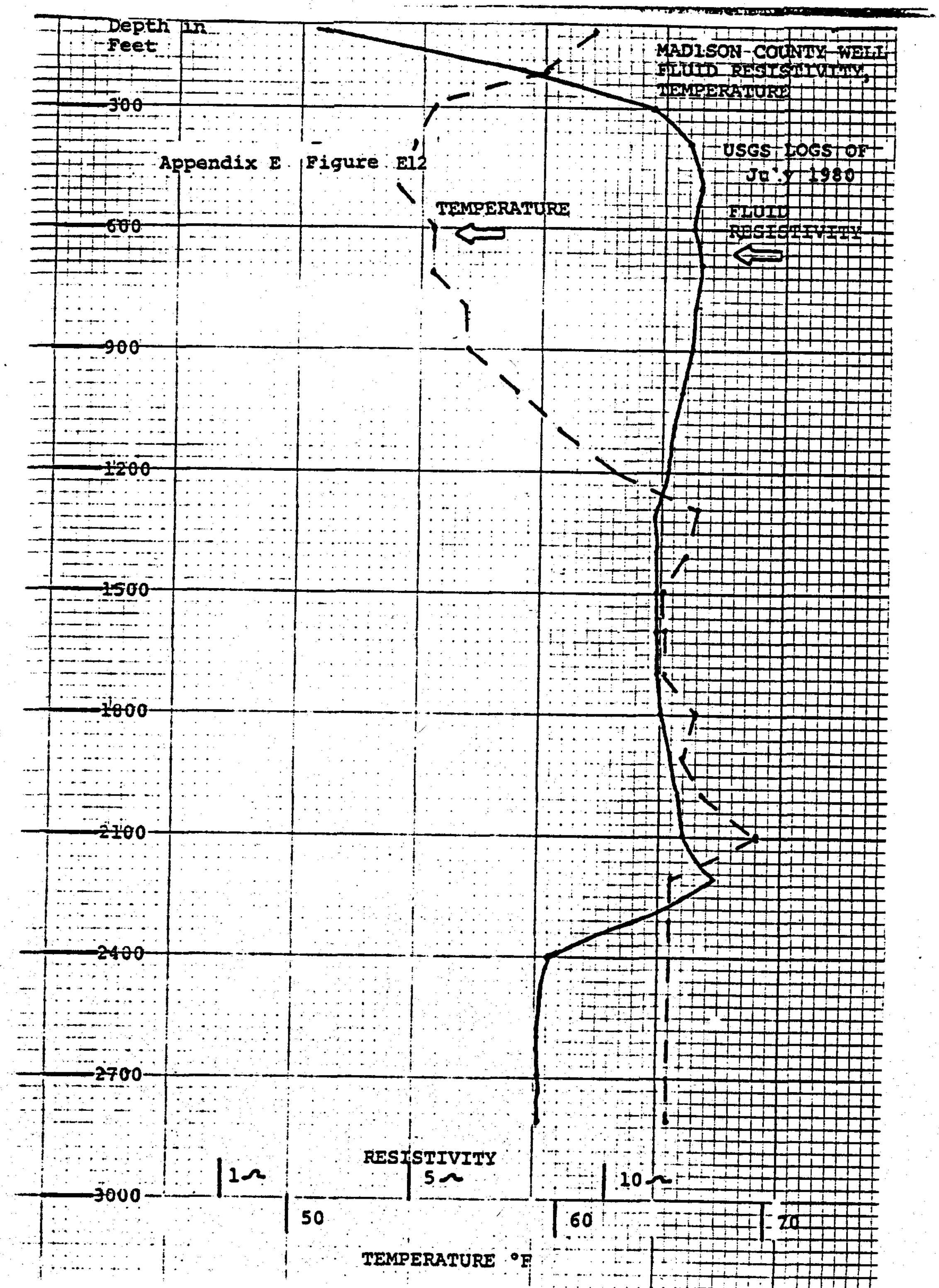
Appendix E Figure E10
MADISON COUNTY
WELL LOG



