GL02733

DP

PROGRAM PLAN - USAF-TAC

DEVELOPMENT OF A GEOTHERMAL SPACE HEATING SYSTEM AT MOUNTAIN HOME AIR FORCE BASE

1.0 Executive Summary

The potential for the existence of geothermal waters beneath Mountain Home AFB has been postulated for years. This project will establish the characteristics of the geothermal resource under the base and if favorable for development, will culminate in the use of the resource for space and hot water heating of the residential areas on the base.

The project will be developed in three phases. Phase I focuses on reservoir exploration and assessment activities including the drilling of small-diameter thermal gradient holes and on the conceptual design of the space and hot water heating system. This work will provide an updated assessment of the potential for a reservoir beneath Mountain Home AFB, a refined estimate on system economics based on data from the small-diameter holes, and a specific location will be selected for the future drilling of a production well. The total estimated time for Phase I is one year, and the estimated cost is $350,000.

Phase II involves the drilling of the production well, well testing and analysis necessary to make predictions concerning the long-time capabilities of the reservoir. This information will be integrated into an update of the system conceptual design and system economics. The total estimated time for Phase II is 14 months, and the estimated cost is $669,000 (includes a 25% contingency).

Phase III provides the detail design, construction, installation and testing of the space and hot water heating system. The total estimated time for Phase III is 25 months, and the estimated cost is $9,259,000 (includes a 25% contingency).

2.0 Introduction

The proposed program is designed to provide the USAF with supplemental space and hot water heating for the residential portion of Mountain Home AFB through the utilization of geothermal energy.

A three-phased approach is proposed. Phase I will focus on reservoir exploration and assessment activities and on the conceptual design of the space heating system.

Phase II will provide a production well and the necessary reservoir engineering to proceed with Phase III. Phase III is the most expensive portion of the program, for it provides for the detail design and construction of the space heating system.

Figure 1 shows the overall plan for the Mountain Home AFB geothermal space heating scenario from initial exploration and assessment activities through system design and construction.

3.0 Scope of Work

This section discusses the scope of work necessary to accomplish the objective outlined in Section 2.

3.1 Phase I Work Breakdown Structure (WBS)

3.1.1 Exploration and Assessment

The potential for the existence of geothermal waters beneath Mountain Home Air Force Base has been postulated in numerous reports for the past several years. To date however, no direct evidence of a geothermal resource has been found, no detailed conceptual resource models have been developed, and no drilling has taken place at sufficient depth to test for any occurrence of a geothermal resource. This proposal covers the work necessary to develop geological data aimed at siting thermal gradient test holes and then to test the deep thermal regime at Mountain Home AFB by drilling these small-diameter thermal gradient holes.

