YOUNG MEN'S CHRISTIAN ASSOCIATION

OF KLAMATH COUNTY

1221 SOUTH ALAMEDA STREET
P.O. BOX 366
KLAMATH FALLS, OREGON 97601
PHONE: 884-4149

DOE/ET/27046--T2

DE82 012892

July 9, 1979

Mr. Michael J. Bonkoski, P. E.
Project Manager, Engineering and Facilities Mgmt. Div.
Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, California 94612

MASTER

Dear Mr. Bonkoski,

Please be advised by delivery of the following Environmental Assessment filed under U. S. Department of Energy Contract Number ~~ET-78-N-03-2047~~, that the Klamath County YMCA intends to comply with the stipulations and conditions set forth. The document has been examined by our project team and has been judged to be acceptable and within the limits of our project capability.

Should any problems or questions arise regarding this document or any other connected with the project, please feel free to contact me.

Sincerely yours,

Brian C. Fitz Gerald
Program Director
Klamath County YMCA Geothermal Project

General Director
Klamath County YMCA

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

KLAMATH COUNTY YMCA
GEOTHERMAL HEATING PROJECT
ENVIRONMENTAL ASSESSMENT

for
KLAMATH COUNTY YOUNG MENS
CHRISTIAN ASSOCIATION
1221 S. ALAMEDA
KLAMATH FALLS, ORE. 97601

UNDER U. S. DEPARTMENT
OF ENERGY CONTRACT NO.
ET-78-N-03-2047

by
Jimmie H. Shreve
Writer/Editor

July 10, 1979

NOTICE

PORTIONS OF THIS REPORT ARE ILLEGIBLE. It
has been reproduced from the best available
copy to permit the broadest possible avail-
ability.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

TABLE OF CONTENTS

Table of Contents - - - - -	page 2
List of Figures - - - - -	page 5
Summary - - - - -	page 6
1. Introduction- - - - -	
1.1 Site Location - - - - -	page 12
1.2 Program Objectives- - - - -	page 12
1.3 Participants- - - - -	page 17
1.4 Relationship to the National Geothermal Development Program - - - - -	page 18
1.5 Activity Schedule - - - - -	page 19
1.6 Projected Costs - - - - -	page 20
2. Description of the Proposed Activity.	
2.2.3 Reservoir Development and Operation	page 21
2.3.1 Resource Utilization-Construction -	page 30
2.3.2 Resource Utilization-Operation- - -	page 31
3. Description of the Existing Environment.	
3.1.1 Site plan - - - - -	page 36
3.1.2 Regional Demography - - - - -	page 37
3.2 Land Use- - - - -	page 39
3.3 Geology - - - - -	page 39
3.4 Hydrology	
1. Surface water- - - - -	page 43
2. Ground water - - - - -	page 48
3. Water use- - - - -	page 60
3.5 Meteorology - - - - -	page 71
3.6 Ecology	
1. Terrestrial- - - - -	page 73

3.	Description of the Existing Environment (contd)	
2.	Aquatic - - - - -	page 73
3.	Endangered species & habitats -	page 73
3.7	Regional Landmarks - - - - -	page 74
3.8	Social Profile - - - - -	page 74
1.	Community characteristics - - -	page 74
2.	Recreation- - - - -	page 76
3.	Ambient noise - - - - -	page 79
4.	Environmental Effects of the Proposed Activity.	
4.1	Physical Environment - - - - -	page 80
1.	Land use- - - - -	page 80
2.	Water use - - - - -	page 81
3.	Water quality - - - - -	page 83
4.	Natural resources - - - - -	page 83
5.	Air Quality - - - - -	page 83
4.2.1	Ecological Terrestrial Environment - - -	page 84
4.3	Socioeconomic Environment- - - - -	page 84
4.4	Potential Mishaps- - - - -	page 85
5.	Environmental and Effluent Measurement and Monitoring Programs - - - - -	page 86
6.	Reclamation- - - - -	page 87
7.	Project Alternatives	
7.1	Delay- - - - -	page 88
7.2	Nonconstruction- - - - -	page 91
8.	Irreversible and Irretrievable Commitment- - -	page 94
9.	Trade-Off Analysis - - - - -	page 94
10.	Compliance With Regulations and Other Controls	page 96
	References - - - - -	page 97

Appendices

- A. Chemical Analyses of Geothermal Wells.- - - - - page 98
- B. Geo-Heat Utilization Center comments on Project.- page 103
- C. Key Project Personnel.- - - - - page 108

LIST OF FIGURES

1.	State Vicinity Map - - - - -	page 14
2.	City Vicinity Map- - - - -	page 15
3.	Local Vicinity Map - - - - -	page 16
4.	Oregon K.G.R.A.'s- - - - -	page 23
5A.	Project Site Plan- - - - -	page 25
5B.	Drilling Mud Lagoon- - - - -	page 28
6A.	Noncondensable Gas Concentrations- - - - -	page 34
6B.	Pollution Emissions from Existing System -	page 35
7.	Regional Population Centers- - - - -	page 38
8.	Land Use Map - - - - -	page 40
9.	Seismic Risk Map - - - - -	page 42
10.	Geological Map of the Klamath Falls Area -	page 44
11.	Local Radium and Radon Concentrations- - -	page 46
12.	Soil Types Map - - - - -	page 47
13.	Ground Water Recharge- - - - -	page 49
14.	Ground Water Units - - - - -	page 52
15.	State Fish & Wildlife Department Comments on Project- - - - -	page 75
16.	City of Klamath Falls Planning Department Comments on Project - - - - -	page 106
17.	State Highway Division Comments on Project	page 107
18.	Economic Impact of Project Delay - - - - -	page 90

SUMMARY

PROJECT DESCRIPTION

The YMCA Geothermal Heating project proposes to obtain approximately 57% of the total facility energy usage through direct application of the Klamath Falls KGRA. This will be accomplished under PON No. ET-78-N-03-2047 through the design and construction of a retrofit and injection system for the utilization of an existing 110 degree F. geothermal energy source at the project site.

The existing 2016 foot well will be outfitted with a turbine pump with variable speed drive. The well head will be enclosed by a 10' x 10' building. The geothermal fluid, pumped at a peak rate of 350 gpm will be transported to the YMCA Facility through 5" diameter schedule 40 black iron pipe fitted with victaulic couplings for expansion. All underground supply pipe will be equipped with magnesium anodes for galvanic protection and will be insulated with 1" thick calcium silicate insulation, with two layers of 45# roofing felt applied with asphaltic compound. All supply lines within the building will be insulated with 1" fiberglass insulation material with a cloth jacket.

The fluids will pass through a heating coil and heat exchanger system to provide heat for the 30,000 square foot YMCA facility as well as for the 90,000 gallon swimming pool. The spent geothermal fluids will then be conveyed through a 4" black iron return pipe to be returned to an acceptable aquifer through the 1500 foot injection well.

The capital cost of the intended system is as follows:

A. Subcontracted Items (Engineering, Construction, Legal Services)	236,297
B. Direct Labor - - - - -	9,260
C. Labor Overhead - - - - -	2,152
D. Travel - - - - -	<u>2,000</u>
Total	\$249,709

Based on a 50 year life cycle and allowing for a 6% inflation of energy costs per year, this system will produce a total energy savings of \$3,106,000, paying for the original installation cost in thirteen (13) years. Replacement of major components such as the pump, coils, and heat exchangers after 25 years of operation would cost an estimated \$133,100 leaving a net savings over the 50 year life of the system of \$2,972,900.

ENVIRONMENTAL IMPACTS

1. Proposed Project

Construction

Short term noise emissions can be anticipated during well drilling operations. Topography of the site, distance to neighbors, and the proximity of the site to a busy State highway all minimize the impact of noise emissions on the immediate neighborhood. Well drilling is a common practice in the Klamath Falls area and is an accepted part of everyday life. Annoyance will further be avoided by limiting the well drilling work schedule to normal work hours, 8:00 a.m. to 5:00 p.m., during the normal work week, Monday thru Friday.

Operation

The operation of the proposed project will lower air pollution emissions by the YMCA facility due to a significant cut back in the use of natural gas. On a long term basis the project, as part of the City Geothermal Heating district, will lower air pollution emissions currently attributed to domestic fossil fuel and wood heating systems.

The primary potential operational impact which must be considered is the influence of pumping and injection on neighboring geothermal wells. Negative impact would be interpreted as a drop in temperature of water level to a degree such as to impair an adjacent users ability to gainfully utilize the heat resource of the geothermal aquifer.

Preliminary testing of the City production field indicates such influence will not be significant. These tests indicated minimal vertical communication between shallow wells, such as those found adjacent to the YMCA project site, and the deep production aquifer to be utilized by the project. A monitoring program will be instituted upon completion of the injection well to detect any influence of the project on neighboring wells.

In the event that production or injection cause a demonstrable negative effect on an adjacent well owners ability to gainfully utilize the geothermal resource, then the following mitigation measures will be available:

- A. Applicable statutes relative to ground water and legal ownership will be adhered to. Current law states

that surface owners having appropriate water rights have the right only to extend their well should a neighboring well cause a drawdown.

B. The following are the procedural steps to be followed and if a complaint is received concerning possible negative impact on existing wells.

1. Meet with well owner to review complaint.

Review with owner the monitoring program and the collected data from such program. Analyze, as best possible, past history of well.

2. Review possible impact in relationship to proximity to production wells and distribution lines.

3. If impact is determined to be a result of the project the YMCA will offer connection to system to supplement heat loss. If well location and use geographically and engineering-wise demonstrates impractical hookup to the project, the YMCA will offer compensation based on condition, expected life and heat value of affected well.

The above are offered as possible negotiated mitigation measures. Should negotiations reach an impasse, applicable Oregon statutes shall be available for final resolution.

2. Delay of Project

The primary consideration for a delay in implementing the proposed project would be the possibility of a better understanding of the geothermal resource gained from the operation of the City Geothermal Heating District. Any such benefit

would be minimal in comparison to the overall understanding of the hydrologic characteristics as could be ascertained by a comprehensive integrated testing program involving both the YMCA and the City Projects.

Any delay of the proposed project will significantly increase the cost of the project due to the inflation rate of construction costs and materials, and the cost of continued reliance on expensive fossil fuels. A two year delay in project implementation would effectively raise the cost of the project by 23%, while a five year delay would raise the project cost by over 62%.

Project delay would, by continued use of fossil fuel to meet heating requirements, contribute to the poor air quality of a non-attainment area. Delay of integrating the YMCA project into the City Heating District could further contribute to poor air quality conditions by allowing continued local reliance on wood and fossil fuel for domestic heating requirements, and could encourage widespread private development of the geothermal resource. Major private development would increase the possibility of one well affecting another and would make overall management of the resource difficult.

3. No Project

If the project is not constructed, continued reliance on fossil fuels by the YMCA to meet its heating requirements would be mandated. The resulting burden of ever increasing energy prices would significantly limit the ability of the YMCA to serve the Klamath Falls Community.

Continued use of fossil fuels by the YMCA facility would

continue present emissions of air pollutants associated with the burning of natural gas. This is significant considering that the project lies within a nonattainment area. Further, local emissions of air pollutants due to wood and fossil fuel used for domestic heating requirements would continue, and perhaps increase due to the unavailability of the proposed project for district heating applications.

Continued reliance on fossil fuels by the YMCA and by the community due to nonavailability of the proposed project as an alternative source of energy would be contrary to National Energy Goals to decrease reliance upon ever dwindling supplies of domestic and imported fossil fuels for our energy needs.

Non-construction of the project would encourage widespread private development of the geothermal resource. This type of development would be expensive to the developers without the economy of size attributed to a district heating project. Multipoint development would increase the possibility of environmental impact and would make long-term reservoir management difficult.

1. INTRODUCTION

1.1 SITE LOCATION

The project site is located on the fourteen acre Klamath County YMCA facility in the eastern portion of the city of Klamath Falls, Klamath County, Oregon. The property lies between Alameda Street to the West, Eberlein Avenue to the South, and State Highway 39 to the Northeast, and generally lies in the Northwest quarter of the Southwest quarter of Section 34, Township 38 South, Range 9 East. State and local vicinity maps are included as Figures 1, 2, and 3.

1.2 PROJECT OBJECTIVES

The project consists of the design and construction of a retrofit and injection system for the utilization of an existing 110 degree F geothermal energy source at the project site. The system will include a 1500 foot reinjection well, approximately 800 feet of five (5) inch transmission pipeline, and heating system retrofit equipment consisting of appropriate heat exchangers, heating coils and necessary adaptation of the existing control system. The existing heating system would remain as a backup or booster component to the new system.

The project itself will consist of three phases. Phase I of this project consists of the drilling of an injection well in a location which may give access to a higher temperature resource than the existing production well. Should this occur, the proposed flow system would be reversed allowing the use of the hotter resource as

the production well. Phase II of the project will entail the physical design of the system, preparation of working drawings and specifications and issuing to contractors within the State for competitive bids. Phase III would be the actual construction of the system including the well pump and all components for a completed system. The specific objectives of the project are listed below:

- 1.) Provide a highly visible, successful project demonstrating the viability of geothermal energy as an excellent alternative energy source.
- 2.) Evidence the value of geothermal energy as a means of conserving non-renewable energy sources.
- 3.) Provide a high level of personal public contact with geothermal heating sources.
- 4.) Provide a demonstration project which is readily transferable to other like organizations by utilizing conventional technology and standard management practices.
- 5.) Demonstrate the viability of direct application of geothermal fluids of a lower temperature range.
- 6.) Evidence the savings of dollars experienced with geothermal heating applications and convert that savings into a greater and more sophisticated program of social services rendered to the community. Specifically, dollars saved on energy usage will go directly toward developing new YMCA program resources. Such resources will be publicized as being funded through this source.