Appendix E Figure E11
MADISON COUNTY
WELL LOG
Taken by the USGS

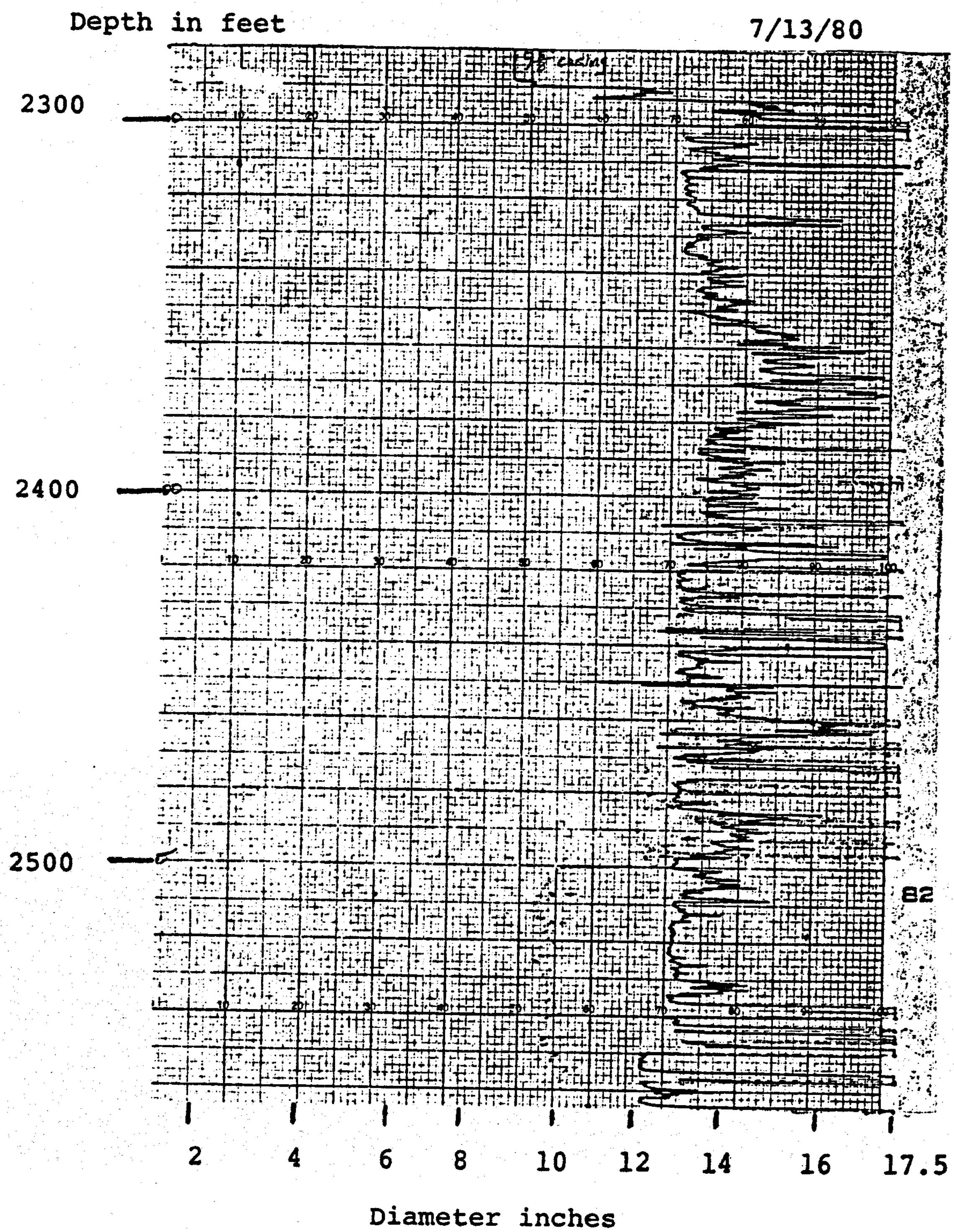


(cont'd on Gamma Log of 6/4/81)