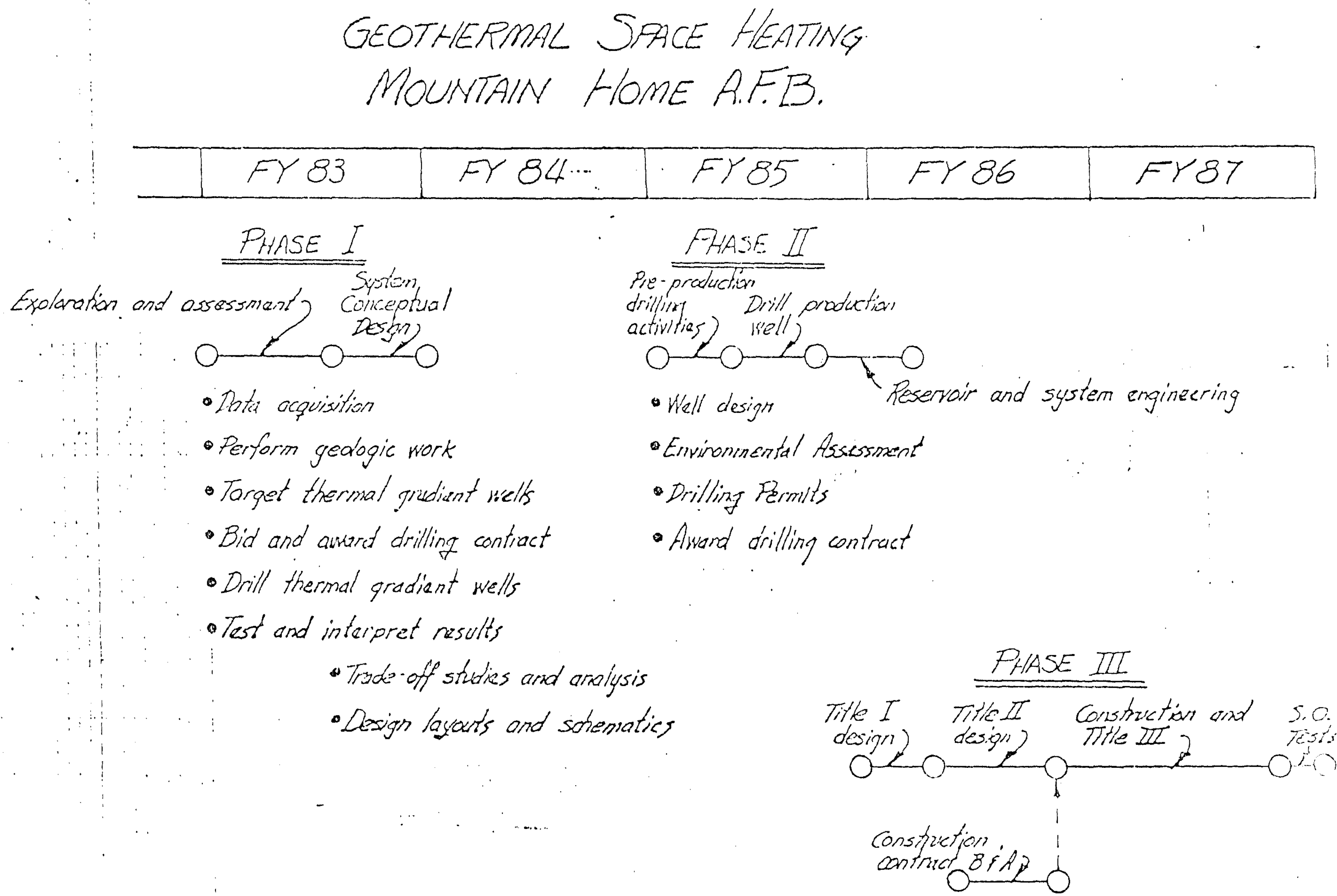


Fig. 1 - Overall Geothermal Space Heating Plan

The geologic portion of this work will be divided into three components:

1. Collection, synthesis and interpretation of available data;
2. Generation of new geological, geochemical and geophysical data as necessary to fill gaps in the existing data base and to allow sites to be selected for drilling thermal gradient test wells, and;
3. Drilling of 2 or 3 small-diameter thermal gradient test wells to aid in selection of sites for the drilling of production and injection wells.

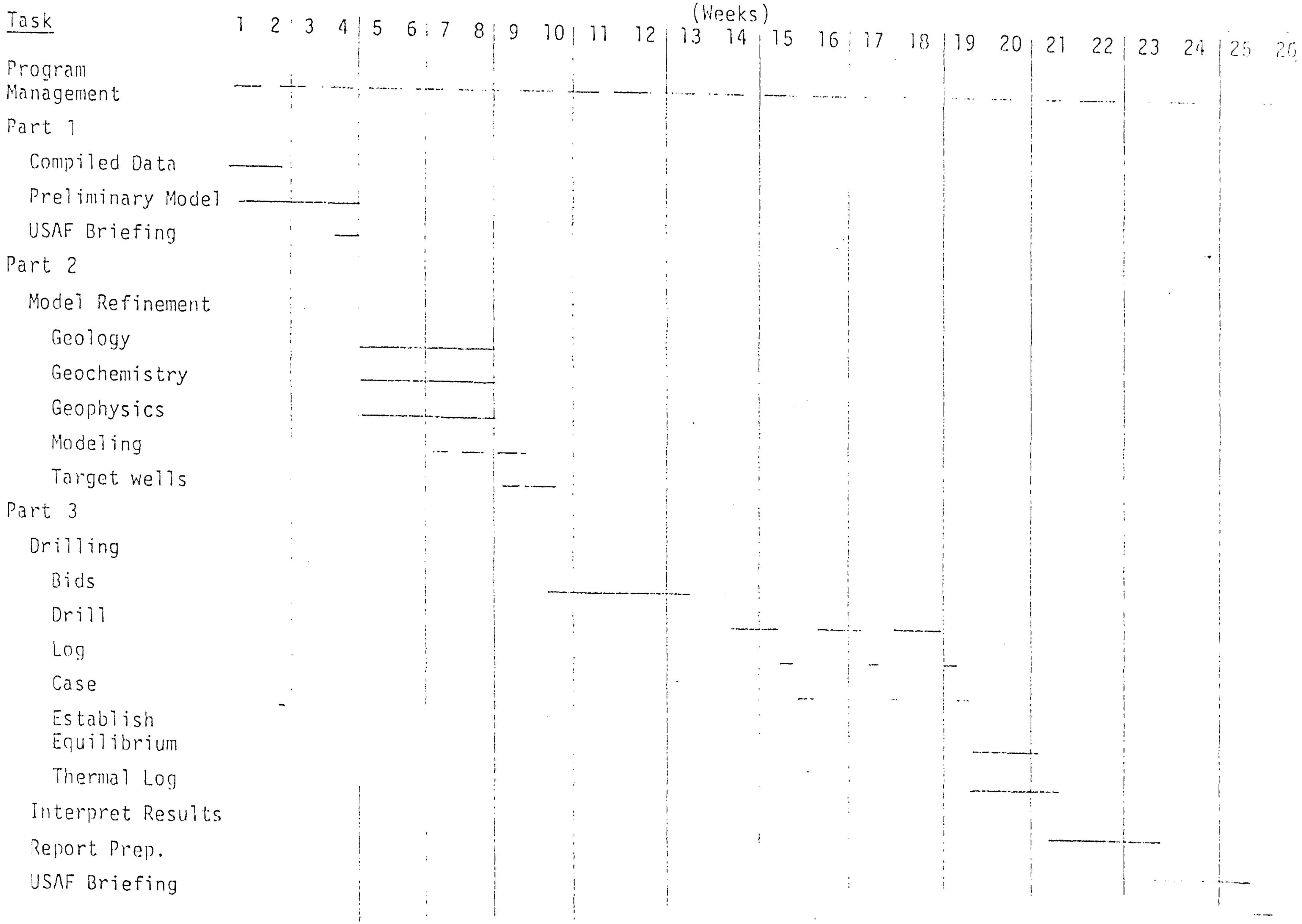
The product of this project will be a report to the Air Force, discussing not only the detailed results of the geological program, but also the economics and engineering of developing the deep geothermal resource. Most importantly, the report will contain recommendations regarding whether to proceed to production drilling, and will suggest how the production drilling phase of the program should be conducted. Figure 2 shows the schedule for this work.