AREA MAP

FIGURE 1.

STATE VICINITY MAP

KLAMATH FALLS MAP

(Main Avenues)

FIGURE 2.

CITY VICINITY MAP

FIGURE 3.

LOCAL VICINITY MAP

1.3 PARTICIPANTS AND RELATIONSHIP TO USER

The participants in the project will consist of the Klamath County YMCA staff and lay Geothermal Energy Committee composed of voting board members with professional commitments to Law, Land Management, and Business enterprise. The Geo-Heat Utilization Center staff, Oregon Institute of Technology, Klamath Falls will provide technical assistance and instrumentation for injection well testing, long term effect of the system on the geothermal reserves, and input on the environmental impact of the project itself. The prime consultants, Balzhiser and Colvin Engineering, will prepare all technical documents as required and will monitor the overall project with special attention given to retrofit. All components of construction will be let to local (State of Oregon) contractors and suppliers on a competitive bid basis.

All land, facilities, buildings, and required rights of way are owned solely by the YMCA. All project components will be owned and operated by the YMCA. Tentative agreement has been made with the City of Klamath Falls for the eventual sale of the YMCA system at such time as the Downtown Geothermal Heating District expands to encompass the YMCA Geothermal Heating Project. Immediate users of the resource will be the Klamath County YMCA membership (currently 2600 people) and program participants (5000 people) over and above the membership.

The Klamath County YMCA's experience is presently limited to study, design, and execution of the project

to its present point - i.e. developement of the existing production well. The YMCA expects to demonstrate that the planning, teaming, project management and execution of geothermal resource generation is well within the scope of any sound and realistic organization capable of applying standard management practices and principles to the project. Technical engineering, resource, and environmental assistance will be provided by the O.I.T. Geo-Heat Utilization Center, and Bazhiser and Colvin Engineering. Both of these organizations have an impressive background of experience which is detailed in the Business Proposal section of the project proposal.

The total project cost is estimated at \$224,287.00. The local share is projected at \$58,904.00 or slightly more than 26% of the total projected cost. The balance of the funding is expected to be made available through a direct grant from the U.S. Department of Energy.

1.4 RELATIONSHIP TO THE NATIONAL GEOTHERMAL DEVELOPEMENT PROGRAM

This project is consistent with National goals to stimulate non-electric geothermal applications and the developement of Technology for cost-effective and environmentally acceptable use of geothermal resources. As a widely known institution providing recreation and education to the public, the YMCA will provide high visability to the project both on a local and a national level. Local YMCA participation will provide 20% of the population with firsthand experience with the project. Local media has shown great interest in the project in the form of news-

paper articles and television interview coverage allowing us to implement a plan of regular news release contact, thus allowing us to reach a large segment of the population. The YMCA National Office has expressed intense interest in the project and has committed itself to national level coverage within the YMCA system, the National Social Service System, and at a national media level. Such coverage will certainly challenge other similar organizations to seek the benefits of geothermal and other alternative energy sources.

The techniques and technology utilized and developed with the project will be readily transferable to other similar projects. This should encourage organizations to investigate geothermal heating as an alternate energy source. Data gathered by the O.I.T. Geo-Heat Center through well testing and monitoring will provide valuable insight on the Klamath Falls K.G.R.A. and will aid both the YMCA and the City of Klamath Falls in the development of Geothermal resource management policies for their respective geothermal heating projects.

1.5 ACTIVITY SCHEDULE

<u>Task</u>	<u>Date</u>
1) Contract award	April 1, 1979
2) Environmental approval	May 1, 1979
3) Injection Well drilling	May 1, 1979
4) Well Test & selection of production/ injection well	July 15, 1979

5) Retrofit Bid Award September 15, 1979

6) Retrofit Construction Sept. 20, 1979

7) Initiate Operation Dec. 15, 1979

1.6 PROJECTED COSTS

Sub-Contracted Items

1) Environmental	1,000	
2) Engineering	12,870	
3) Injection Well	49,968	
4) Production Well	58,254	
5) Well Testing	3,476	
6) Outside Plumbing	21,160	
7) Retrofit-In building	43,563	
8) Reporting-Technical	13,860	
9) Pump - Controls	26,390	
10) Electrical	2,156	
11) Legal Services	3,600	
Total		236,297

Direct Labor

1) General Management	6,000	
2) Secretarial-Controller	1,800	
3) Custodian	1,460	
Total		9,260

Labor Overhead

1) Management	1,500	
2) Secretarial-Controller	360	
3) Custodian	292	
Total		2,152

Travel

1) Transportation	816	
2) Per Diem	1,184	
Total		2,000

TOTAL ESTIMATED COST

(Projected costs as of January 30, 1979,
subject to further revision.) \$249,709

2. DESCRIPTION OF THE PROPOSED ACTIVITY

2.2.3 Reservoir Development and Operation

The Klamath County YMCA Geothermal Heating Project is located within the Klamath Falls K.G.R.A. (Figure 4). The K.G.R.A. is divided into three separate portions, with a total surface area of 240 km² (Lund, 78). The project is located in the Northern and largest portion of the K.G.R.A. Recent work suggests the existence of a two-reservoir system consisting of a shallow, low temperature reservoir (130-140° C) at a depth of 3000 to 4000 feet, and a deeper reservoir with an estimated base temperature of 185° C (Lund, 1978). The Klamath Falls K.G.R.A. has the most outstanding potential of any K.G.R.A. within the State of Oregon, with an estimated 30×10^{18} jules of heat available for beneficial use (Justice, 1979).

Initial testing of the production well now in place at the project site show a proven available resource of 450 GPM at 43° C. While this resource is more than sufficient to supply peak heating demands for the YMCA facilities, bottom-hole ground temperatures (80° C at

2000 feet) suggest the existence of an even higher temperature resource. Hence, upon completion of the proposed injection well a program of more intensive testing will be performed to fully determine the production capabilities of both wells. At this time an evaluation will be made in order to designate the well with the highest temperature resource as the production well. Upon installation of the permanent production pump, tests will be conducted to fully evaluate the capabilities of the injection well at different rates of injection. During all well tests performed, temperature and draw-down will be monitored in the test well and in other wells in the vicinity in order to establish both the capability and impact of the test well. Full evaluation of well testing will be performed by the O.I.T. Geo-Heat Utilization Center.

The layout of the production and injection wells and pipelines are shown in Figure 5A. The production well and the injection well will be approximately 500 feet apart. Due to the proximity of the proposed injection well site to existing roads and YMCA parking facilities no new roads, either temporary or permanent will need to be constructed. Traffic across unimproved land will be confined to placing and removing the drilling rig and related equipment at the well site. Due to the relatively low temperatures and pressures of the resource, drill pad preparation will be minimal and in accord with technology developed through years of local experience. Well drilling casing and cementation procedures will be performed by

Geothermal Areas of Interest

and Associated KGRA'S

W A S H I N G T O N

FIGURE 4.

OREGON KGRA'S

a licensed and bonded well drilling company and will fully comply with current Oregon State rules and regulations prescribing general standards for the construction and maintenance of water wells in Oregon (Chapter 690, Division 60). All testing procedures will be conducted by a local private firm, to be selected at a future date, under the direction and supervision of the O.I.T. Geo-Heat Utilization Center.

Estimated requirements for development of the well field are as follows: approximately one-half acre of land for drilling pad and equipment storage; nominal amounts of water necessary for drilling operations (which are readily available on the drilling site); conventional electrical utility service for miscellaneous electrical, e.g. lighting needs (also readily available on the drilling site); nominal amounts of gasoline and diesel fuel for drill equipment; approximately four persons to operate drilling equipment; and one rotary drilling rig capable of 2,000 foot well depths, together with ancillary equipment.

Drilling effluent will consist of a variable mixture whose chemical makeup will be dependent on site and time specific requirements. All additives will be non-toxic and suitable for use in potable water. Drilling effluent will be contained on site.

Noise control during well field development will be achieved through proper muffling of all mechanical equipment in accordance with all applicable noise regulations.

EXHIBIT "A"

PROPOSED
NEW WELL

FIGURE 5A

PROJECT SITE PLAN

Topography of the site and the proximity of the site to a state highway minimize any impact created by the short term noise emission from the construction activities. Solid waste disposal will be accomplished through regularly scheduled refuse collections throughout the well field development.

A temporary lagoon will be constructed at the project site to contain the drilling mud and cuttings generated by the drilling of the well (Figure 5B). The impervious layer of diatomite found at the project site will preclude any degradation of ground water. The lagoon and the surrounding berm will be properly sized to fully contain all drilling fluids generated in order to avoid any degradation of surface water in the area. All constituents of the drilling mud will be limited to materials approved for use in potable water. Upon completion of the well, the drilling mud in the lagoon will be allowed to dry, whereupon it will be buried in situs. Material excavated for the lagoon will be backfilled as a cover material. This is an accepted means of disposal requiring no special permits. The impermeable nature of the burial strata will provide a permanent disposal site for the drilling mud and cuttings. After completion of construction activities surface restoration will be accomplished in accordance with standard YMCA landscaping policies in order to blend with the existing facilities.

Department of Environmental Quality

CENTRAL REGION

Klamath Falls Branch

403 PINE, RM. 240, KLAMATH FALLS, OR 97601 PHONE (503) 884-2747

MAILING ADDRESS: POST OFFICE BOX L, KLAMATH FALLS, OR 97601

July 11, 1979

Brian Fitzgerald
YMCA
1221 S. Alameda
Klamath Falls, OR 97601

Dear Mr. Fitzgerald:

We are glad to hear of your plans to drill an injection well for your geothermal effluent. The containment of the drilling mud is DEQ's primary consideration. Your plan of digging a pit or a lagoon for drill mud is the best way to deal with the wastes on the property. Let the mud dry before capping with the soil you have removed.

Let us know when you will begin drilling so we can see how it is working.

We will keep you posted on any further considerations.

Sincerely,

Ron Smith, R.S.
Sanitarian

RS:dr

Figure 5B. Drilling Mud Lagoon

Operation of the heating project will not differ significantly from development of the well field. There currently is no estimated production well replacement scheduled. Such scheduling would be developed through the long-term management of the resource. Projected life of major components such as the pump, coils, and heat exchangers is approximately twenty-five years. Well head components at the production well will be limited to the electrical drive motor for the pump, the variable speed (Nelson) drive unit mounted on the well head casing, and appropriate automatic controls to adjust pumping rates to heating system requirements. A ten foot by ten foot one story well house with a cement slab floor will be constructed over the production well. Extensive local experience with the resource show that low temperatures and pressures negate the need for well head components such as blowout preventors or steam liquid separators. The location of the injection well and accompanying pipeline systems are shown on the project plot plan (Figure 5A, page 25).

Local experience with injection of spent geothermal fluids over the past 15 years has been successful in returning an average of 1,000 acre-feet of water per year with no noticable impact on surrounding wells (see Geo-Heat center comments, Appendix B).

The production and injection well, distribution line, and heating system will be maintained by the YMCA through its existing maintenance staff or when necessary by

contracting companies. Well plugging and abandonment is not anticipated, but if necessary will be conducted in accordance with applicable state regulations (OAR Chapter 690, Water Resources Department).

Operation of the system will require a ten foot square plot for housing of the production well. No permanent water service will be required. Conventional electrical utility service (already available at the project site) will be required for pump operation. Normal operation and maintenance for the project system will be comparable to that of the present system, hence no additional manpower will be required for these tasks. Regularly scheduled refuse collections which are a part of normal YMCA operations will facilitate any solid waste generated during the operation of the project. All restored landscaped areas will continue to receive standard YMCA maintenance throughout the life of the project.

2.3.1 Resource Utilization - Construction.

The projects utilization system will consist of approximately 800 feet of five inch transmission pipe together with a centrifugal hot water type turbine pump driven by electric motor through a variable speed drive unit, retrofit heat exchangers, and the necessary control units. The location of the utilization system is shown on the project plot plan (Figure 5A, page 25). The construction of the utilization system will exist entirely on land, facilities, buildings, and rights of way wholly owned and operated by the YMCA. The relatively small size

of the project will allow any necessary materials and supplies to be stored onsite with minimum impact to the facility. No new roads, either temporary or permanent, will be constructed. Disposal of construction trash and chemical wastes will be accomplished through regular refuse collections and will utilize approved disposal sites. Excavating will be limited to placement of the distribution lines for the project and will require no clearing of vegetation since all rights of way will be within areas now in use for normal YMCA activities. All excavated earth will be retained onsite for back-fill purposes once pipelines are installed. The duration of such trenching is expected to take one week. During this period atmospheric emissions will be limited to conventional excavation machinery such as tractors. The nature of the excavation work and the affected soil is such that explosives will not be required. Noise and movement of men will be limited to normal machinery operations during trenching and installation of the distribution system, and again during backfill operations. It is expected that approximately five people will be involved in on-site utilization system construction.