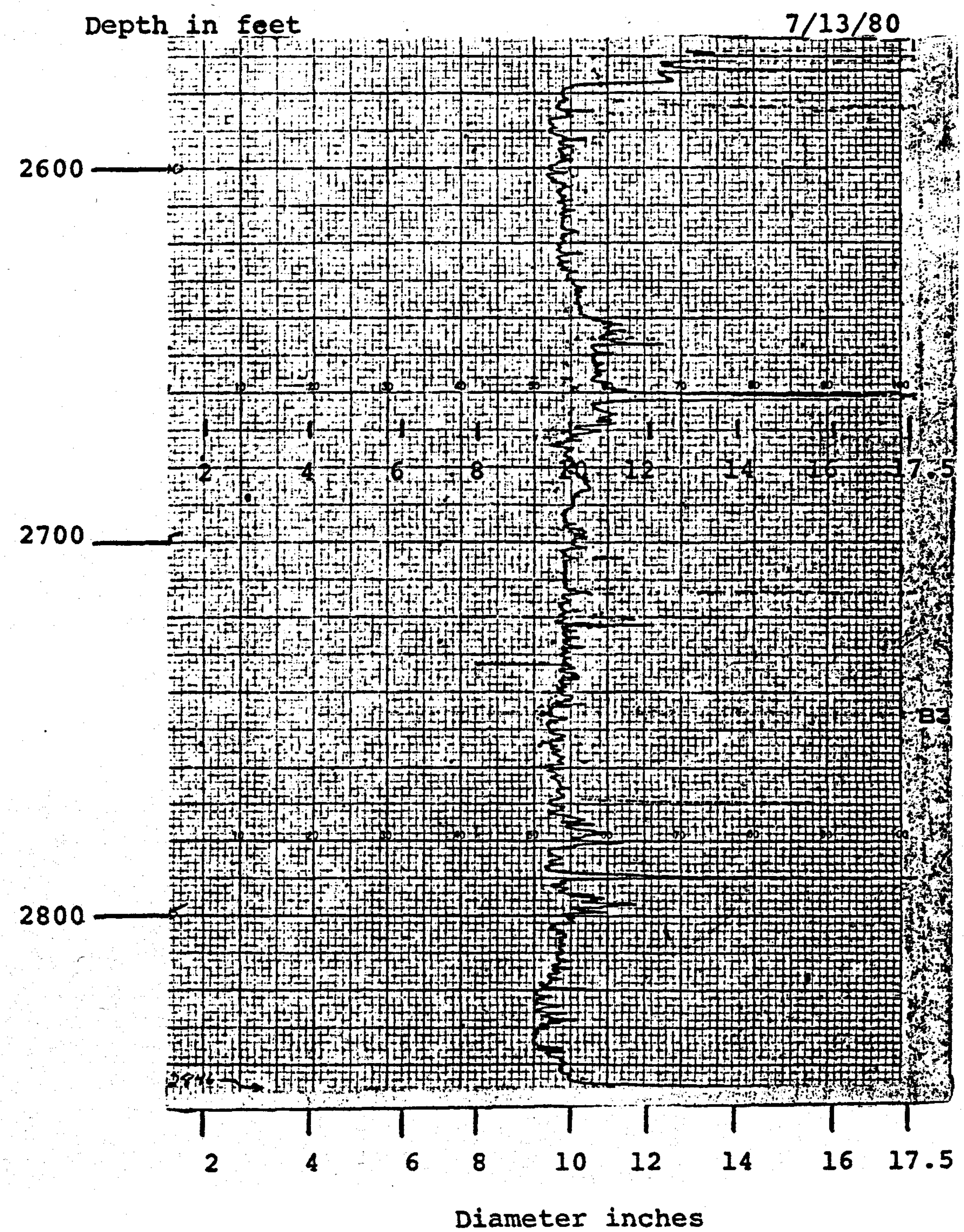
Depth in Feet
300
600
900
1200
1500
1800
2100
2400
2700
3000
MADISON COUNTY WELL
FLUID RESISTIVITY,
TEMPERATURE
Appendix E Figure E12
USGS LOGS OF
July 1980
TEMPERATURE
FLUID
RESISTIVITY
RESISTIVITY
1
5
10
50
60
70
TEMPERATURE °F