Part 1 - Collection, Interpretation and Synthesis of Available Data

The goal of Part 1 of the proposed study is to develop a preliminary model of geothermal resources in the vicinity of Mountain Home Air Force Base for use in estimating the liklihood of occurrence of a resource on or near the base proper and for estimating the water temperature, quality, and productivity that might be expected at depth. Part 1, based entirely on existing data, is composed of data compilation, interpretation and model development stages. A briefing will be given to Mountain Home personnel at the conclusion of this part.

Data Compilation

Because there are very little data on geothermal potential at Mountain Home AFB project, most of the existing data to be compiled and interpreted will be regional in nature. Data on the geothermal, hydrologic, geological,



Assumptions are that drill bids on street for two weeks, driller immediately available, and no institutional delays, either Air Force, Department of Energy, State Federal or local regulations or land status problems will arise. Three holes drilled at eight days each.

Figure 2. Exploration and Assessment Schedule

geochemical and geophysical environments of the Snake River Plain in the vicinity of Mountain Home AFB exist in published and unpublished formats. Most published data on the geothermal resources and many reports on geological, geochemical, and geophysical characteristics of the Snake River Plain are on file at the ESL library. Unpublished well logs and other data including geochemical data exist at the Idaho Department of Water Resources in Boise. The U.S.G.S. District Office in Boise has had professionals working on the hydrology of the Snake River Plain for many years, and has both unpublished and open-file data pertinent to this project. The U.S. Department of Energy in Idaho Falls has data from two deep geothermal wells in the Snake Plain, which pertain to possible drilling conditions at Mountain Home. Other important sources of information are studies that have been made of the Boise, Twin Falls, Bruneau-Grandview and other hydrothermal systems in the Snake River Plain. These sources of information will be used and all relevant data will be assembled.

Preliminary Model Development

The existing data will be integrated and interpreted, in order to develop a likely target model for the existence of geothermal resources beneath or near Mountain Home AFB. This model will be based on geologic, structural and stratigraphic data, and regional geochemical and geophysical information and will include input from the known geothermal systems on the Snake River Plain.

USAF Briefing

The results of Part 1 will be presented to the USAF at Mountain Home AFB. This briefing will keep USAF apprised of progress on the program.

Part 2 - Selection of Sites for Slim-hole Thermal Gradient Drilling

The goals of Part 2 of this study are to refine the target model for geothermal resources developed in Part 1 by collecting appropriate new data on Mountain Home AFB, and to test the thermal component of the resource model by drilling 2 or 3 deep thermal gradient holes. Geological, geochemical, and geophysical studies will be undertaken to refine the model. Subcontracting and drilling of thermal gradient holes will be the major time and financial commitment in Part 3. A comprehensive final report will be prepared.

Model Refinement

The target model developed in Part 1 will be based on identification of likely water-bearing rock units that may exist at depth, location of fault and fracture channels that could allow upward circulation of deep, warm waters into shallower horizons and other appropriate data. New data to be compiled during Part 2 will be used to refine the resource model and to locate specific fracture channels, in order to site optimally the thermal gradient holes.