2.3.2 Resource Utilization - Operation

The external appearance of the project will be limited to a ten foot by ten foot one story pump building constructed over the production well. This building will be designed to blend in with the immediate and surrounding area in regards to both appearance and size. All other system

facilities will be buried underground or installed in existing structures. Water use will be contained to geothermal fluids which will be drawn from the production well, circulated through heat exchangers within the YMCA buildings and returned to an equivalent aquifer through the injection well. Calculated peak demands for geothermal fluids are 340 gallons per minute (GPM) during the winter heating season and 150 GPM for summertime. Initial testing of the existing production well shows these demands to be easily obtainable, and injection of the spent fluid will maintain the hydraulic balance of the resource.

The project will generate no significant gaseous emissions, due to both the chemical and physical characteristics of the resource. A comprehensive chemical survey was performed on a geothermal well in the immediate vicinity of the project area by Pacific Northwest Laboratory of Richland, Washington in May, 1979 (see appendix A). This survey is representative of conditions at the project site. A summary of noncondensable gas concentrations found in this survey is shown in Figure 6A. Hydrogen sulfide is typically the component of greatest concern for geothermal projects. Hydrogen sulfide appears to be universally present in geothermal fluids and can cause an odor nuisance in concentrations of less than 1 ppm. While Federal ambient air quality criteria do not include H_2S , California has imposed a State ambient standard of 0.03 ppm by volume as a 1 hour average. While well head concentrations exceed this level, physical conditions of the project resource

are such that ambient concentrations in the project area are not expected to exceed this standard.

Gaseous emissions, particularly that of H_2S are primarily significant in high pressure, high temperature systems, such as those associated with the generation of electrical power, where the venting of steam and condensates provide a transfer medium for emissions of noncondensables. In a low temperature, low pressure resource, such as the proposed project the physical mechanism for emitting gases is minimized. Lower temperatures and pressures encourage gases to remain dissolved in the geothermal fluids. Without the venting of steam to carry noncondensables into the atmosphere, emissions are limited to the escape of gases into the atmosphere at the air-water interface within the 12" diameter well casing. Such an exchange will be minimal.

Extensive local experience with geothermal wells has shown no evidence of significant emissions. There are currently more than 400 known geothermal wells in use within the Klamath Falls urban area. The majority of these are "open wells", wells without a proper seal at the top of the casing. This condition maximizes the possibility of gaseous emissions. As the ambient air standard for H_2S of 0.03 ppm is set at the odor threshold, any significant emission of H_2S by these local wells would not have gone unnoticed. No such problem exists locally, thus no significant emissions are expected to be generated by the project.

<u>Parameter</u>	<u>Concentration (PPM)</u>
CO ₂	129
H ₂ S	0.01
NO _x	2.6
O ₃	0.0

Fig. 6A, Noncondensable Gas Concentrations.

Liquid waste disposal will be limited to injection of the spent geothermal fluid after passage through the heat exchangers. Other project components will not generate liquid or solid wastes.

Other project related support systems are limited to the existing heating equipment which will remain as a back-up to the new system. The existing heating system is gas fired and uses an average of 67,500 therms of gas per year. Total replacement of this gas use by geothermal heating would contribute to the air quality of the Klamath Basin by eliminating the following emissions:

<u>Pollutant</u>	<u>Parts per Mil. Cu. Ft.</u>	<u>Parts per Yr.</u>	
Particulates	5 - 15	1012.5	
Sulphur Oxides	.6	40.5	1000 Btu/CF
Carbon Monoxide	20	1350	
Hydrocarbons	8	540	
Nitrogen Oxides	80	5400	

(Figure 6B, adapted from Lienau, 77)

The project will require no additional personnel over and above existing YMCA staff as the project will require no more man-hours as does the present heating system. Periodic system maintenance for components such as control systems may require temporary subcontracting to a private maintenance firm. Regular maintenance will be performed in accordance with manufactures instructions and written instruction on operation and mainenance to be provided to the YMCA, along with instruction by Balzhiser and Colvin Engineering Company during testing

of the system. During any outages of the system, planned or otherwise, the existing gas-fired system will be utilized.

Noise control will not be a major consideration in as much as the sole source of noise for this project, the electrical pump drive, will be contained within an appropriate pump building. Similar setups now in operation at the Oregon Institute of Technology are not significant contributors to ambient noise levels.

The neighborhood immediately adjacent to the project consists of a church, a sporting goods outlet, a flower shop and nursery, and a private residence. All of these neighbors wholeheartedly support the YMCA in its efforts to develop a geothermal heating system, and have expressed an interest in connecting to the YMCA system in order to purchase hot water for heating requirements.

Support for the project has been expressed by the community as a whole. Although the project has been subject of many news articles and local television coverage over the last two years no negative feedback or opposition to the project of any kind has been voiced to date. The YMCA will implement a plan of regular news release contact in order to maintain public awareness of the project.

3. DESCRIPTION OF THE EXISTING ENVIRONMENT

3.1.1 Site Plan

The appropriate site plan is included as Figure 5, page 25.

3.1.2 Regional Demography

A regional map of population centers can be seen in Figure 7. Populations for incorporated areas in the vicinity of the project, as reported by the Population Research and Census Center at Portland State University, were as follows as of July 1, 1978:

<u>Area</u>	<u>Population</u>
Klamath County	58,700
Klamath Falls	18,300
Merrill	900
Malin	595
Bonanza	265
Chiloquin	850

The City of Klamath Falls is part of a large metropolitan area with an estimated total population of 47,000.

FIGURE 7.
REGIONAL POPULATION CENTERS

3.2 Land Use

A land use map is included as Figure 8. Land use in the vicinity of the project includes moderate density residential, general commercial, and various public uses. The project is adjacent to State Highway 39 (designated as a Federal Aid Primary route).

3.3 Geology

Klamath Falls lies within the geological region of Oregon referred to as Basin and Range. This is an area of horst and graben structure typified by the North and Northward trending ridges. Klamath Basin is a graben oriented to the Northwest and extending from Crater Lake to the North, to Medicine Lake Highland at the Southern edge. The main structural formation of the area is the steeply dipping normal faults (60°) that form the graben. Vertical displacement of some local faults (Stukel Mountain, Rattlesnake point) has been estimated at 1,600 feet while others may be as much as 6,000 feet (Lund, 1978-A).

Within historical times the Klamath Basin has been geologically stable, with fault displacement ending during the Pleistocene epoch. No historic surface breaks or fault movements have been recorded in Oregon (Couch and Lowell, 1971). The Klamath Falls area is located in a Seismic Risk Zone 1, as shown in Figure 9. A Zone 1 designation refers to a very low probability of any significant earthquake related damage in this area.

Lava flows and volcanic breccia (locally referred to as "cinders") make up some of the principle geologic

FIGURE 8.

LAND USE MAP

formations of the area. Local volcanic activity occurred mostly during the Pleistocene epoch. There are no instances of contemporary volcanism occurring locally. Evidence of recent regional volcanic activity is confined to Crater Lake (formerly Mt. Mazama which erupted approximately 6,500 years ago), Lava Beds National Monument with flows as recent as 500 years ago, and Mt. Lassen which erupted in 1914-17 (Lund, 1974-A).

Other principle geologic formations are extensive deposits of tuffaceous siltstone and sandstone and lacustrine diatomite, locally known as "Chalk rock". Divisions between these principle formations are not distinct due to intermixing between many of the deposits. In general the cinders and fractured basalts form a highly porous zone capped by a nearly impervious zone of chalk rock, referred to locally as the Yonna Formation. All deposits are Pliocene or more recent and are underlain by andesites and basalts of Cascade Lava flows. A generalized geological map of the Klamath Falls Area is included as Figure 10.

A recent E.P.A. study of radioactivity associated with geothermal waters (O'Connell, 1976) found no abnormally high levels of radiation in the Klamath Falls area. Of the five localities studied in the western United States (see Figure 11), wells surveyed in the Klamath Falls area were found to have relatively low concentrations of radon and radium. Radioactivity, therefore, is not a potential problem with this project.

FIGURE 9.

SEISMIC RISK MAP

The project area consists of well drained soils (see soils discussion, section 3.6.1) with slow to medium runoff characteristics. Erosion hazard is slight to moderate with some problems occurring locally where extensive foot and vehicular remove the protective overgrowth. Post-construction site restoration procedures will minimize any project related erosional problems. Average annual precipitation is 10 to 14 inches and there are no flood hazard areas in the project vicinity (HUD, 1978).

3.4.1 Hydrology - Surface Water (Sammel, 1976)

Most of the surface water in the vicinity of Klamath Falls is derived from three streams: Sprague River, Williamson River, and Wood River. Williamson and Wood Rivers flow into Upper Klamath Lake and the Sprague River is a tributary to the Williamson. A significant amount of water also enters Upper Klamath Lake from springs and seeps in or near the lake and from small tributaries on its periphery. The average annual flow from all the above sources for the period 1930-1968 is estimated to be about 1,400,000 acre-ft (1.7×10^9 cubic meters, m^3) (Oregon State Water Resources Board, 1971, table 21).

Upper Klamath Lake, the largest natural lake in Oregon, has a surface area that varies between 98 and 140 mi^2 (254 and 362 km^2), depending on the lake stage, and a length of about 22 mi (35 km). Agency Lake, about 6 $\frac{1}{2}$ mi (10 $\frac{1}{2}$ km) in length, is appended to the northern end of Upper Klamath Lake. The average depth of Upper Klamath Lake is only 8 ft. (2.4 m), although depths reach 40 to 50 ft

Geologic map of the Klamath Falls area

FIGURE 10.

EXPLANATION

FIGURE 10.

Continued

Radon concentrations in water

Radium concentrations in water

FIGURE 12.

AREA SOILS CHARACTERISTICS

(12 to 15 m) in a narrow trench between Eagle Ridge and Bare Island (Hubbard, 1970). Because of its shallow depth, regulated outflow, and generally warm waters, Upper Klamath Lake is undergoing relatively rapid eutrophication.

3.4.2 Hydrology - Ground Water (Illian, 70)

A portion of the precipitation that seeps into the ground in the Klamath Basin may be absorbed by water-deficient soil and plants. The remaining water percolates vertically downward to the water table (top of the saturated zone). Downward percolating water in the Klamath Basin (ground-water recharge) may cause a slight rise in the water table elevation resulting in an increase in ground-water storage. If there is an increase in the quantity of ground-water recharge, there will also be an increase in the quantity of natural ground-water discharge from the basin. If the total amount of downward percolating recharge is insufficient to maintain a balance with the total basin discharge, then the water table elevation will decline. Large quantities of ground water artificially discharged by wells may also cause water table elevations to decline. To date, no serious water level declines have occurred in the Klamath Basin. Local recharge areas are shown in Figure 13.

The areas in which ground-water recharge is taking place within the Klamath Basin are the Cascade Mountains, Yamsay Mountain, Winter Rim, and similar elevated areas possessing permeable soil and receiving large amounts of rainfall. Well log information is sparse in mountainous

areas, therefore, it is difficult to accurately locate recharge boundaries. In the Klamath Basin it is assumed that ground-water boundaries will lie beneath topographic divides.

Deep wells must be constructed in order to withdraw water from ground-water recharge areas. Such wells experience progressive declines in water levels as the wells are deepened. They are subject to large pumping declines and slow recovery rates. Water from wells drilled in recharge areas is usually of excellent chemical quality having low temperatures (40° F. to 50° F.) and small quantities of dissolved chemical constituents. The total dissolved solids are usually less than 100 parts per million.

Ground water moves through spaces between rock particles or fractures in solid rock. Rarely are these spaces larger than a fraction of an inch. Reports of underground rivers encountered by wells are usually based on misinterpretations of permeable aquifer materials. Lava tubes are present within the Klamath Basin, but only rarely do wells encounter these structures.

For the purposes of this report, the varied rock units described in the Klamath Basin by previous investigators have been grouped together into four main groups, each having unique water-bearing properties. These four groups represent the general hydraulic characteristics of each of the lithologic units present within each group.

Sedimentary Aquifer (SA)--

The first aquifer unit is designated SA (Sedimentary Aquifer) in Figure 14. This water-bearing formation is composed of alluvium, alluvial terrace, and shallow lake deposits; and some interbedded basalt, rhyolite ash deposits, and pumice. The sedimentary aquifer is found throughout the Klamath Basin and the thickest deposits are in the major valleys. A survey of water wells completed in this aquifer unit indicated that specific capacities range from .01 to 5 gallons per minute per foot of drawdown and averages about .45 gpm/ft. A black sand or gravel layer, when it is encountered in this unit, may yield from 2 to 10 gpm/ft. Generally, these sedimentary beds yield only sufficient quantities of water for domestic purposes.

Volcanic Centers Aquifer (VCA)--

The second aquifer unit is designated VCA (Volcanic Centers Aquifer) in Figure 14. This unit is composed of basalt and volcanic ejecta consisting of ash, cinders, and agglomerate. These units represent eruptive centers of old volcanoes. The Volcanic Centers Aquifer is most commonly located in mountainous areas, however, a few local exposures are found on the valley floors. Their water-yielding characteristics are excellent due to well-sorted coarse cinders, highly fractured lava rock, and scoriaceous interbeds. Water wells constructed in these rock types demonstrate a wide range in specific capacity, varying from less than 1 to over 100 gallons per minute per foot of drawdown. Large yielding wells can be constructed in this aquifer unit.

FIGURE 14.