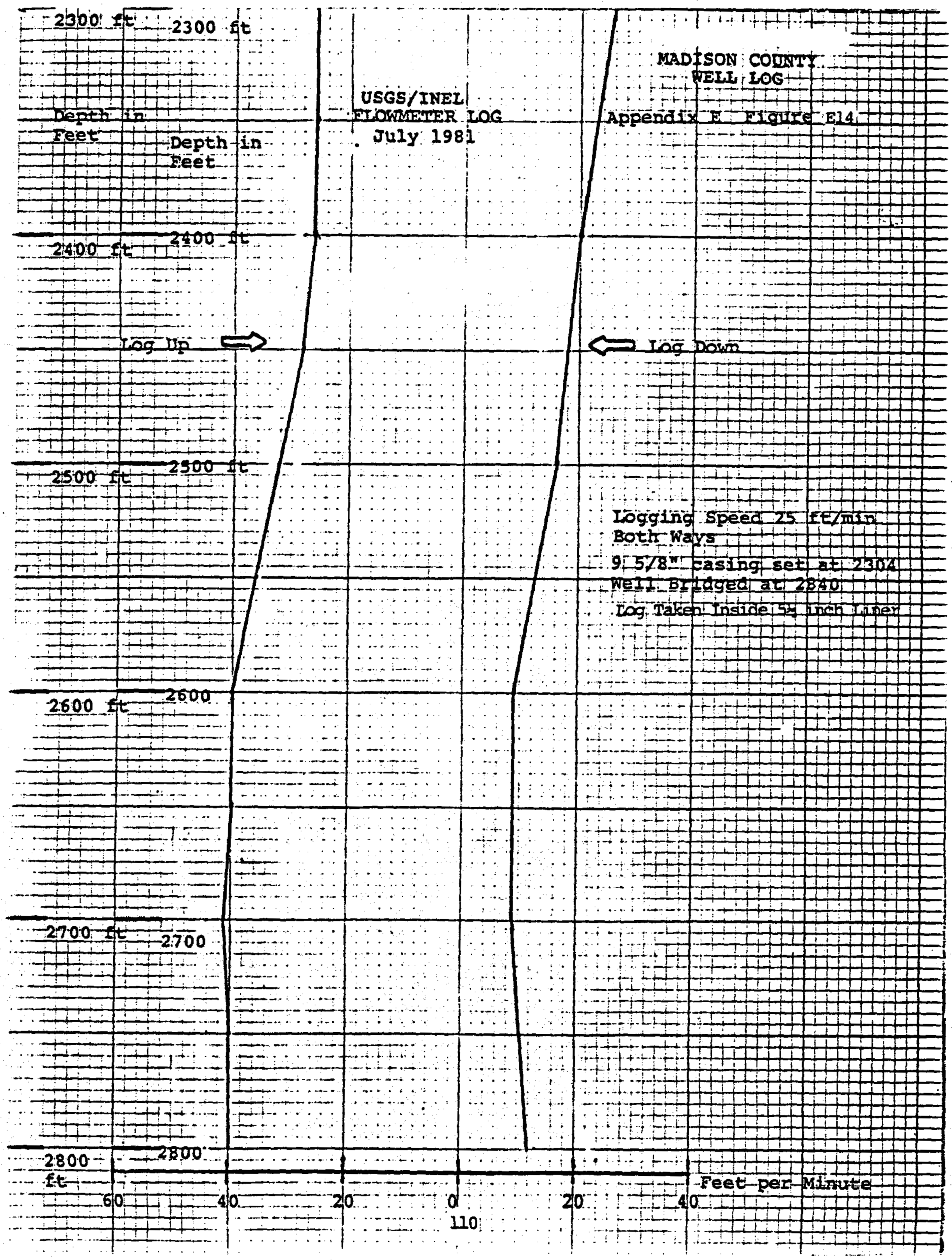
Appendix E Figure E13
MADISON COUNTY
WELL LOG
Taken by the USGS
CALIPER