Geologic data on stratigraphy will be supplemented through field investigation of the anticipated deep aquifers where they crop out along the Snake River Plain. Fault and fracture analysis will be done through interpretation of aerial photographs and satellite images.

Appropriate new groundwater geochemistry data will be obtained from existing cold and warm wells and springs, in order to refine water-rock interaction models, to postulate the kind of rocks the waters have circulated through and to perform chemical geothermometer analyses. This will help refine expected sursurface temperature estimates.

Geophysical studies will emphasize identification of deep fractures along which water could circulate, and, if detectable, deep thermal aquifers. Appropriate wells on and near Mountain Home AFB for which no available precise data on water temperature or thermal gradient measurements can be found, will have such measurements made. Relevant private sector geophysical data such as oil company seismic data, will be identified and purchased (if appropriate) and interpreted during Part 2. New Part 2 site-specific data will be used to supplement the regional data of Part 1, and modify the preliminary resource target model as appropriate for the anticipated conditions at the base.

The refined geologic model will be used to select the optimum sites for drilling thermal gradient holes.

Part 3 - Thermal Gradient Drilling

Relatively deep, small-diameter thermal gradient holes are commonly used by the geothermal industry in exploration in terrains such as that at Mountain Home AFB, where a shallow cold-water aquifer may mask deeper thermal waters. It is anticipated that up to three such holes, as deep as 2000 feet, may be drilled during Part 3 of this program. These holes will provide temperature, heat flow, rock property, and water chemistry data, which will be used to infer the nature of any deeper geothermal resource.

Although well design and bid package preparation are relatively straightforward for thermal gradient holes, commencement of drilling will be controlled by bid responses and drilling mobilization time. It must be emphasized, even at this early stage, that drilling costs usually increase dramatically during freezing weather. Drilling of the gradient holes therefore, should be completed prior to mid-November 1982, or following March 1983.

Preliminary evaluation of drilling conditions and programs suggests that approximately eight days will be required for drilling, geophysical logging, and casing each hole. This time estimate is subject to much variation, depending on lithologies encountered and attendant drilling problems.

Drilling disturbs the natural thermal conditions around a well, by the introduction of surface temperature drilling fluids. It is necessary, therefore, to allow time for the wells to reach thermal equilibrium before accurate thermal gradients can be measured. Two weeks are allowed in the schedule for thermal equilibrium to be reached; this should be adequate. Once thermal equilibrium is reached, detailed temperature profiles of the wells will be made.

Data Interpretation, Report Preparation

The data from the drilling program will be interpreted to modify the resource target models as required, and to infer the nature of deeper geothermal resources near the base, as appropriate. The most likely site for the production well will be identified.

Report Preparation, USAF Briefing

All of the data from the program will be combined into a final report to the USAF, which will include an estimate of geothermal resources likely to be encountered at the base. This report will be presented to the USAF at a briefing at Mountain Home AFB.

3.1.2 System Conceptual Design

Upon receipt of preliminary site specific information from the exploration and assessment activities, work will proceed on the conceptual design of the space and water heating system for the base. Trade-off studies will be performed, economic evaluations updated to reflect input of new data, and analysis necessary to back up the conceptual design will be done.

The conceptual design report resulting from this effort will also include preliminary engineering schematics showing the distribution system, site plans, P&IDs, and individual housing sketches.

3.2 Phase II WBS

3.2.1 Pre-production drilling activities

A drilling consultant will be secured to insure a safe and successful design and completion of the well. It is well understood that the inclusion of local drilling expertise in a project of this magnitude is very cost effective.

The drilling consultant will aid   in the following functions which will include but not be limited to: designing the well, preparing and distributing the drilling contractor bid invitation, selection of drilling contractor, supervision of drilling and geophysical logging operations, supervision of casing the drill hole, and ascertaining that all drilling and testing operations comply with all state and federal regulations.

The advance planning of all aspects of the drill hole will assure the proper match between the drill hole, geologic conditions and planned fluid production, as well as provide input for the Environmental Assessment and permitting processes. The ultimate controlling factor affecting the well design is the size of casing required to produce geothermal fluid at the prescribed rate. That objective, along with knowledge of the stratigraphic section to be penetrated and special drilling problems provide the input for a set of programs that define the drilling and completion of the well. The drill bit program optimizes the types of bits to be used in each depth interval or formation. The drilling fluid program defines the drilling fluids to be used to most efficiently drill each formation; special emphasis will be placed on controlling lost circulation. The casing program will detail the size(s) and length(s) of casing to be placed in the drill hole and at what depths. The cementing program will define in detail the procedures and equipment to be used to cement the casing into the drill hole.