GROUND WATER UNITS OF THE KLAMATH BASIN

Lower Basalt Aquifer (LBA)--

A third aquifer unit labeled LBA (Lower Basalt Aquifer) in Figure 14 is the Lower Lava Unit described by Newcomb and Hart (1958). It is composed primarily of basaltic lava flows. This unit underlies the Yonna Formation and is the aquifer which yields large amounts of water to irrigation wells in the Klamath Basin. Surface exposures of the Lower Basalt Aquifer are found in the Quartz Mountain - Winter Rim areas. Well logs report it at depths exceeding 1,000 feet below land surface in most of the valleys of the Klamath Basin. The aquifer's high permeability is the result of weathered surfaces, open scoriaceous zones between flows, and fractures in the basalt flows. The Lower Basalt Aquifer has specific capacities which range from 33 to 500 gallons per minute per foot of drawdown and averages about 145 gpm/ft. Large yielding wells can be constructed in this rock unit.

Volcanic Ash Aquifer (VAA)--

A fourth ground water unit shown in Figure 14, is labeled VAA (Volcanic Ash Aquifer). This unit is composed of volcanic ash, tuff, breccia, related sedimentary materials, and occasional basalt flows. This formation is similar to the Sedimentary Aquifer previously described. Little is known of the hydrologic characteristics of this unit. It underlies the LBA unit. Few wells have been constructed into these fuffaceous sediments. Well logs indicated that this formation lies at considerable depth and has been penetrated by few wells in the Klamath Basin.

The cost of drilling deep wells (in excess of 1,000 feet in depth) to encounter this formation would generally discourage attempts to develop ground water from this unit. East of the Klamath Basin, in Lake County, where this formation outcrops extensively, well yields are moderate to low and comparable to the sedimentary aquifer described above.

Ground-Water Discharge.

Ground water from the mountainous recharge areas flows downward through diverse geologic materials toward lowland areas where it reappears as ground-water discharge. A large amount of ground water is forced to land surface as natural discharge within the lowlands of the Klamath and Sycan Marshes and the valleys of the Williamson, Sprague, Lost, and Klamath Rivers. Numerous springs, such as Big Spring and Bonanza Springs, and marsh lands of Upper and Lower Klamath Lakes also serve as major ground-water discharge areas in the Klamath Basin. Nature's balance between natural recharge and discharge is altered by man's use of wells. This use constitutes an artificial discharge of ground water to which nature must adjust.

Geothermal Ground Water.

Geothermal ground water occurs at several localities within the Klamath River Basin. Some local development of low and moderate temperature ground water has been made in two main areas of the basin. The larger, more developed area is located in a northeastern residential district

within the City of Klamath Falls. This area extends about $4\frac{1}{2}$ miles along the western margin of a faulted area near Klamath Lake. A second thermal area occurs near the southwestern flank of the Klamath Hills in a similar geologic environment. Thermal springs and wells have also been located in other portions of the regional discharge area within the Klamath Basin. Hot springs at Olene flow into Lost River; and in Langell Valley thermal springs occur $1\frac{1}{2}$ miles south of Lorella. In northeastern Klamath Falls approximately 350 wells have been drilled to extract thermal ground water for use in heating requirements for residences, schools, swimming pools, and business establishments. The Klamath Falls' city school systems estimates an annual savings of about \$23,000 in heating costs per year. Thermal ground water, 140° F. to 192° F., is also used to heat the new Oregon Technical Institute campus. The O.I.T. wells are the deepest thermal wells of the area, ranging between 1,150 and 1,805 feet in depth.

THE ASSOCIATION OF GROUNDWATER TO THE GEOTHERMAL RESERVOIR

(Sammel, 1976)

Temperature profiles that show downward convective flow indicate that meteoric water recharges the shallow ground-water reservoir over large areas of both uplands and lowlands. Little of this widespread recharge reaches the lower aquifers, however. Hydraulic heads in all the deepest wells inventoried for this study are lower than heads in the surrounding shallow aquifers, thus indicating that vertical transport is impeded by low hydraulic conductivities. The recharge potential, however, is large. Few data are available from higher elevations on the up-~~l~~-raised fault blocks, but the available data suggest that the highlands are relatively permeable to vertical flow.

On the basis of chemical characteristics, the hot waters are assumed to originate as meteoric water, but analysis of shallow ground water from areas within a 50-mile radius of Klamath Falls show that most ground waters in the region have similar chemical compositions. The precise origin of the water thus cannot be ascertained.

The discharge conduits that produce hot water appear to be hydraulically isolated from the shallow ground water system in their vicinity. The hydraulic evidence for this

assertion is clear for only one of the geothermal areas, but chemical data from the three zones are similar and tend to support this view. Thus, static water levels in hot wells at OIT and the Presbyterian hospital are discordant with the surrounding water table, and the chemical characteristics of the hot water clearly distinguish it from the cold water. The very similar chemical nature of the water from Olene Gap and the Klamath Hills suggest, by analogy, that aquifers supplying these springs and wells are also hydraulically isolated from the shallow waters.

Additional evidence from a pumping test shows that at the OIT site the hot-water aquifer may have a higher hydraulic conductivity than the surrounding cold-water bearing rocks. Rates of pumping from the hot wells at the Klamath Hills suggest that at this site also the thermal aquifer is more permeable than typical basalt aquifers near Klamath Falls.

It is concluded on the basis of hydraulic evidence and the locations of the geothermal areas that the hot waters rise from depth through conduits associated with major faults. These conduits may be the few permeable channels remaining of many that formerly existed during the period when large-scale silicification of the country rock occurred. The present channels have probably been largely sealed off from the surrounding rocks by deposition of silica. Thus,

the term "aquifer" used above in connection with the apparent hydraulic conductivity of the hot-water zone is probably a misnomer. Observations of flow rates, pumping rates, and drawdowns may relate only to hydraulic conditions in the upper part of the distribution system rather than conditions in the thermal aquifers or reservoir.

Legal Restraints On Water Availability

In Oregon, geothermal resources are recognized as a special occurrence of water and not a special occurrence of heat. The water resources of an area are to transport the heat of the earth to the surface for mans use. Oregon's Revised Statutes 522.035 states that "ownership rights to geothermal resources shall be in the owner of the surface property overlying the geothermal resource unless such rights had been otherwise reserved or conveyed." All waters within the state of Oregon have been declared public property by the Oregon legislature. Ground water, defined by the ORS 537.515 as "any water, except capillary moisture, beneath the land surface or beneath the bed of any stream, lake, reservoir, or other body of surface water within the boundaries of this state whatever be the geologic formation or structure in which such water stands, flows, percolates, or otherwise moves," is appropriated for use through the issuance of certificates of water rights. Current ground water availability in the Klamath Basin is such that there is no real restriction on allocation of water rights certificates. These certificates are normally available within 30 days from the Oregon State Department of Water Resources.

3.4.3 Water Use-Surface Water (Sammel, 1976)

Water from Upper Klamath Lake flows through a narrow strait on the western edge of the city of Klamath Falls, meanders through marshlands toward the southwest, and then, after passing over a dam near the town of Keno, leaves the area through a narrow gorge cut into bedrock. Below Klamath Falls, the stream becomes the Klamath River.

More than 300,000 acre-ft ($3.7 \times 10^8 \text{ m}^3$) of water is diverted annually from Upper Klamath Lake and the Klamath River above Keno. This water is taken through three canals, the "A", the North, and the Ady, for use in irrigation in the Lower Klamath Lake basin. These canals are part of a major drainage and irrigation scheme built, and for the most part, operated by the U.S. Bureau of Reclamation (USBR). The project was begun in 1904, and is one of the oldest USBR projects in existence.

On the east side of the Lower Klamath Lake valley, Lost River enters through a narrow gap in the bordering hills and flows south into California. This stream has also been incorporated into the USBR project, and its flow is now totally regulated. From a diversion dam north of Stukel Mountain, water is either diverted to the Klamath River or is returned to the Lost River channel for use downstream. About 116,000 acre-ft ($1.4 \times 10^8 \text{ m}^3$) of water is annually distributed in the lower valley in this manner.

The network of canals and laterals which now serve the USBR Klamath Project totals about 700 mi (1,120 km) in length and irrigates about 200,000 acres (80,900 hectares,

ha) of land in Oregon and California. Water in these canals flows generally south to the lowest part of the valley in the vicinity of Tulelake, California. Here, tailwater and ground-water seepage collect in a closed basin, which serves as a major wildlife refuge. The extent of the water surface in this swamp area is closely regulated, and excess water is pumped back to the north through the Klamath Straits Drain into the Klamath River. About 108,000 acre-ft ($1.3 \times 10^8 \text{m}^3$) is annually pumped out of the lower valley in addition to an average net of 141,000 acre-ft ($1.8 \times 10^8 \text{m}^3$) diverted to the Klamath River from Lost River through the Lost River Diversion Channel.

The above description of the USBR Klamath Project is an over-simplification of an extremely complex system. The average figures for inflow and outflow mean little in attempts to evaluate the hydrology of the Lower Klamath Lake valley. Only the major canals and drains are gauged and the patterns of irrigation use and drainage are not readily available for quantitative evaluation. In the absence of detailed data, only the crudest generalizations are possible regarding consumptive use, evapotranspiration, or recharge to the ground-water reservoir.

Ground Water Use (Lund, 1978-A)

A majority of the geothermal wells used for space heating extract heat by means of a downhole heat exchanger are described earlier. The obvious main advantage with this heat extraction method is that no fluid is removed from

the well, due to the closed system. The disadvantage with this method is that the amount of heat that can be extracted is limited, especially if the well is improperly completed. The largest known heat extraction by downhole heat exchangers in the urban area is at Ponderosa School. Here, a well with 12-inch diameter casing using three "loops"; one 3 inches in diameter, and two 2-inches in diameter. Up to four million BTUs per hour can be produced for heating. The details of this system is described in the Appendix.

Poor well completion practice, by either not casing the well full depth or locating the perforations incorrectly, prevents a vertical convection cell from developing in the well. An isothermal gradient is not developed in the well, thus the upper portion of the well is colder than if the convection cell was developed. To develop the upward flow of hot water in the well, many are pumped and the water wasted to the storm or sanitary sewer. Heating may be obtained by using the geothermal water directly in the heating convectors or using the downhole heat exchangers when pumping the well. By using the geothermal waters directly, it is estimated that up to ten times the heat output can be obtained as compared to downhole heat exchangers.

One main area of pumped and/or naturally artesian flowing wells has been developed in the community. This is in the area of the original artesian hot springs, at Modoc Field, in the vicinity of Main and East Main Streets and south of Ponderosa Field. These were older wells which were probably cased only to a depth of 30 to 60 feet.

Stopping the artesian flow in most cases would cool down the wells causing them to produce less heat. During one summer about ten years ago, the City forced the well owners to shut off the artesian flow to conserve the resource when it was not being used. That fall it took extensive pumping to stimulate the artesian flow and to get the wells flowing again. This preventative measure has not been attempted since. The City no longer allows the disposal of fluids in the storm or sanitary sewer system by new wells. Artesian pressure heads of as much as 20 feet above the ground surface have been reported in the vicinity of East Main and Holly Streets. The author has seen a photograph of this flow behind Lucas and Howard furniture company. This head existed about 20 years ago, with the present head being about 5 feet. Today most of the wells in the area have artesian heads of from 5 feet above ground level to 5 feet below ground level. There has been a steady decline of the head over the past 50 years.

In order to get a better understanding of the disposal of fluids in the urban area, an inventory of the wells disposing of fluids, their location, and quantity of flow were determined. Three areas of geothermal flow and disposal were delineated, three areas of pumping and injection, two areas of low temperature (around 20°C) heat pump use and disposal were found in the urban area. These are shown on Map #8. The main area is the one described above from Modoc Field to East Main Street. Forty-six wells dispose of geothermal fluid in this area

for a total winter time use of 760 gpm (50 l/sec) and summer time use of 90 gpm (6 l/sec). Most of these wells are used only during the winter, with only about ten being pumped in the summer. The main summer use is by the Municipal Pool (which unfortunately is not used during the winter).

The second major use and disposal area is on the north end of town. Here, Oregon Institute of Technology and Presbyterian Intercommunity Hospital use the same field to heat over 750,000 square feet of floor space with four wells. OIT has three wells varying from 1200 to 1800 feet deep, each capable of producing 500 gallons per minute of 192°F fluid, while the hospital has one well almost 1600 feet deep producing up to 500 gallons per minute. The total field is used as a maximum rate of 1200 gpm (80 l/sec) in the winter and as low as 200 gpm (13 l/sec) in the summer (mainly for domestic tap water heating). The waste water is disposed of in a ditch which eventually runs into upper Klamath Lake. The flow rate will vary since all of the wells are equipped with variable speed torque converters, thus allowing the institutions to pump only the amount of water needed at a specific time. OIT normally uses only one well, with a second being used in extreme cold weather. The third well is used as a standby in case of breakdown of one of the other two. During the summer of 1974, a pump test was run on one of the OIT wells (E. Sammel of USGS). OIT #5 (located in the extreme SE of the field) was pumped around 500 gpm, producing a draw-down of about 3 feet in OIT #6 (500 feet to the west)

and only 1 foot in the PIH well (about 800 feet to the NW).

The third area of pumped use in the urban area is on the southeast limits of the community. These include four scattered wells: Maywood Industries, Union Manor, L. O'Neill School, Kingswood Apartments and Shadow Hills Apartments. All of these are deep wells generally around 1500 feet deep. A total of 150 gpm (10 l/sec) are pumped from these wells in the winter with less than 50 gpm (3 l/sec) being used in the summer.