Appendix E Figure E13
(continued)
MADISON COUNTY
WELL LOG

CALIPER

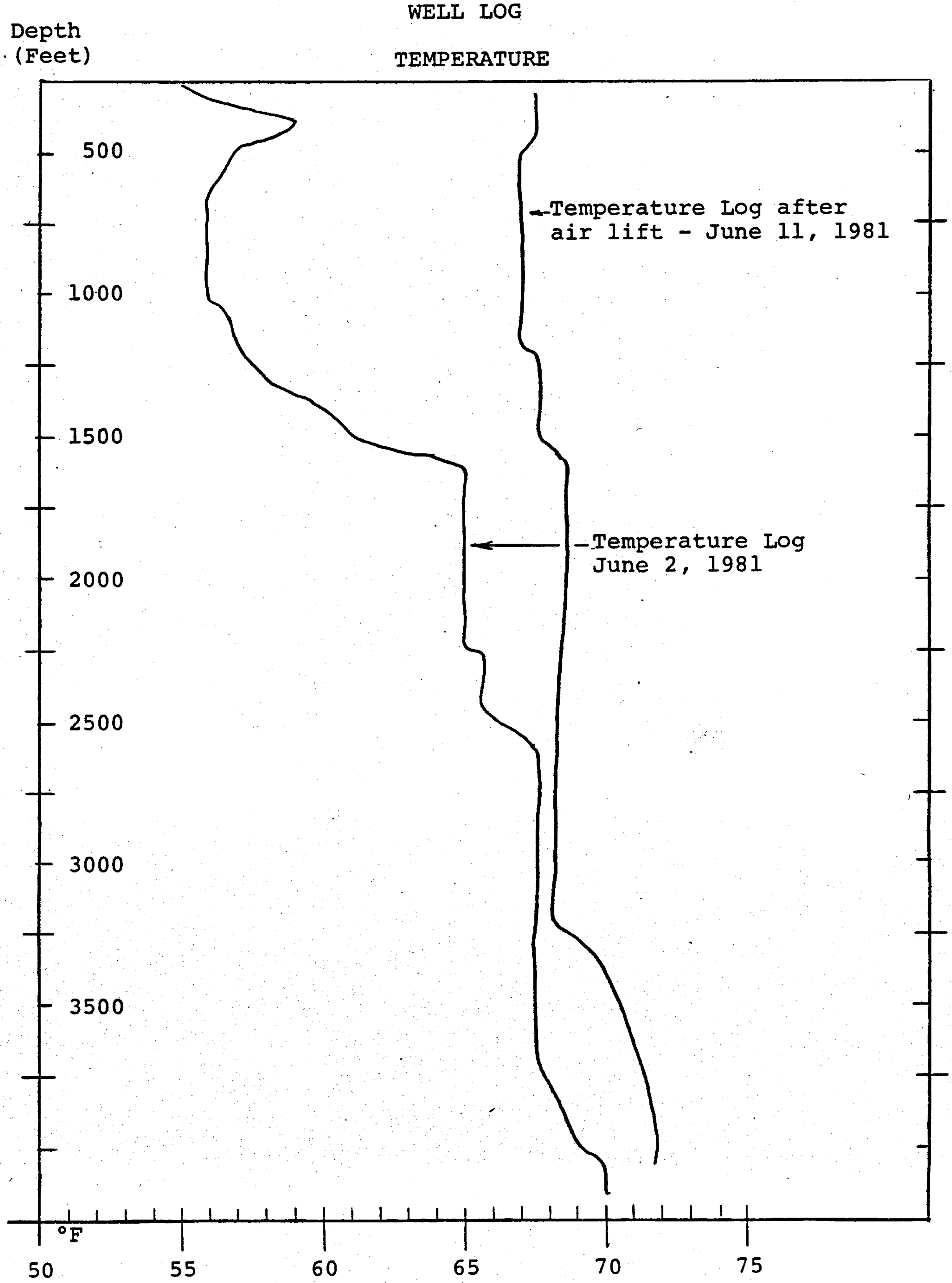




MADISON COUNTY
WELL LOG
Appendix E Figure E14
USGS/INEL
FLOWMETER LOG
July 1981
2300 ft
2300 ft
Depth in Feet
Depth in Feet
2400 ft
2400 ft
Log Up
Log Down
2500 ft
2500 ft
Logging Speed 25 ft/min
Both Ways
9 5/8" casing set at 2304
Well Bridged at 2840
Log Taken Inside 5½ inch Liner
2600 ft
2600
2700 ft
2700
2800 ft
2800
60
40
20
0
20
40
Feet per Minute