An environmental assessment document will then be prepared according to the requirements of AFR 19-2. It is anticipated that the document will include eight sections as follows:

1. Introduction - Brief overview of the project. The discussion would include such topics as program objectives, location and schedule of major development activities.

2. Description of the Proposed Activity - Discussion of the regions drilling history, exploration program, proposed well design, drilling schedule, well testing, fluid disposal, well control, etc.

3. Description of the Existing Environmental and Potential Environmental Concerns - Address geological hazards, air quality, and water quality protection and concerns, floral and faunal impacts, etc.

4. Alternatives - Reaffirm that the trade-offs involved in developing the geothermal resource at that site are favorable compared to other energy options.

5. Restoration - Plans and procedures that would be used to restore the site and/or close the well (if well is to be abandoned).

6. Irreversible and Irretrievable Impacts - Describe such impacts that may result from the proposed development, if any.

7. Monitoring Program - Define the analyses to be performed on the geothermal fluids. Describe any other environmental monitoring programs planned or required for the project.

8. Regulations and Permits - As a minimum the following information should be provided:

   - Document the right to develop the geothermal resource
   - Approval of drilling activity
   - Fluid disposal approval
   - Air discharge waiver (if needed)

Finally, the necessary permit will be obtained, and a drilling contract for the production wells will be awarded after a formal bid process. The RFP for the drilling contract will provide the dimensions of the hole to be drilled, the procedures to be followed, and the anticipated schedule.

This stage of the project will optimize the prospects for an economically drilled, and successfully completed drill hole. The selection of a drilling contractor will be done by the project management team in conjunction with the drilling consultant.

3.2.2 Drill Production Wells

The necessary site preparation will be done prior to the arrival of the drill rig on the site; a mud pit and a secondary pit for fluid collection and cooling during well testing will be dug and lined (if necessary).

Drilling will then commence at the earliest date consistent with completion of the Environmental Assessment and securing necessary permits. All aspects of drilling will be supervised by ESL personnel with the assistance of the local drilling consultant. Appropriate hydrologic monitoring during drilling will be by Reservoir Engineering and Resource Development personnel.

Immediately following initial logging of the wellbore, the well will be completed by installing the production casing, cementing it in place and air-lifting to clean the production zone.

3.2.3 Reservoir Engineering

This task will be initiated upon completion of the well drilling and logging operations. The well will be tested in order to infer reservoir size, evaluate hydraulic characteristics, and assess long-term well production capability. Well testing will consist of a series of short-term (one hour to several days) pulse tests to provide early time data relative to boundary conditions and thermal effects. The data collected from the pulse tests will be utilized to select the optimum flow rate for a long-term constant rate flow test, approximately three to four weeks in duration.

Data will be collected to determine the following well parameters: specific capacity, well efficiency, productivity index, skin factor, wellbore storage, aquifer transmissivity (T) and storage coefficient (S), aquifer permeability (K), or thickness-permeability product (kh), and porosity-compressibility thickness-product (Oc_th).

Analysis of data will be divided into two parts: geologic results and interpretation of the drilling, logging, and rock and water sampling program, and results and interpretation of the aquifer testing program.

The analysis of the drilling and logging program will include details of the drilling program, downhole interpretation of the rock units encountered, interpretation of the well logs, and results of rock and water chemical analyses. An analysis of the drilling, with suggestions for procedures to be used in a wellfield development program, will be provided, and this information will be integrated into an update of the system conceptual design and system economics.

The results of the Phase II work will be reported to the USAF in a formal briefing at Mountain Home AFB along with recommendations concerning the Phase III Space Heating System Design and Construction activities.

3.3 Phase III WBS

The most costly phase of the geothermal space and hot water heating system is Phase III. The work involved in this phase will be Title I and Title II design including system and equipment specifications, design analysis, engineering drawings, etc. A construction contract will be awarded, Title III inspection and as-built drawings produced, and the completed system will be tested.

4. Cost Estimate

Costs estimates for Phases I, II, and III are as follows:

	Base	With Contingency
Phase I -	$ 350,000	$ 350,000
Phase II -	535,000	669,000
Phase III -	7,407,000	9,259,000
Total:	$8,292,000	$10,278,000

All estimates are in 1982 dollars.

Details of the cost basis for Phase I are shown on Table 1. This estimate includes a detailed analysis of the tasks that are necessary to select slim drill sites, drill the slim holes, select the production well drill site and assess project economics. The base costs for Phase II and III have been obtained from the optimistic case summarized in Section 5 of this proposal. Specific cost items for Phase II are summarized on Table 2. The Phase III costs include all of those remaining in the optimistic case.