Two areas of cold water pumping exist in the urban area, the first on the OIT campus north of the hot water field. On the east boundary of campus, two cold water wells 1200 feet deep are used to provide cold water to the campus. These are assumed to tap water from the back side of the fault block (upthrow side) whereas the hot water wells are drilled into the downthrow side of the fault. The cold water varies from 75° to 92°F and is used at a rate of 200 gpm (13 l/sec) year around.

The city of Klamath Falls (formerly Oregon Water Corporation) has four cold water wells in the urban area near Link River used for domestic water supply. A summary of their characteristics are shown on the following page.

<u>Well Name</u>	<u>Location</u>	<u>Depth</u>	<u>Maximum Pumping Rate</u>	<u>Temp.</u>
Fremont	Calif. & Nevada St.	701'	1100 gpm	62°F
#8	Conger & Calif. Ave	850'	4550 gpm	65°F
#9	Conger & Calif. Ave	435'	3000 gpm	65°F
#11	Conger & Calif. Ave	620'	3400 gpm	65°F

The three Conger St. wells when pumped simultaneously will

produce 4300, 2700, and 3100 gpm respectively, thus with the Fremont well, the maximum rate is 11,200 gpm. During the summer months, the maximum daily use rate is 13.2 million gallons or about 9000 gpm (600 l/sec), and the maximum winter day is 4.3 million gallons or about 3000 gpm (200 l/sec). It is reported that these wells draw water from lava tubes or large fissures in the bedrock, however the source of recharge is unknown. It is also unknown if these wells have any effect on the geothermal system.

Two areas of heat pump operations are known in town. One is located on the south side of Campus Drive near the OIT campus where doctors' offices and businesses use the water for heating and cooling. The water is disposed of on the surface after use. The second area is at the western end of Main Street near the Link River. Again the water is used for heating and cooling and then disposed of to the sewer system. Most of the wells are 300 to 400 feet deep producing water from 65° to 75°F. It is estimated that these areas use around 200 gpm (13 l/sec) during peak production. A total of five wells is known in the Main Street area and one in the Campus Drive area. Four others are known to have been drilled in the Campus Drive area for businesses presently under construction.

Three existing areas of production and injection wells are known in the community with another area under development. The three existing areas are Klamath Union High School (Modoc Field), Mills School, and Mazama School. In heavy use periods, Mills School will dispose

of some water to the sewer system. In each of these cases the production and injection wells are located within 500 feet of each other with no noticeable affect on each other. Fortunately the temperature difference between the pumped and disposed fluid is only around 20°F. The area under development consists of two locations adjacent to each other; one is the County Health Center on the hill overlooking the East Side Bypass and the other is the YMCA. Both should be in use within a year.

Mr. Richard G. Bowen, geologist from Portland, has investigated the three cases of reinjection of geothermal fluid in the urban area for us. His observations are as follows.

Three of the geothermal heating systems operated by the Klamath Falls schools have been using return wells for many years. The three systems are different in design but all have been successful in that they have returned the fluids for many years and have had no measurable effect on the deliverability capabilities of the production wells.

Klamath Union High School

The Klamath Union High School heating system was originally built to use fuel oil but in 1946 it was converted to use geothermal water. Until 1962, the geothermal waste water was put into the nearby irrigation canal. At that time another well was drilled to 257 feet (78 M) to heat the field house and swimming pool about 300 feet (91 M) from the main production well. Because the well at the field house was about the same temperature as the water being

returned to the irrigational canal, it was decided to put the hot return water into the field house well so additional heat could be extracted from the downhole exchanger. Consequently, a pipeline was built to the field house and since 1962 all the geothermal waste water has been returned to that well.

The high school heating system is designed for a constant flow of 500 gallons per minute (31 l/s) delivered to the heat exchangers. The production well is pumped constantly at that rate from the time school starts in September until closing in June, approximately nine months a year. In a heating season, this amounts to 597 acre-feet ($7.36 \times 10^5 \text{ m}^3$). During this period of time the return well has been operating, there have been no measurable effects on temperature or productivity of either the return or production well.

Mills School

At Mills School a similar return system was installed also originally to increase the capacity of wells that did not produce enough heat. In the case of Mills School the three production wells all use downhole heat exchangers, but as #3 well is artesian, it is allowed to flow and its water is then put into wells #2 and #1, adding additional heat to those two wells.

At Mills School only one well flows at present, probably at less than 50 gallons per minute (3 l/s), so the amount of fluid returned to the reservoir is in the range of one-tenth that in the high school system, or

50 to 60 acre-feet ($6-7 \times 10^4 \text{m}^3$) per year. In the 12 years of its operation, this has amounted to 600 to 700 acre-feet ($7-8 \times 10^5 \text{m}^3$) of water and a significant energy return to prolong the reservoir life. At Mills School the main production well #3 is about 150 feet (45 m) from #1 and #2 which are only about 25 feet (7.6 m) apart. When well #3 was drilled and production tested in 1961, water temperature was 89°C (192°F). A recent measurement and possibly more accurate, gave a temperature of 91°C (196°F).

The three wells all produce from nearly the same level and even in this case where the production and return wells are only about 150 feet (45 m) apart, there has been no cooling of the aquifer. Operating experience over the last 12 years since the system was installed does not appear to have had any measurable effects on the reservoir, nor have there been any other problems with the system.

Mazama School

At Mazama School the return well was planned as an integral part of the system. Production and return wells both were drilled and tested prior to designing the heating system. The production well had a temperature of 62°C (143°F) and is 930 feet (282 m) deep. The return well drilled 400 feet (121 M) north of the production well was 1,210 feet (366 m) deep and had a water temperature of 58°C (136°F).

This system is similar to the one in the high school in that inbuilding heat exchangers are used and water is pumped continuously during the heating season at a rate of 360 gallons per minute (23 l/s). The water circulated in the system amounts to 140 million gallons (5.30×10^8 l) or 429.5 acre-feet ($5.30 \times 10^5 \text{ m}^3$) per season or 5155 acre-feet ($6.36 \times 10^6 \text{ m}^3$) in its 12 years of operation.

As in the other two return well systems, there does not appear to have been any adverse effects on productivity of the wells or changes in the reservoir temperature. When the production well was drilled, temperature was reported to be 62°C (143°F) while recent measurements give 61°C (141°F). This difference may be accounted for by variation in the thermometers. There have been no problems relating to either the production or return wells during their 12 years of operation.

Summary

In addition to the benefit of the return wells maintaining water levels, its effect on increasing the useful heat available in the reservoir should also be considered. At the high school and Mazama School the amount of heat extracted at any particular time varies, but averages about 5° to 6°C or 10°F . If the reservoir is recharged with the normal cold water of the area at a temperature of 10°C (50°F), more heat could be required to raise this water to the outflow temperature than is required to raise the temperature of the already warm geothermal waters. At the high school, the amount of thermal energy returned to the reservoir is 3.98×10^{13} cal (1.58×10^{11} BTU) during the

heating season. Mazama School thermal energy returns 2.79×10^{13} cal during the season while Mills School appears to return about 4×10^{12} cal. From the three schools, this is a total return of 7.17×10^{13} cal (2.84×10^{11} BTU) or equivalent to 49,056 barrels of oil per season in thermal energy.

The overall operating experience in return wells at these three schools has indicated that geothermal return wells are a practical method of prolonging reservoir life, conserving water and reducing storm sewer pumping costs. Possibly, most importantly it should provide a demonstration of long duration that no harmful effects have come from this practice.

3.5 Meteorology

The Klamath Basin has a semiarid winter-rainfall type of climate with mild summers and cold winters. At Klamath Falls, temperatures as high as 105°F have been recorded in July and as low as -24°F in January. The normal annual precipitation varies with altitude, from 14.06 inches at Klamath Falls to 17.72 inches at Chiloquin and more than 60 inches in the highest parts of the mountains. Seventy percent of the precipitation falls during October to March and only 9 percent during July through September.

Table 3.5A. shows the variation in annual precipitation at Klamath Falls and Chiloquin. Precipitation at Klamath Falls has ranged from only about 7 inches in 1959 to nearly 21 inches in 1957.

As in other high-altitude areas in Oregon, the Klamath Basin has a short growing season. According to National Weather Service records, the average dates for the last killing frost

(28°F) in spring in May 4 and the first in autumn is October 18. However, temperatures of 28°F or below have been recorded at Klamath Falls every month of the year, and a frost such as that which damaged crops in August 1969 is not unusual. At higher altitudes the growing season is still shorter, and at Chemult the average period between killing frosts of 28°F is only 16 days.

Table 3.5A. Annual Precipitation, Klamath Falls and Chiloquin, (Leonard, 1974):

3.6.1 Ecology - Terrestrial

The project site is situated on soil classified by the U.S.D.A. Soil Conservation Service as Dodes loam and Harriman-Lorella complex (see figure 12). These soils consist of well-drained soils formed in sediments weathered from diatomite, tuff, and basalt. Erosion hazard is slight to moderate. Flora are confined to bunch grasses in undeveloped portions of the site, and ornamental trees and lawn in landscaped areas of the facility. Fauna are limited to small numbers of riparian species, such as muskrats, along the irrigation canal near the project, and fewer numbers of skunks which are active in the lower-density residential areas. The nature of the project, being largely underground, is not expected to affect either soils, flora, or fauna in the area.

3.6.2 Ecology - Aquatic

The only aquatic habitat in the project area is the aforementioned irrigation canal, which supports bunch grass on its banks, no fish, and small numbers of muskrats. The irrigation water also supports large levels of phytoplankton and zooplankton. Seasonal changes attendant to this aquatic habitat are those of the April through October operational period of the canal, and its dry non-use in the remaining months.

3.6.3 Ecology - Endangered species and habitats.

There are no endangered or threatened species or habitats in the project area (see figure 15) as determined by the Oregon State Department of Fish and Wildlife.

3.7 Regional Landmarks

No regional landmarks of historical or archeological significance are located on or adjacent to the project site. The project will have no historical or archeological impact.

3.8.1 Social Profile - Community Characteristics

The city of Klamath Falls currently has a population of 18,300 persons, the median age being 28 years, and sex distribution being equally 50% for male and female. The urban area of the community comprises approximately 20 square miles, with another 10 square miles of low-density suburban development, all of which is surrounded by rural environs. In addition to the city government, County government is headquartered in Klamath Falls. There are also 10 special service districts operating in the unincorporated portions of the urban area. The regional economy is structured around agriculture (40%), lumber, wood and related manufacturing (40%) and diversified services, including tourism (20%). The 1976 total County gross farm income was \$95 million, with a like amount for timber income. Retail sales in 1976 reached a total of \$181 million. Median family income in 1976 was \$12,751. Unemployment rates consistently range between 7 and 9%, despite a 16% increase in the labor force between 1970 and 1975. The City has an assessed valuation of nearly \$200 million, which generated approximately \$3 million in property tax revenues; the total annual City budget

ROBERT W. STRAUB
GOVERNOR

Department of Fish and Wildlife

REGION 3—CENTRAL OREGON

61374 PARRELL ROAD, BEND, OREGON 97701 PHONE 382-5113

- 75 -

MAR 9 REC'D

March 6, 1979

4343 Miller Island Road
Klamath Falls, Oregon 97601

Brian C. Fitzgerald, General Director
Young Men's Christian Association
1221 South Alameda Street
Klamath Falls, Oregon 97601

Dear Mr. Fitzgerald:

This is in reply to your inquiry dated February 27, 1979 relative to an Environmental Impact Report on geothermal fluid reinjection on "Y" property. There are no known resident rare, threatened, or endangered wildlife species on or adjacent to YMCA property. I can't foresee any impact from such a practice on such species which may be present nearby.

Sincerely,

Ralph Opp
Wildlife Biologist
Klamath District

RO/mo

FIGURE 15.

STATE FISH & GAME COMMENTS ON PROJECT

exceeds \$10 million. Community services include a full range of police, fire, elementary and secondary education, parks and recreation, sewer and water service, solid waste disposal, health care and welfare service.

3.8.2 Recreation

Klamath Falls supports a well-established parks and recreation program. Within the City are 18 facilities, 14 neighborhood parks and four special use parks. These are outlined on the following page.

Generally the City's parks and recreation programs are busy. Attendance levels indicate that a large portion of the urban area population is consistently using Moore Park, the swimming pool, most recreation programs, and even some neighborhood parks (primarily Veterans Memorial and Kit Carson). During the three months of the year when the Klamath Falls Municipal Swimming Pool is open, a variety of recreation classes, public swim sessions, and special events are held there. The activities pursued in the pool complex break down to 72 percent user ratio for the swimming pool itself, eight percent for the wading pool, 20 percent usage by spectators and sunbathers. The majority (60 percent) are from the Klamath Falls suburbs, 30 percent of the users are from the City and only two percent are from outlying areas.

Moore Park, the City's premier facility, attracts a diverse group of visitors, representing all ages, origins, and recreational interests. Because of its location, it is reached almost exclusively by auto, and has become a popular gathering spot for young "cruisers" who now constitute

its largest user group. The most frequent visitors to the park are City and suburban residents (48 percent and 43 percent respectively), traveling an average of from one to five and from five to ten miles to reach the park. As the City's only regional facility, it receives a large number of visitors from outside the urban area (nine percent). The park's proximity to Highways 97 and 140 contributes to tourist rest stops and picnic uses, and for outlying residents it serves as a regional focal point for recreation, especially lake-oriented activities. Activity participation rates break down as follows (1977 data): picnic, 18 percent; spectators, 17 percent; tennis, 13 percent; field activities, 13 percent; cruising, eight percent; boating, six percent; zoo, six percent; wading pool, four percent; nature trail, two percent; cultural activities, two percent; day camp, one percent; and archery, one percent.