Appendix E Figure E15

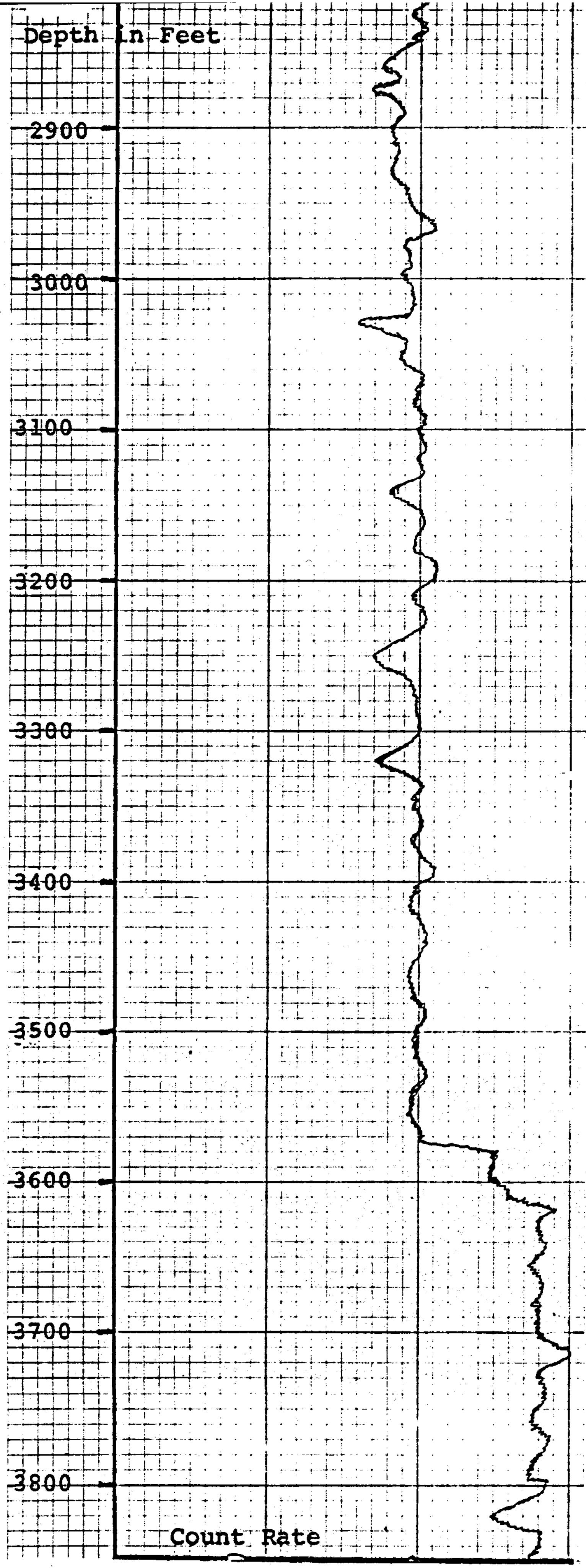
MADISON COUNTY
WELL LOG



Appendix E Figure E16
MADISON COUNTY
WELL LOG

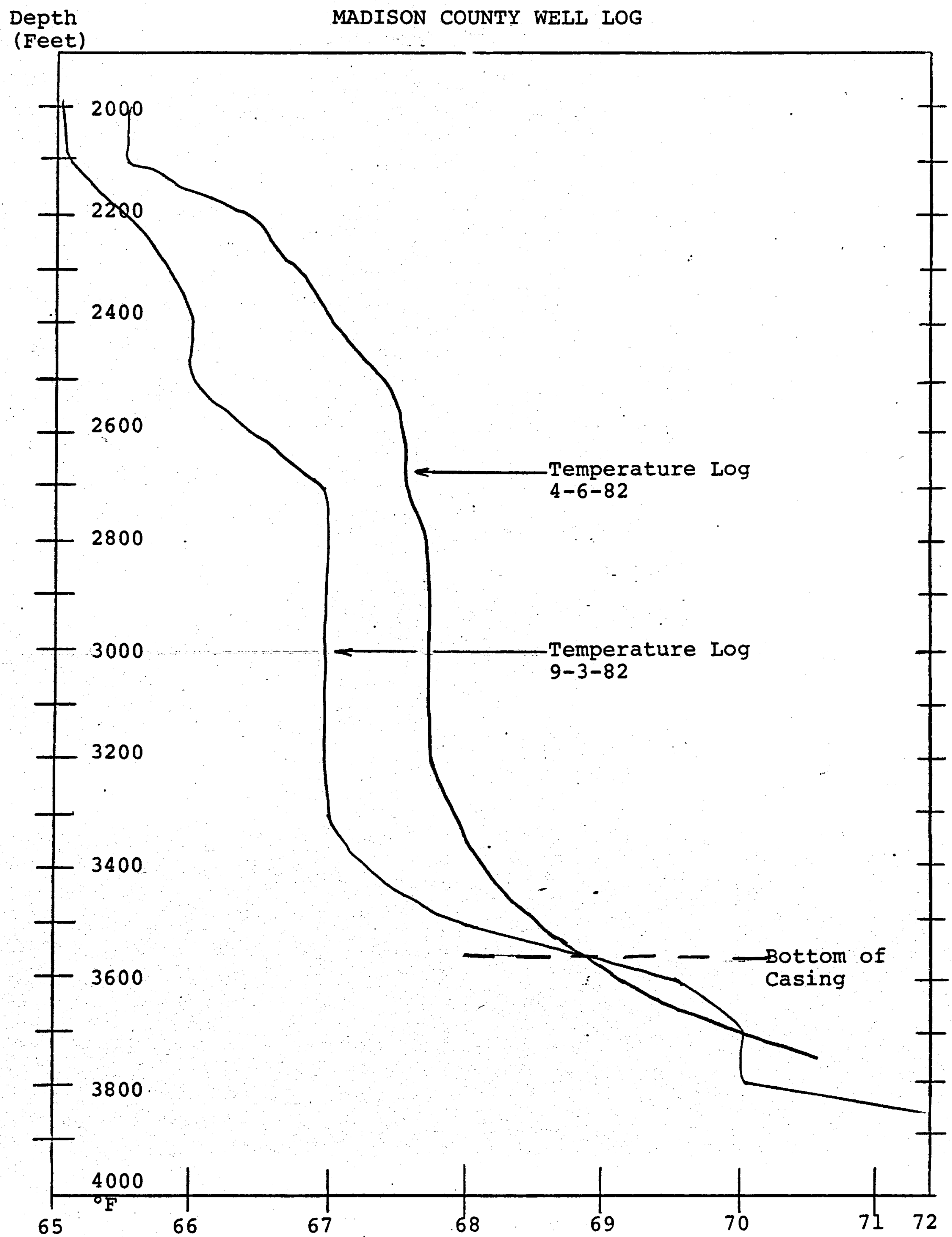
Taken by the USGS
GAMMA

6/4/81



Appendix E Figure E17

MADISON COUNTY WELL LOG



ENERGY SERVICES
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Energy Engineering and Development
Airport Plaza #2 1084 North Skyline Drive
Idaho Falls, Idaho 83401
(208) 529-3064

Appendix F

MADISON COUNTY GEOTHERMAL WELL

FINAL AIRLIFT TESTING

Week of April 12-16, 1982

Well is cased to 3,540 ft.

April 12 - Initial water level 12 ft. from surface.

Started airlift at 10:40 a.m. with pipe set at 140 ft and a 300 scfm compressor.

Time	Temperature	Flow Estimate	Comments
10:40 a.m.	53°F	200 gpm	
11:00	61°F	200 gpm	Some dirt in water
11:20	62°F	200 gpm	Water color turned black
12:30	67°F	300 gpm	Water color cleared
2:40	68°F	300 gpm	
4:30	68°F	300 gpm	Test terminated (shutdown)