To take into account the optimistic assumptions in this base case, the Phase II costs have arbitrarily been increased by twenty-five percent. This contingency is on top of the normal engineering contingency of 10% which is included in the base case.

Phase II cost estimates also include the assumption that a suitable surface disposal method can be found for water produced during well testing. If this is not the case, an injection well will be required before testing can begin.

TABLE 1

PHASE I COST ESTIMATE

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A. Resource Assessment

Part I - Preliminary Model Development

Salary & Benefits	$ 5,000
Supplies, Travel, Reporting	2,000
Consultants	2,000
Indirect, G&A	6,000
	$ 15,000

Parts II & III-Thermal Gradient Well Siting & Drilling

Salary & Benefits	33,000
Supplies, Travel, Reporting	9,000
Data Processing	2,000
Consultants	3,000
Indirect, G&A	2,800
	$ 75,000

Total Parts I, II, III:	$ 90,000

B. Engineering Contractor

Environmental Report & Permitting	$ 10,000
Hydrology	4,000
Conceptual Design, Engineering Studies	26,000
Management and Travel	20,000
	$ 60,000

C. Thermal Gradient Hole Drilling (up to 3 holes)	$200,000	170K
Total Phase I	$350,000	

Table 2

PHASE II COST ESTIMATE

Well Drilling	$ 350,000
Permitting & Environmental Analysis	20,000
Pumps & Piping	50,000
Testing & Analysis	50,000
Update System Conceptual Design & Engineering Analysis	50,000
Report	15,000
	$ 535,000

Note: These costs do not include site restoration, which would be required if the well was a failure and the program terminated. Approximate restoration costs are $25,000.

5. Projected System Economics

Estimates have been made of the total cost of providing residential space heating at Mountain Home AFB, using geothermal energy. The characteristics of the geothermal resource at the base itself are not known so two sets of cost projections were made, one with a set of cost conservative assumptions and one with optimistic assumptions. The assumptions used for each case are shown in Table 3.

Payback periods were calculated for each case:

Optimistic:	5.2 years simple payback	
	7.1 years discounted (7%) payback	
Conservative:	9.1 years simple payback	
	15.0 years discounted payback	

The optimistic case demonstrates that geothermal energy has the potential to be very attractive economically. The conservative assumptions result in an unacceptable payback and emphasize the need for careful analysis as the project proceeds. During Phase I more detailed engineering studies will be made to more precisely pinpoint the costs and study the factors which lead to the unacceptable payback. The key differences between the two cases relate to resource quality, in terms of depth, temperature, and water quality. Our current information supports the optimistic assumptions. Phase I resource evaluation and slim hole drilling will reduce the uncertainty in these assumptions, particularly in the area close to the housing where it will be most desireable to drill the production wells. A recommendation to proceed will be contingent on obtaining ten year or less discounted payback for the system.

The optimistic geothermal system can be expanded to accommodate load growth either by the addition of more production wells or a heat pump at the injection well site. The heat pump option could provide 165°F water at the injection site for about $2.70/MMBtu. This cost includes operating and capital costs. It does not include the cost of a distribution system to transfer the energy to the point of use.

Optimistic Case Description - The optimistic system consists of a heating system in which the geofluid flows through heating coils in each residence to provide space and water heating. The production well is located on one side of the residential area and the injection well on the other side. The system provides 50% of the peak heating load with 30% of the peak water heating load. Ninety-four percent of the annual load is provided by geothermal and existing furnaces provide peaking. Production well flow of 1200 gpm at 160°F water is assumed. One production well serves the entire residential area of 1538 units. The production and injection wells are located adjacent to the residential area. Capital and operating costs are shown in Tables 4 and 5.

Conservative Case Description - The geothermal fluid is assumed to be of poor quality and not suitable for use in a direct heating system. Heat is exchanged from the geofluid to an intermediate loop, and a heat pump and heat exchanger transfer heat from the intermediate loop to a heat delivery system. One well producing 500 gpm is used (with a heat pump) to heat 85% of the residences. A heat pump is cost effective with these conservative assumptions because a central heat exchange point is required with piping to both wells from that point, and multiple wells would be required without a heat pump. The production well is located 10,000 feet from the residential area, and the injection well is 800 feet away.