Statistics on the use of Kiger Stadium and Maple Park (the art gallery) are not currently available.

The recreation programs begun in 1938 fluctuate with the public interest. To a large extent the City acts as a "clearing house", coordinating the capabilities of private instructors with public needs, rather than maintaining a full-time public recreation staff. The City relies on other organizations as well as its own park system to provide physical facilities for the programs. One primary resource is the public schools, and numerous activities are held both indoors and outside on the school grounds.

The 1977 summer programs consisted of some 22 different

activities with a total participation of 2,717. These included: swimming lessons (981), track and field (600), archery shoots (193), Pee Wee softball (182), tennis lessons (160), arts and crafts (133), Babe Ruth baseball (91), baton and tap dance (80), bike races (53), American Legion baseball (39), recreational rowing (29), jogging/walking (29), drama classes (27), skateboard tournament (25), drawing (17), folk dance and creative movement (15), Casey Stengel baseball (15), tumbling for tots (13), slim and trim exercise (11), mountaineering (9), Hatha Yoga (8), beginning ballet (8).

It can be assumed that the largest majority of participants were children, and, to a lesser extent, young adults. Although this is a City-sponsored program, 50 percent of the participants were from the suburbs of Klamath Falls and only 40 percent were from within the City limits. The remaining 10 percent were from outlying areas.

Winter recreation programs included Saturday open gyms at six City schools (Roosevelt, Conger, Mills, Fairview, Pelican and Riverside), swimming at the Klamath Union High School pool, two basketball leagues, volleyball, a Special Olympics recreation program, and adult open gym facilities for such recreation as basketball and tennis one weekday at the junior high school.

Many of the recreational programs include special sessions and activities for the handicapped youth and adults of the Klamath Falls urban area.

The City is not the only entity in the recreation business

in Klamath Falls. Oregon Tech offers a wide range of physical education programs on a college credit basis. The County schools, like the City schools, open their facilities to public use under certain special guidelines. Another major element in the urban area is the Wiard Park District, serving the south suburbs.

Private recreational facilities are also available. The Yacht Club, Klamath Basin Boaters, Reams Golf and Country Club, the Elks Club, Lake Ewauna Rowing Club, the Racquet Club, two gun clubs, private tennis courts, two bowling alleys a youth center and numerous indoor table game amusements offer recreation for the local citizenry.

One other well-known recreational facility is the YMCA. Its present programs vary from Yoga to soccer, women's weight lifting to modern dance. It also offers classes in various subjects such as interior design and finance seminars. Structured youth leagues in basketball and soccer have also been formed. During the summer the Y provides day camp programs and skills classes to range from sports to art. The aquatics department is one of the best in the county, offering lessons for all ages ranging from infants to adults, and lap swims, open recreational swims, and a handicap swim for those mentally or physically disadvantaged.

3.8.3 Social Profile - Ambient Noise

The project site is immediately adjacent to a state highway which generates noise levels estimated to exceed 70 dbA at a distance of 100 feet (Wilsey and Ham, 1978) during peak hour traffic. This is comparable to the short

term noise emissions which are expected to be generated by the well drilling activities for the project, thus no significant change in ambient noise levels will be brought about by the construction activities for the project. Near by residences are separated from both the project site and the highway by topography, distance and vegetation all of which serve to minimize the impact of noise emissions.

Actual drilling at the well site will be confined to normal work hours, 8:00 a.m. to 5:00 p.m., and to the normal work week, Monday thru Friday, in order to minimize noise annoyance to neighbors. This schedule was used for the construction of the existing project well with no reports or complaints of annoyance to neighbors. Noise attenuation will be immediately provided if complaints are received.

Other than short term construction activity related to the proposed well, no significant noise emissions will be contributed by this project.

4. ENVIRONMENTAL EFFECTS OF THE PROJECT

4.1.1 Physical Environment - Land Use

Land-use impacts are expected to be virtually

non-existent. The project site is currently occupied by existing YMCA facilities. The project is a conforming land use under the present zoning designation for the site, and will have no impact on land use on adjacent sites (see Senior City Planners Remarks, Figure 16, and State Highway Division remarks, Figure 17).

4.1.2 Physical Environment - Water Use

The project is not expected to affect water supplies in the area. Injection of the spent geothermal fluid into the production reservoir will help maintain fluid pressure and minimize impact on other wells in the vicinity. Locally the Klamath Falls School District has used injection to return spent geothermal fluids from three schools, returning an average of 1,000 acre-feet of water per year with no apparent deleterious effects. This experience in returning large flows of geothermal water, developed over the last 15 years indicates that the impact of injection of our spent geothermal fluid upon other wells should not be significant. Upon completion of the well construction a testing program will be initiated under the guidance of the O.I.T. Geo-Heat Utilization Center to fully determine any noticable effects of fluid withdrawal and injection on nearby wells. This data will be assessed along with information provided by the City of Klamath Falls from a similar, more intensive testing program to be conducted for their Downtown Geothermal Heating District Project. From this information a management plan for proper utilization of the resource will be developed.

In the event that complaints of excessive drawdown are received from adjacent well owners, the Project Coordinator will review said claims in conjunction with available information from joint monitoring programs for the YMCA and the City Heating projects. The Project Coordinator may call upon the Oregon Institute of Technology Geo-Heat Utilization Center for technical assistance, and may, at his discretion, authorize an intensified monitoring program should he deem it necessary. In the event that production well pumping or injection caused a demonstrable impairment on an adjacent well owners ability to gainfully utilize the heat resource of the geothermal aquifer, then the following mitigation measures, as described in B on page 9, will be followed.

4.1.3 Physical Environment - Water Quality

The project will have no significant impact on water quality in the project area. Injection of the geothermal fluids into the producing aquifer will eliminate any impact upon surface water quality. Utilization of the geothermal fluids will not constitute any qualitative change in the waters other than temperature change and thus will have no impact upon water quality in the producing aquifer.

4.1.4 Physical Environment - Natural Resources

The project will have the positive impact on the geothermal resource of constituting a managed use of the resource. Injection of the geothermal fluids are a necessary step for long range maintenance of the resource. Future integration of the project system into the proposed city-wide geothermal heating district will provide area residents with an economical alternative to extensive private development of the resource, allowing for a lessening of area dependence on fossil fuels for heat and better resource management through centralized control.

4.1.5 Physical Environment - Air Quality

There will be no discernable negative effect on air quality as a result of this project. No significant amounts of non condensible gaseous effluents, water vapor, particulate matter or hydrogen sulfide will be emitted by the project facilities. The project could have the positive impact on air quality through decreasing air

pollution emissions from the YMCA heating system by as much as 1,025 per year (see section 2.3.2, page 22). This would be a significant contribution to the air quality of the area.

4.2.1 Ecological Environment - Terrestrial

The project will alter less than 3,000 square feet of soil during well construction activities. As the project site is totally within YMCA property which is utilized for recreational activities, soil productivity is not an applicable concern. Erosion potential is minimal and will be minimized by landscaping restoration. The only plant communities to be affected will be natural weeds and grasses, and lawns. Due to the residential setting of the project site no appreciable wildlife impacts are expected. No animals will be destroyed or displaced, and there will be no loss of food resources, protective cover, or breeding areas. There will be no interference with movements of species. There will be no impacts of pollutants on adjacent terrestrial biota, either through wind or water transport.

4.3 Socioeconomic Environment

Neither the construction nor the operation of the project will have significant impact on the existing socioeconomic environment in the Klamath Falls Area. The labor force required for construction is small and can easily be supplied from the local area, creating no increase in demands for community facilities and

services. Operation and maintenance of the project will require no additional manpower above the requirements for the existing system.

4.4 Potential Mishaps

Potential mishaps associated with this project include subsurface well casing failure, surface or subsurface pipe failure, diesel fuel spills or fires, and drilling rig accidents.

Well casing failure during drilling is not a problem in this area and is considered highly unlikely due to the low temperatures and pressures which are characteristic of this area. A blowout preventer will not be used during drilling since the hydrostatic pressure of the formations can easily be controlled with the drilling fluid.

Any fuel spill at the site can be easily cleaned up and will be handled in accordance with Oregon State Department of Environmental Quality guidelines. Fire protection will be provided by the City of Klamath Falls.

Rig and construction related accidents are always possible. The effects of any such accidents will be limited to personnel directly involved. An experienced, licensed and bonded well drilling firm will carry out well drilling operations.

During operation, failure of surface or subsurface piping could occur. Selection of pipe materials will minimize the chance of corrosion-related failures of piping. In the event of a piping failure, automatic

pressure sensitive controls would shut down the system, greatly limiting the amount of geothermal fluids lost. The high quality of the local geothermal water (acceptable under Federal and State drinking water standards) minimizes any adverse impact from lost geothermal fluids.

5 Measurement and Monitoring Programs

The environmental measurement and monitoring program for the proposed project will focus on determining the effects, if any, of the project on adjacent wells and the geothermal reservoir itself. The low pressure, low temperature nature of the geothermal resource to be utilized by the proposed project will preclude any significant noise or gaseous emissions. Significant noise emission associated with high temperature, high pressure geothermal resource utilization, such as electrical power generation, can be attributed to steam venting (EPA, 1978) and escape of geothermal fluids under high pressure. The absence of the conditions necessary for such noise emissions will rule out the need for a ambient noise monitoring program at the project site, therefore, no such program will be provided.

Significant gaseous emissions are also associated with high pressure, high temperature systems, depending on active system venting as a media of transfer to the atmosphere. Low temperature and pressure systems associated with nonelectric geothermal applications such as the proposed project experience no more than passive venting caused by normal vaporization at the air-water interface within

the well casing itself. Any possible contribution to ambient air contaminant levels by the operation of the proposed project is considered to be so insignificant as to preclude the need for a costly emission monitoring control system for a project of this size. Therefore, no such monitoring program will be provided.

Upon completion of the production well a monitoring program will be instituted by the Oregon Institute of Technology Geo-Heat Center to determine influence between the deep production well of the project and the adjacent shallow wells. All testing will be fully integrated with a similar program designed for the City of Klamath Falls Downtown geothermal Heating District.

The City plans to install temperature and water level measuring devices in ten existing wells in the area of their production wells. This data will be applied through computer modeling techniques to obtain hydrologic characteristics of the resource. A similar, smaller scale monitoring program will be designed for the YMCA project. This program will be structured to compliment and benefit from the monitoring program for the city project.

6. Reclamation

Project construction will include well site construction, installation of distribution and injection pipeline and installation of retrofit equipment within the existing YMCA facilities. Land disturbances will be wholly limited to conventional pipeline trenching within YMCA

property. After installation of the pipeline, back filling and conventional landscaping procedures will constitute project restoration. All restored and landscaped areas will continue to receive normal YMCA maintenance.

7. Project alternatives

7.1 Delay in project.

Positive impacts attributed to a delay in the construction and implementation of the project are limited to any increased understanding of local hydrological characteristics acquired through the monitoring program to be instituted by the City of Klamath Falls for their Downtown Geothermal Heating District. Such information might influence the design and general management of the project. Any such benefits to be derived from information acquired during a project delay would necessarily be of limited value.

Hydrological conditions existing at the Downtown Heating District production field cannot be applied directly to the YMCA project, except in general terms due to the varied and discontinuous subterranean geology found in the Klamath Falls area. The benefits and overall understanding of the Klamath Falls K.G.R.A. to be derived from a joint-testing program involving both the Klamath Falls Downtown Heating District and the YMCA project far outweigh the possible limited information to be derived from the City's testing program during a project delay. A project delay would however have several negative impacts.

The most obvious negative impact attributed to a project delay would be economic. Any substantial delay in the project would be reflected by a significant rise in the cost of the project. As shown in Figure 18, a two year delay in the project would result in an increase in construction costs of \$30,711 over and above present cost estimates, while a 5 year delay would result in an increase of \$84,401. These estimates are based on an assumed annual inflation rate of 6%. Actual cost increases could be significantly higher.

The geothermal system as proposed will provide in terms of total overall energy usage, 57% of the energy requirement for the facility. Any delay in implementing the proposed project would require the substitution of another, more expensive energy source. The increased cost of energy due to the unavailability of geothermal energy would be significant, especially when viewed in conjunction with estimated construction costs. A two year project delay would cause an estimated 22.6% increase in the overall cost of the project, while a 5 year delay would boost this to an estimated 62.1% increase in total project costs.

Another negative impact associated with project delay and thus a continued use of fossil fuels to meet heating requirements for the YMCA facility would be the subsequent continued emission of air pollutants (6B, page 35). The continued emission of 96 lbs. per year of particulate

	<u>Two-year Delay</u>	<u>Five-year Delay</u>
Cost to replace geothermal energy contribution (allowing for a 6% annual inflation rate in energy costs)	25,840	70,710
Additional construction cost (allowing for a 6% annual inflation rate in construction costs)	<u>30,711</u>	<u>84,401</u>
Total increase in cost of project	\$56,551	\$155,111
 % of Present Value of Cost of Project	 22.6%	 62.1%

Figure 18. ECONOMIC IMPACT OF PROJECT DELAY

matter is significant for Klamath Falls, designated a non-attainment area for total suspended particulates since ambient air monitoring began in 1970 (DEQ, 1978). Emissions of nitrogen oxides, hydrocarbons and carbon monoxides would also be significant. Data on ambient levels of these pollutants and thus current attainment status is not currently available.