Total well volume = 9,227 gallons. Total volume pumped during this day = 120,000 gallons. Number of turnover of the well is 13 times.

April 13

Started airlift at 10:15 a.m.

Time	Temperature	Flow Estimate	Comments
10:15 a.m.	60°F	300 gpm	
11:40	66°F	300 gpm	
12:00	68°F	300 gpm	
4:30	68°F	300 gpm	Shutdown

Total well volume = 9,227 gallons.
Total volume pumped this day = 126,000 gallons
Number of turnover of well is 13.65 times

April 14 (continuous airlift through April 16)

Air lift started at 10:00 a.m.

Time	Temperature	Flow Estimate	Comments
10:00 a.m.	60°F	300 gpm	
12:00	68°F	300 gpm	
5:30 p.m.	68°F	300 gpm	
8:00	68°F	300 gpm	
12:00	68°F	300 gpm	

April 15

1:00 a.m.	68°F	300 gpm	
10:00	70°F	'	
12:00	70°F	'	
2:00 p.m.	70°F	'	
4:00	70°F	'	Fluctuates up to 72°F
6:00	70°F	'	
10:00	70°F	'	
12:00	70°F	'	

April 16

1:00 a.m.	71°F	300 gpm	
1:30	71°F	'	
2:00	72°F	'	
2:30	71°F	'	
3:00	71°F	'	
4:00	70°F	'	
5:00	70°F	'	
7:00	70°F	'	
9:00	70°F	'	
12:00	70°F	'	
1:00 p.m.	70°F	'	
2:00	70°F	'	
2:30	70°F	'	Shutdown

Total well volume = 9,227 gallons
Total volume pumped during 52½ hours = 945,000 gallons
Number of turnovers of the well are 102.4 Times.

MADISON COUNTY GEOTHERMAL WELL

AIRLIFT TESTING

Appendix F (continued)

Maximum temperature seen = $72^{\circ}F$
Minimum temperature seen = $53^{\circ}F$
Maximum flow rate = 300 gpm (±25%)
Minimum flow rate (initially) = 200 gpm (±30%)
Total gallons removed = 1,191,000 gallons (±25%)
Total number of well turnovers = 129.07

PH of water was 6.8
Conductivity was 420 μmhos/cm (corresponds to 275 ppm or mg/liter TDS)

The flow rates are estimates, based on deduced velocities from the 6-inch pipe and the estimated fraction of water in the discharge air to water stream.

Drawdown could not be estimated during the airlift. Based upon the relative discharges for various amounts of air, it appears that the well's specific capacity is between 5 and 10 gpm/ft of drawdown.