TABLE 3

Mountain Home AFB Geothermal Space Heating

Assumptions and System Descriptors

Parameter	Optimistic Case	Conservative Case
1. Number of Production Wells	1	1
2. Number of Injection Wells	1	1
3. Number of Residences Heated	1538	1307
4. Well Production Rate	1200 gpm	500 gpm
5. Well Injection Rate	1200 gpm	500 gpm
6. Wellhead Temperature	160°F	160°F
7. Production Well Depth	3500 ft	6000 ft
8. Injection Well Depth	3500 ft	6000 ft
9. Reinjection Temperature	100°F	60°F
10. Production Well Lift	400 ft	600 ft
11. Injection Pressure	100 psi	200 psi
12. Well Cost	$100/ft	$100/ft
13. Production-Injection Well Separation	5500 ft	10,800 ft
14. Production Well Proximity to use	200 ft	10,000 ft
15. Injection Well Proximity to use	200 ft	800 ft
16. Intermediate Heat Exchanger Required	No	Yes
17. Heat Pump Delivery Temperature	N/A	165°F
18. Heat Pump Return Temperature	N/A	100°F
19. Design Temperature	6°F	6°F
20. Annual Degree Days	5939	5939
21. Heat Loss Rate	561 BtuH/°F-Unit	561 BtuH/°-Unit
22. Geothermal Fraction of Design Load	50%	50%
23. Geothermal Fraction of Annual Load	94%	94%
24. Domestic Hot Water Load	19×10^6 BtuY/unit	19×10^6 BtuY/un
25. Water Heating Energy Delivery Rate	4.5 kW	4.5 kW

	Parameter	Optimistic Case	Conservative Case
26.	Well Maintenance (per well-year)	$1900	$30,000
27.	Heated Air Distribution System	Existing	New
28.	Building Spacing	Per Drawing	Per Drawing
29.	Operating and Maintenance Crew	Existing	Existing
30.	1982 Natural Gas Costs	$\$5.59/10^6$Btu	$\$5.59/10^6$Btu
31.	Natural Gas - Real Escalation	per Fed. Reg.	Per Fed. Reg.
32.	1982 Electricity Rate	2.4¢/kWh	2.4¢/kWh
33.	Electricity - Real Escalation	2%	2%
34.	1982 Oil Costs	$1.34/gallon	$1.34/gallon
35.	Oil - Real Escalation	2%	2%
36.	Discount Rate	7%	7%

TABLE 2

Mountain Home Air Force Base

Geothermal Space Heating

Capital Costs

Cost Item	Optimistic Case	Conservative Case
Resource Exploration & Identification (Phase I)	350,000	350,000
Permitting & Environmental Assessment	20,000	20,000
Field Development		
Production Wells	350,000	600,000
Injection Wells	350,000	600,000
Collection & Reinjection Piping	-	304,000
Production & Injection Pumps	112,000	79,000
Pump Installation (30%)	34,000	24,000
Subtotal-Exploration & Development	1,216,000	1,977,000
Equipment		
Distribution Piping	2,363,000	2,244,000
Filters	150,000	128,000
Heating System Pumps	-	9,000
Surge Tanks	6,000	13,000
Heat Pumps	-	394,000
Residential In-House Equipment & Hookup	1,166,000	1,645,000
Equipment Building	N/A	17,000
System Heat Exchangers	N/A	279,000
Subtotal-Equipment	3,685,000	4,729,000
Instrument & Control (10% Equip)	368,000	473,000
Labor (30% Equipment + I&C)	1,216,000	1,561,000
Subtotal-Direct Costs (except Field Development)	5,269,000	6,763,000
Construction Management (15% Direct Costs)	790,000	1,014,000
Design (5% Direct Costs)	263,000	338,000
Subtotal Installed Equipment	6,322,000	8,115,000
Field Development (from above)	1,216,000	1,977,000
Subtotal Project Costs	7,538,000	10,092,000
Contingency (10%)	754,000	1,009,000
TOTAL	$8,292,000	$11,101,000

TABLE 5

Mountain Home Air Force Base

Geothermal Heating Operation Costs

Cost Item	Optimistic Case	Conservative Case
Geothermal System		
Electricity at 2.4¢/kWh		
Water Heating - Peaking	$ 9,000	$ 7,700
Production Well Pump	20,600	10,700
Injection Well Pump	7,400	7,600
Heat Pump	N/A	161,100
Heating Loop Circulation	N/A	1,300
Subtotal Electricity	$37,000	$188,400
Natural Gas at $5.59/$10^6$Btu		
Space Heating - Peaking	14,300	12,200
Water Heating - Peaking	3,400	2,900
Subtotal Gas	$17,700	$ 15,100
Oil at $1.34/gallon		
Space Heating - Peaking	62,100	52,800
Subtotal Oil	$62,100	$52,800
Maintenance		
Wells	3,800	60,000
System (over existing system)	40,000	47,000
Subtotal Maintenance	$43,800	$107,000
Total Annual Costs	$160,600	$363,300
Existing System		
Electricity at 2.4¢/kWh	148,600	126,300
Oil at 1.34/gallon	1,034,800	879,600
Gas at $5.59/$10^6$Btu	294,700	250,500
	$1,478,100	$1,256,400

Economic Analysis

A 20-year economic analysis was performed for each of the cases comparing the projected geothermal system capital costs and operations and maintenance costs vs continued use of natural gas and oil. This analysis used a 7% discount rate for future projected savings and incorporated escalation rates for natural gas prices from the Energy Information Administration Report, "The Current State of the Natural Gas Market"[1]. As this report provided projections only to 1990, no real escalation was used beyond that time. Electricity costs and oil costs were escalated at 2% per year. All costs are in present dollars (no inflation).