A third negative impact associated with a delay in the project would stem from the resulting delay in integrating the YMCA system with the City Geothermal Heating District. The unavailability of district heating capabilities combined with the steadily rising cost of conventional energy sources would encourage widespread development of individual geothermal home heating systems. Individual utilization of the geothermal reservoir would be, at best, difficult to manage. Negative impact of neighboring wells upon each other in such a situation could be significant, and the potential for influence of the proposed project upon an increase number of neighboring wells might be substantially increased. Long term management of the resource would be difficult. The economics of size to be found in a large heating district, would of course be lost, resulting in a higher energy cost to the community.

7.2 No Project

Abandonment of the proposed project would have no positive impacts on the environment other than assurance of no possible influence on adjacent wells by the project.

This positive impact would however, be nullified and in time superseded by the negative impacts associated with widespread individual development of the resource, as discussed above. There are many other negative impacts associated with the no project alternative.

Continued reliance on conventional sources to supply the total energy needs of the YMCA facility, an estimated 70,000 Therms per year, would mean an annual energy cost to the facility within ten years of more than \$32,000, or almost double present costs. This substantial increase in operating costs to a non-profit organization such as the YMCA would certainly hamper efforts to expand services available to the community, and could possibly result in a curtailment in program availability. For a facility which provides programs and services to 20% of the urban population, any such curtailment would have a significant negative impact on recreational resources available to the community.

Non-construction of the project would have a definite negative impact upon the ambient air quality of the Klamath Falls area. A direct effect of the persistent use of fossil fuels by the YMCA facility as an energy source would be, as previously discussed, the continued emission of air pollutants, notably suspended particulates, within the air-shed of a designated non-attainment area. However, non-construction of the project and hence an eventual delay in availability of district heating capabilities could

have an even more significant impact upon the air quality of the Klamath air-shed.

The inavailability of district heating capabilities, along with the ever increasing cost of heating homes by conventional means would encourage home owners to seek alternate home heating systems. While some would develop private geothermal heating systems, many would turn to wood burning systems due to the relative local abundance of wood as a fuel. Local vegetative burn sources such as fireplaces and woodstoves contribute significantly to ambient total suspended particulate (TSP) levels in urban areas.

Such sources have been shown to be the second largest contributor to TSP levels within the Portland Air Quality Maintenance Area (Cooper, 1979). Domestic wood very possibly is just as significant in contributing to already excessive levels of TSP in the Klamath Falls area. A substantial increase in TSP loading of the Klamath air basin due to increase use of wood fuel for domestic heating could have serious detrimental impacts upon the air quality of this area.

Non-construction of the project, and the resulting reliance by the YMCA facility would be contrary to National Energy goals to decrease reliance on ever shortening supplies of domestic and imported fossil fuels, and to increase the contribution of alternate energy sources to our energy budget. Natural gas, imported from Canada,

supplies a significant portion of local energy needs, including the YMCA facility. Construction of the proposed project would not only virtually replace natural gas as an energy source for the YMCA facility, but as the project is integrated into the City Heating District and domestic heating capabilities are brought on line it will replace natural gas as a fuel for many local residences as well.

8. Irreversible and Irretrievable Commitments

Irreversible and irretrievable commitments for this project will essentially be limited to construction fuels and nonrecyclable building materials. A ten foot by ten foot portion of the YMCA facilities will be committed as the site of a small pump building for the duration of the project.

As with the development of any resource, there is the possibility of direct commitment in terms of resource depletion over a long-term period. The project will extract from the geothermal reservoir over the estimated 50 year life cycle of the project an estimated 2.4×10^{14} joules of energy. With a projected available resource of 30×10^{18} joules of thermal energy, the project will deplete less than 1/1000% of the projected geothermal resource. This small commitment of the resource is negligible.

9. Trade-Off Analysis

9.1 Environmental Analysis

The project involves long term commitment of a geothermal resource on a small scale to an environmentally

acceptable application towards space heating. Alternatives to this project include continued private development with its inherent problems of inefficiency and difficulty in resource management, and continued dependence upon the environmentally insulting and costly fossil fuels as a heat source. The proposed project is environmentally sound.

9.2 Estimate of Life Cycle Energy Costs

Based on a 50 year life cycle and allowing for a 6% inflation of energy costs per year, this system will produce a total energy savings of \$3,106,000 and will pay for the original installation cost in approximately thirteen (13) years.

The savings in energy is the equivalent of 2,216,650 Therms of gas, or 39,926 Barrels of oil over the 50 year life. Even at today's cost of oil this would equal a savings of \$670,800.

The normal expected life of the major components such as the pump, coils and heat exchangers is approximately 25 years according to data supplied by ASHRAE. Therefore, this would reduce the dollar savings. This can be considered replacement value. The present value of those items that will have to be replaced after 25 years is approximately \$31,000. This value at 25 years, again allowing for 6% inflation, would then cost \$133,100 or an estimated savings over the 50 years of \$2,972,900.

Maintenance is not considered in the above calculations since the cost of maintenance on the new system would

be about the same as for the existing system.

10. Compliance with Regulations and Other Controls

The project will be affected by the following controls:

City: The project complies with current and proposed city land use ordinances. The drilling of the well will require a City of Klamath Falls Hot Well Permit, normally obtainable within 30 days. The construction of the pump house over the production well will require a City of Klamath Falls Building Permit, normally obtainable within 30 days.

County: The installation of retrofit equipment into the existing facilities will require a Klamath County Plumbing Permit, normally obtainable within 30 days.

State: The drilling of the well will require an Oregon State Department of Water Resources Well Drilling Permit, normally obtainable within 30 days.

Federal: No Federal permits will be required for this project.

REFERENCES

- Couch, R. W. and Lowell, R. P., 1971, "Earthquakes and Seismic Energy Release in Oregon", Ore Bin, v. 33, no. 4, p. 61-84.
- Environmental Protection Agency, 1978, Pollution Control Guidance for Geothermal Energy Development; Report No. 600/7-78-101; Office of Research and Development.
- Illian, J. R., 1970, "Interim Report on the Ground Water in the Klamath Basin, Oregon", Oregon State Engineer, Salem, Oregon.
- Justice, D., 1979, Conference on Environmental Concerns to Geothermal Development, Oregon Institute of Technology, Klamath Falls, Oregon.
- Leonard, A. R., and Harris, A. B., 1974, "Ground Water in Selected Areas in the Klamath Basin, Oregon", Oregon State Engineer Ground Water Report No. 21, Salem, Oregon.
- Lienau, P. J., Lund, J. W., and Culver, G.G., 1977, Klamath County Geo-Heating District Feasibility Study, Geo-Heat Utilization Center, Oregon Institute of Technology, Klamath Falls, Oregon.
- Lund, J. W., et al., 1978, Geothermal Hydrology and Geochemistry of Klamath Falls, Oregon, Urban Area, (U.S.G.S. Grant No. 14-08-0001-G-291), Oregon Institute of Technology, Klamath Falls, Oregon.
- Lund, J. W., et al., 1978, "Rough Draft, Conceptual Design of the Klamath Falls Downtown Geothermal Heating District", LLC Consultants, Klamath Falls, Oregon.
- O'Connell, M. F., and Kaufmann, R. F., 1976, "Radioactivity Associated with Geothermal Waters in the United States," Technical Note ORP/LV-75-8A, U. S. Environmental Protection Agency, Las Vegas, Nevada.
- U. S. Department of Housing and Urban Development, 1978, "Flood Hazard Boundary Map, Klamath County, Oregon".
- U. S. Geological Survey, 1978, "Assesment of Geothermal Resources of the United States", U.S.G.S. Circular No. 790, Arlington, Virginia.
- Cooper, J. A., and Watson, J. G., 1979, "Final Report Summary", Portland Aerosol Characterization Study, Oregon Graduate Center, Beaverton, Oregon.
- Department of Environmental Quality, 1978, Oregon Air Quality Report 1977; Air Quality Control Division, Portland, Oregon.

APPENDIX A.

Chemical analyses of geothermal
well water in the vicinity of
the project site (Kingswood
Apt. wellhead) and at O.I.T.
performed May, 1979 by Pacific
Northwest Laboratory, Richland,
Washington

- 99 -

PACIFIC NORTHWEST LABORATORY, RICHLAND, WA
MATERIALS DEPT., CORROSION RES. AND ENGINEERING

DATE: 5/1/79

PROJECT: OIT

CONCENTRATION (mg/l) OR OTHER

SAMPLE ID PARAMETER	OIT Well #2 4/17/79	OIT Well #6 4/17/79	Kingswood Apt. Wellhead-4/18/79	Kingswood Apt. 2969 - 4/18/79
pH	8.65	8.66	8.39	8.18
CONDUCTIVITY	840 μ mhos/cm	840 μ mhos/cm	710 μ mhos/cm	710 μ mhos/cm
TDS	789	798	643	644
SUSPENDED SOLIDS	ND ¹	ND ¹	ND ¹	ND ¹
TURBIDITY	3 FTU	ND ¹	ND ¹	3 FTU
HCO ₃ ⁻ (TITRATION)	30	31	92	89
CO ₃ ⁼ (TITRATION)	3.9	ND ¹	ND ¹	ND ¹
SO ₄ ⁼ (TURBIDIMETRIC)	340	340	260	260
SO ₄ ⁼ (ION CHROM.)	378	395	271	270
F ⁻ (ION CHROM.)	1.2	1.3	0.6	0.6
Cl ⁻ (TITRATION)	48	49	36	36
NH ₃ (ELECTRODE)	<0.2	0.2	2.6	1.7
SiO ₂ (COLORIMETRIC)	79	76	87	87
NO ₃ ⁻ (ION CHROM.)	<0.25	<0.25	<0.25	<0.25
OTHER: K (ION CHROM.)	4.2	4.5	4.4	4.5
Cl (ION CHROM.)	43	43	28	35
NH ₃ (ION CHROM.)	<1.0	<1.0	3.0	2.1
H ₂ S (Zn(OAC) ₂ Sample 2)	0.5	0.3	0.1	0.3
CO ₂ (NaOH Sample)	40	37	129	122
H ₂ S ² (Field)	0.1	0.1	0.2, 0.1	<0.1
Pressure (Field)	51 psig	52 psig	35 psig	Gravity
Temp. (°C)	84	89	47	37
pH (Field)	8.7 (25°C)	8.7 (28°C)	8.5 (12°C)	8.4 (24°C)

ARGON PLASMA EMISSION SPECTROMETER RESULTS
 CONCENTRATION (mg/l)

SAMPLE ID PARAMETER	OIT Well #2 4/17/79	OIT Well #6 4/17/79	Kingswood Apt. Wellhead-4/18/79	Kingswood Apt. 2969 - 4/18/79
Al	<0.10	<0.10	<0.10	<0.10
As	<0.05	<0.05	<0.05	<0.05
B	0.90	0.92	0.56	0.56
Ba	<0.01	<0.01	0.01	0.01
Ca	23	24	13	13
Fe	<0.10	<0.10	<0.10	0.10
K	----	----	----	----
Li	0.18	0.18	0.11	0.11
Mn	<0.05	<0.05	0.73	0.76
Na	240	250	200	190
P	<0.05	<0.05	<0.05	<0.05
Si	39	39	43	43
Sr	0.27	0.29	0.04	0.04

PACIFIC NORTHWEST LABORATORY, RICHLAND, WA
MATERIALS DEPT., CORROSION RES. AND ENGINEERING

- 100 -

DATE: 5/1/79

ARGON PLASMA EMISSION SPECTROMETER RESULTS

PROJECT: OIT

CONCENTRATION (mg/l)

PARAMETER \ SAMPLE ID	OIT Well #2 4/17/79	OIT Well #6 4/17/79	Kingswood Apt. Wellhead-4/18/79	Kingswood Apt. 2969-4/18/79
Ag	< 0.01	< 0.01	< 0.01	< 0.01
Cd	< 0.01	< 0.01	< 0.01	< 0.01
Co	< 0.01	< 0.01	< 0.01	< 0.01
Cr	< 0.05	< 0.05	< 0.05	< 0.05
Cu	< 0.01	< 0.01	< 0.01	< 0.01
Mn	< 0.01	< 0.01	0.02	0.02
Mo	< 0.50	< 0.50	< 0.50	< 0.50
Ni	< 0.01	< 0.01	< 0.01	0.02
Pb	< 0.10	< 0.10	< 0.10	< 0.10
Sb	< 0.05	< 0.05	< 0.05	< 0.05
Se	< 0.10	< 0.10	< 0.10	< 0.10
Sn	< 0.10	< 0.10	< 0.10	< 0.10
Th	< 0.10	< 0.10	< 0.10	< 0.10
Ti	< 0.05	< 0.05	< 0.05	< 0.05
Tl	< 0.10	< 0.10	< 0.10	< 0.10
U	< 0.05	< 0.05	< 0.05	< 0.05
Zn	< 0.05	< 0.05	0.10	< 0.05
Zr	< 0.05	< 0.05	< 0.05	< 0.05

REMARKS: 1. Footnotes

ND¹ - None Detected

H₂S² - Chemetrics Kit

NH₄³ - Chemetrics Kit

2. H₂S in system drain line (@ wier - ditch below green house) - 0 ppm

H₂S Simon #1 Bldg - supply - 0 ppm

H₂S Simon #1 Bldg. exit after HX - 0 ppm

H₂S campus drain below greenhouse - 0 ppm

3. O₂ at wellhead pts: (Chemetrics Field Test)

Sample ID	O ₂ (ppb)	Comment
Wellhead #2	40	Leak at outlet valve on main val
Wellhead #6	30, 10, 10, 10	---
Kingswood Apt. Wellhead	0	---
Kingswood Apt. 2969	100	Bubble surge when getting sample

PACIFIC NORTHWEST LABORATORY, RICHLAND, WA
MATERIALS DEPT., CORROSION RES. AND ENGINEERING

- 101 -

DATE: 5/1/79

PROJECT: OIT

CONCENTRATION (mg/l) OR OTHER

PARAMETER	SAMPLE ID	TEST INLET 4/19/79	TEST OUTLET 4/19/79		
pH		8.65	8.65		
CONDUCTIVITY		820 μ mhos/cm	810 μ mhos/cm		
TDS		793	796		
SUSPENDED SOLIDS		ND ¹	ND ¹		
TURBIDITY		ND ¹	ND ¹		
HCO ₃ ⁻ (TITRATION)		32	42		
CO ₃ ⁼ (TITRATION)		5.9	ND ¹		
SO ₄ ⁼ (TURBIDIMETRIC)		360	340		
SO ₄ ⁼ (ION CHROM.)		388	386		
F ⁻ (ION CHROM.)		1.3	1.4		
Cl ⁻ (TITRATION)		49	49		
NH ₃ (ELECTRODE)		0.3	0.5		
SiO ₂ (COLORIMETRIC)		74	76		
NO ₃ ⁻ (ION CHROM.)		<0.25	<0.25		
OTHER: K (ION CHROM.)		4.6	5.1		
Cl (ION CHROM.)		46	49		
NH ₃ (ION CHROM.)		<1.0	<1.0		
H ₂ S (Zn (OAC) ₂ Sample 2)		0.3	0.3		
CO ₂ (NaOH Sample)		32	37		
H ₂ S ² (Field)		0.2	0.2		
Pressure (Field)		12 psig	6 psig		
Temp. (°C)		86 (10 SAMPLES) 89 (10 TEST FAC.)	84		
pH (Field)		8.7 (28°C)	8.7 (12°C)		
NH ₄ ⁺ (Field)		0.6	0.4 - 0.6		

ARGON PLASMA EMISSION SPECTROMETER RESULTS

CONCENTRATION (mg/l)

PARAMETER	SAMPLE ID	TEST INLET 4/19/79	TEST INLET 4/19/79		
Al		<0.10	<0.10		
As		<0.05	<0.05		
B		0.89	0.89		
Ba		<0.01	<0.01		
Ca		24	24		
Fe		<0.10	<0.10		
K		----	----		
Li		0.16	0.15		
Mn		<0.05	<0.05		
Na		230	220		
P		<0.05	<0.05		
Si		38	38		
Sr		0.28	0.28		

PACIFIC NORTHWEST LABORATORY, RICHLAND, WA
MATERIALS DEPT., CORROSION RES. AND ENGINEERING

- 102 -

DATE: 5/1/79

ARGON PLASMA EMISSION SPECTROMETER RESULTS

PROJECT: OIT

CONCENTRATION (mg/l)

PARAMETER \ SAMPLE ID	TEST INLET 4/19/79	TEST OUTLET 4/19/79		
Ag	<0.01	<0.01		
Cd	<0.01	<0.01		
Co	<0.01	<0.01		
Cr	<0.05	<0.05		
Cu	<0.01	<0.01		
Mn	<0.01	<0.01		
Mo	<0.50	<0.50		
Ni	0.01	0.01		
Pb	<0.10	<0.10		
Sb	<0.05	<0.05		
Se	<0.10	<0.10		
Sn	<0.10	<0.10		
Th	<0.10	<0.10		
Ti	<0.05	<0.05		
Tl	<0.10	<0.10		
U	<0.05	<0.05		
Zn	<0.05	<0.05		
Zr	<0.05	<0.05		

REMARKS:

1. Footnotes

ND¹ - None Detected

H₂S² - Chemetrics Kit

2. O₂ (Chemetrics Test Kit):

Sample PT.	O ₂ ppb	Remarks
A. Drain Pipe @ Bottom of Settling Tank	100 10 5-10	] Sampling tube had air trapped on inner surfaces Probably most representative
B. Drain Pipe @ Bottom of Settling Tank	0 1-2	
C. Drain Pipe @ Bottom of Settling Tank	0	Vent valve closed, tanks pressurized by well head pumps & gravity
D. Test Inlet	0	-----
E. Test Outlet	0	-----

3. Flow Thru Test Fac. - 4.7 gpm

APPENDIX B.

Geo-Heat Center comments on
project in regards to local
experience with injection
of geothermal fluids.

GEO-HEAT UTILIZATION CENTER

OREGON INSTITUTE OF TECHNOLOGY - KLAMATH FALLS, OREGON 97601

July 10, 1978

Ph: 503/882-6321

DIRECTOR

Paul J. Lienou

ASSOCIATE DIRECTORS

Gene Culver

John W. Lund

COORDINATOR

John Smith

RESEARCH ASSOCIATES

Gordon Bloomquist

Keith Brown

Thomas Connors

Leroy Fisk

Charles Higbee

William Johnson

Debra Justus

Don Karr

Robert Koeppen

Saul Laskin

Donald Markle

David McClain

Walter Richartz

Jay Silva

Larsen Svanevik

Brian C. Fitzgerald
General Director
YMCA

P.O. Box 366
Klamath Falls, OR 97601

Dear Mr. Fitzgerald:

This letter is addressed to the environmental impact of your wells for the proposed YMCA geothermal project.

Your proposal includes a production and injection well to be located on the property 500-1000 feet apart. The use of an injection well for fluid disposal will conserve and protect the resource in the Basin. Additionally, this method of disposal eliminates contamination of surface waters that might result if surface disposal methods are used. Fortunately, the geothermal waters in the Basin are relatively pure, having only 800-1000 ppm dissolved solids (primarily sulfates).

Experience in returning large flows of geothermal water has been developed in Klamath Falls over the last 15 years by the Klamath Falls School District. Three schools use geothermal heating systems in which the hot water is circulated through heat exchangers in the buildings, then returned to the reservoir via return wells. These three systems, which have been in operation since 1962, 1965 and 1967, have returned an average of 1,000 acre-feet of water a year into the reservoirs with no apparent deleterious effects. The supply and return wells in all cases are located within 500 feet of each other.

Pipelines to the building and wells will probably be buried and insulated, thus causing no surface impact. As long as the spent fluid is returned to the same producing aquifers, no measurable impact should occur.

FIGURE 6.

GEO-HEAT CENTER COMMENTS ON PROJECT

Brian C. Fitzgerald
July 10, 1978
Page 2

Good luck with your project.

John W. Lund
Civil Engineer &
Associate Director
of Geo-Heat Utilization
Center

Sincerely,

Paul J. Lienau
Director, Geo-Heat
Utilization Center

JWL/PJL:db

References on the Klamath Falls KGRA

1. Peterson, Norman V. and Edward A. Groh, "Geothermal Potential of the Klamath Falls Area, Oregon--A Preliminary Study, The Ore Bin, Vol. 29, No. 11, State of Oregon Department of Geology and Mineral Industries, Portland, November 1967.
2. Peterson, Norman V. and James R. McIntyre, "The Reconnaissance Geology and Mineral Resources of Eastern Klamath County and Western Lake County, Oregon," Bulletin 66, State of Oregon Department of Geology and Mineral Industries, Portland, 1970.
3. Sammel, E. A., "Hydrologic Reconnaissance of the Geothermal Area Near Klamath Falls, Oregon," Open-File Report URI 76-127 USDI, Geological Survey, Menlo Park, California, 1976.
4. Culver, G. Gene, John W. Lund and Larsen S. Svanevik, "Klamath Falls Hot Water Well Study," Lawrence Livermore Laboratory, Report #13614, California, October 1974.
5. Lund, John W., "Geology and Hydrology of the Klamath Falls Urban Area," USGS, July 1978.

CITY OF KLAMATH FALLS, OREGON

226 SO. FIFTH STREET
ZIP CODE 97601

TELEPHONE 884-3161
AREA CODE 503

March 30, 1979

Young Men's Christian Association
1221 South Alameda Street
Klamath Falls, OR 97601

ATTENTION: Brian C. Fitzgerald

RE: Geothermal Injection Well

Dear Mr. Fitzgerald:

It has come to my attention that the Klamath County YMCA is in the process of developing an injection well as part of your facility's geothermal heating system.

I would commend the YMCA for your efficient approach towards the utilization of this resource, and I foresee no conflicts with any current or proposed City land use plans or regulations.

Sincerely,

A handwritten signature in cursive script that reads "Andy Coughanour".

ANDY COUGHANOUR
Senior Planner

AC:hg

FIGURE 16. CITY PLANNING DEPARTMENT COMMENTS

SISTER CITY
ROTORUA, NEW ZEALAND

OREGON STATE
HIGHWAY DIVISION

2557 Altamont Drive
Klamath Falls, OR 97601

- 107 -

ROBERT W. STRAUB
GOVERNOR

F. B. KLABOE
Administrator and
State Highway Engineer

Mar. 8, 1979

MAR 9 REC'D

Mr. Brian C. Fitz Gerald
General Director
1221 So. Alameda St.
Klamath Falls, OR 97601

Dear Mr. Fitz Gerald:

This is in response to your letter dated February 27, 1979 where you requested comments on a reinjection well you plan on installing at the YMCA.

Please be advised the State Highway Division has no objection to said installation if all County, City and State codes are met.

Very truly yours,

John L. Gunter
District Engineer

JLG:tlc

FIGURE 17.

STATE HIGHWAY DIVISION COMMENTS ON PROJECT

APPENDIX C.

Key personnel involved in the
YMCA geothermal heating project.

Key Personnel

- a. Project Coordinator - Brian Fitz Gerald, General Director YMCA of Klamath Falls; B.A. Industrial Psychology, Business Management. University of Houston, 1969, Graduate American Management Assoc. Supervisory Management - 1973, Program Director Westland YMCA, Houston, Texas 1967-72, Executive Director Westside YMCA, Tulsa, Oklahoma 1972-77, General Director Klamath County YMCA 1977 to present.
- b. YMCA President, Chairman of Board - Chairman of Energy Committee, Don Johnson, Vice-President Wood Products Division, Weyerhaeuser Corporation, presently in charge of a \$3,000,000 plant renovation project. YMCA Board - 5 years, 1st Vice-President 2 years.
- c. YMCA 1st Vice President, Energy Committee member, Ray Harris, General Manager, Montgomery Ward's Department Store. YMCA Board - 4 years.
- d. 2nd Vice-President, Energy Committee member, Alan Lee, local attorney-at-law, practicing civil, criminal and corporate law - YMCA Board 4 years - one of two originators of the geothermal project.
- e. YMCA Past President, Energy Committee Vice Chairman - Dick Ledgerwood, Stockbroker with Foster and Marshall - 6 years on the board, original initiator of geothermal project 2 years ago - made contact with O.I.T. and let the original well-drilling contract.

f. YMCA Treasurer, Energy Committee member, Robert McQuown, Past Personnel Supervisor, Western Division U.S. Forest Service, Presently Head Ranger, Klamath District, U.S. Forest Service - YMCA Board 5 years.

g. Consulting Engineer - Paul Lienau, Director, O.I.T. Geo-Heat Utilization Center; B.S., Physical Science, Black Hills State College, 1959; M.S., Physics, Temple University, 1963; faculty, Willmar State College, 1963-68; faculty, Oregon Institute of Technology, 1968-present.

Areas of specialty include utilization of low temperature geothermal water, corrosion and electrolysis on downhole heat exchangers, geothermal economic analysis, geothermal district feasibilities.

h. Consulting Engineer - John Lund, Assoc. Director, O.I.T. Geo-Heat Utilization Center; B.S., Civil Engineering, University of California, 1962; Ph.D., Civil Engineering, University of Colorado, 1967; faculty, University of Alaska, 1964-65; faculty, Oregon Institute of Technology, 1967-present.

Areas of specialty include highway materials, transportation design, geology (engineering & field, geomorphology, perma frost), geothermal development (geophysical, geology, nonelectric applications).

i. Consulting Engineer - G. Gene Culver, Assoc. Director, O.I.T. Geo-Heat Utilization Center; B.S., Production Technology, Oregon State University, 1969.

Faculty, Oregon Institute of Technology, 1966-present.
Areas of specialty include mechanical engineering,
plastics engineering, high vacuum engineering; applica-
tions of low temperature geothermal fluids.

- j. EIR Writer/Editor - Jimmie Shreve, A.S. Environmental
Technology, Lane Community College, 1977; B.S. Environ-
mental Technology, Oregon Institute of Technology, 1980;
primary author, EIR for the Klamath Falls Downtown
Geothermal Heating District; Water Quality Specialist,
Klamath County Department of Health Services, 1977-79;
currently engaged in water quality and environmental
assessment projects for the U.S. Forest Service.
Areas of specialty include technical report writing,
water quality assessment, potable water supply systems,
waste water treatment systems, and geothermal direct
utilization systems.