In the tabulations for each case which follow, the "savings" represent the cost of not operating the present system; the "expenses" represent the cost of operating the geothermal system including fuel for the peaking system, electricity and maintenance; and the net revenue ins the difference between savings and expenses. NPV is the present value of the Net Revenue discounted at 7%. Simple and discounted (at 7%) payback periods have alos been calculated.

1. The Current State of the Natural Gas Market, December 1981, DOE/EIA-0313.

1982 $'S		NATURAL GAS YEAR	WELLHEAD PRICE	ESC. FACTOR	CUM ESC FACTOR	ELECTRICAL @ 2 % CUM ESC FACTOR
SAVINGS		1982	1.91	1.00	1.00	1.00
GAS	294700	1983	2.09	1.09	1.09	1.02
OIL & EL	1183400	1984	2.26	1.08	1.18	1.04
OTHER	0	1985	3.62	1.60	1.90	1.06
TOTAL	1478100	1986	3.83	1.06	2.01	1.08
		1987	3.98	1.04	2.08	1.10
EXPENSES		1988	4.15	1.04	2.17	1.13
GAS	17700	1989	4.31	1.04	2.26	1.15
ELECTR.	37000	1990	4.47	1.04	2.34	1.17
OIL	62100					
OTHER	43600					
TOTAL	160600					
INITIAL INVESTMENT	5292000					

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MTN HOME A. F. B. OPTIMISTIC 2

YEAR	SAVINGS	EXPENSES	NET REV		
1982	1478100	160600	1317500		
1983	1529541	164250	1365291	NPV @ 7%	9722465
1984	1579912	167847	1412065		
1985	1814375	182512	1631863	SIMPLE PAYBACK	5.21
1986	1871893	186562	1685331		
1987	1920656	190097	1730559		
1988	1973017	193861	1779157	D'CTD PAYBACK	7.14
1989	2024358	197576	1826783		
1990	2076232	201335	1874897		
1991	2076232	201335	1874897		
1992	2076232	201335	1874897		
1993	2076232	201335	1874897		
1994	2076232	201335	1874897		
1995	2076232	201335	1874897		
1996	2076232	201335	1874897		
1997	2076232	201335	1874897		
1998	2076232	201335	1874897		
1999	2076232	201335	1874897		
2000	2076232	201335	1874897		
2001	2076232	201335	1874897		

NPV @ 7%= 9722465

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NATURAL GAS

ELECTRICAL 2 %

1982 $'S	
SAVINGS	
GAS	250500
OIL & EL	1005900
OTHER	0
TOTAL	1256400
EXPENSES	
GAS	15100
ELECTR.	188400
OIL	52800
OTHER	107000
TOTAL	363300
INITIAL INVESTMENT	11101000

YEAR	WELLHEAD PRICE	ESC. FACTOR	CUM ESC FACTOR	CUM ESC FACTOR
1982	1.91	1.00	1.00	1.00
1983	2.09	1.09	1.09	1.02
1984	2.26	1.08	1.18	1.04
1985	3.62	1.60	1.90	1.06
1986	3.83	1.06	2.01	1.08
1987	3.98	1.04	2.08	1.10
1988	4.15	1.04	2.17	1.13
1989	4.31	1.04	2.26	1.15
1990	4.47	1.04	2.34	1.17

MTN HOME A. F. B. CONSERVATIVE 2

YEAR	SAVINGS	EXPENSES	NET REV
1982	1256400	363300	893100
1983	1300125	369547	930578
1984	1342942	375811	967130
1985	1542239	391582	1150657
1986	1591130	398362	1192768
1987	1632579	404769	1227810
1988	1677087	411439	1265648
1989	1720727	418137	1302591
1990	1764821	424943	1339878
1991	1764821	424943	1339878
1992	1764821	424943	1339878
1993	1764821	424943	1339878
1994	1764821	424943	1339878
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1999	1764821	424943	1339878
2000	1764821	424943	1339878
2001	1764821	424943	1339878

NPV @ 7%= 1622517

NPV @ 7%	1622517
SIMPLE PAYBACK	9.12
D'CTD PAYBACK	15.04