GEO-HEAT CENTER

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PRELIMINARY FEASIBILITY STUDY FOR A GEOTHERMAL HEAT PUMP SYSTEM AT THE IDAHO FISH AND GAME HEADQUARTERS, BOISE, IDAHO

EXECUTIVE SUMMARY

The Geo-Heat Center conducted a preliminary assessment of the feasibility of a geothermal heat pump system at the new planned Idaho Fish and Game Headquarters, located in Boise, ID. We considered three options for the geothermal part of the system: (i) an open-loop with supply and injection well, (ii) a vertical borehole, closed-loop earth heat exchanger, and (iii) a horizontal closed-loop earth heat exchanger.

Estimation of the Heating and Cooling Loads and the HVAC System

The heating and cooling loads at this preliminary stage were estimated using a simple software tool. The peak cooling load is estimated at about 164 tons and the peak heating load is estimated at about 532,000 Btu/hr.

A conventional heating, ventilating, and air-conditioning (HVAC) system has not been designed at this time, but it is the Geo-Heat Center's opinion that the most appropriate type of system would be either a 4-pipe boiler/chiller system or a water-source heat pump system with low-temperature boiler and cooling tower. A multi-zone rooftop system might also be an option. Typical installed costs for these types of systems range from $\$12/ft^2$ to $\$15/ft^2$ of floor space, with multi-zone rooftop systems at the lower end and 4-pipe systems at the upper end of the range.

Based on recent case studies by the Geo-Heat Center, "inside the building" mechanical and plumbing work associated with geothermal heat pump systems can be installed for about $\$11/ft^2$ of floor space. This was the assumed cost for this study.

Geological Conditions

Review of two well logs drilled on the property shows that the site is underlain by alternating layers of sands and clays. A significant amount of groundwater is also present; a 500-ft deep well drilled in 1964, that had been previously used for heating, was flow-tested at 700 gpm, and a shallower well, drilled to 83 ft, is currently used for irrigation purposes and produces about 150 gpm. Thus, the site geology would be suitable for either an open-loop or closed-loop geothermal heat exchange system.

Open-Loop Geothermal Option

This type of system would consist of a production well and an injection well. The existing irrigation well could possibly be re-used as an injection well. The groundwater loop would be isolated from the building loop with a plate heat exchanger. Assuming 60°F groundwater, it is estimated that a well yielding 250 gpm could handle the peak cooling load.

Vertical Closed-Loop Geothermal Option

This type of system would consist of a network of vertical boreholes, each consisting of a high-density polyethylene (HDPE) plastic u-tube heat exchanger. The required total borehole heat exchanger length is dependent on the average underground earth temperature and thermal properties. It is estimated that the new building will require about 140 vertical boreholes, each 250 ft deep. At 20-ft lateral spacing, this would take up about 40% of the parking lot area, or about 33,000 ft^2. Prior to final design, a test hole should be drilled and a thermal conductivity test be conducted.

Horizontal Closed-Loop Geothermal Option

This type of system would consist of a very compact network of buried "slinky" coils. Horizontal loops require much more pipe than vertical loops because they are buried at depths that still experience some seasonal temperature fluctuations, and thus burial depths should be no less than 6 ft. The estimated size of a horizontal loop for the new building would take up about 70% of the parking lot area, or about 58,000 ft^2.

Economic Comparison of Alternatives

The following table summarizes the economics of the proposed geothermal project. The energy savings are based on energy rates from recent utility bills for the existing Idaho Fish and Game Office.

HVAC System	Typical Installed Cost (Inside the Building) *($/sq. ft of floor space)*	Typical Installed Cost (Geothermal Earth Work) *($/ton of cooling)*	Total Installed System Cost	Annual Energy Savings	Simple Payback On energy Savings *(yrs)*
Conventional	$13.50	-	$1,080,000	-	-
Open-Loop Geothermal	$11.00	$750	$1,003,000	$11,800	0.0
Vertical Closed-Loop Geothermal	$11.00	$1,750	$1,167,000	$12,500	7.0
Horizontal Closed-Loop Geothermal	$11.00	$1,250	$1,085,000	$10,000	0.5

All geothermal options are quite economically favorable, particularly the open-loop and horizontal closed-loop options. A sensitivity analysis done on the capital costs, which is presented in the form of contour maps in this letter report, show that the worst case cost scenarios increase the payback period to 7 years for an open-loop system, 19 years for a vertical closed-loop system, and 16 years for a horizontal closed-loop system.

Recommendations

The Geo-Heat Center recommends that this is a good time to refine project goals with a geothermal heat pump system in mind so that the design can proceed without having to go back and re-design the building's mechanical system. It is our opinion that in order to make this process somewhat easier, as well as making future bid evaluations more streamlined, Idaho Fish and Game should consider the base HVAC design to be a water-source heat pump loop with a boiler and cooling tower. Therefore, the base mechanical system and geothermal "in the building" system would essentially be equivalent (except for the mechanical room), and these could be designed in a similar fashion. The geothermal earth loop design can take place independently as necessary as more geological information becomes available. This allows a base conventional and alternate geothermal bid to be solicited and compared economically without wasting design time and cost, should a geothermal bid be unacceptable.

Sincerely,

Andrew Chiasson, P.E.

INTRODUCTION

The Geo-Heat Center was contacted by the Idaho Energy Division to conduct a preliminary assessment of installing a geothermal heat pump system at the planned new Idaho Fish and Game Headquarters, located in Boise, ID. This assessment is considered preliminary because the building design has not been finalized at this time.

For this preliminary study, the Geo-Heat Center considered the feasibility of three possible options for the geothermal part of the system: (i) open-loop earth heat exchange with a supply and injection well, (ii) a vertical borehole, closed-loop earth heat exchanger, and (iii) a horizontal, closed-loop earth heat exchanger.

ESTIMATION OF THE HEATING AND COOLING LOADS

The peak hour and total annual heating and cooling loads were estimated using RETScreen, a simple tool developed by Natural Resources Canada. Figure 1 shows a screen capture of input assumptions and the estimated loads.

RETScreen® Heating and Cooling Load Calculation - Ground-Source Heat Pump Project

Site Conditions		Estimate	Notes/Range
Nearest location for weather data		Boise, ID	*See Weather Database*
Heating design temperature	°C	-12.8	-40.0 to 15.0
Cooling design temperature	°C	34.5	10.0 to 40.0
Average summer daily temperature range	°C	15.8	5.0 to 15.0
Cooling humidity level	-	Medium	
Latitude of project location	°N	43.6	-90.0 to 90.0
Mean earth temperature	°C	10.0	*Visit NASA satellite data site*
Annual earth temperature amplitude	°C	12.0	5.0 to 20.0
Depth of measurement of earth temperature	m	3.0	0.0 to 3.0

Building Heating and Cooling Load		Estimate	Notes/Range
Type of building	-	Commercial	
Available information	-	Descriptive data	
Building floor area	m²	7,432	
Number of floors	floor	3	1 to 6
Window area	-	Standard	
Insulation level	-	Medium	
Occupancy type	-	Daytime	
Equipment and lighting usage	-	Moderate	
Building design heating load	kW	155.8	
	million Btu/h	0.532	
Building heating energy demand	MWh	291.6	
	million Btu	994.8	
Building design cooling load	kW	577.3	
	ton (cooling)	164.2	
Building cooling energy demand	MWh	1,038.5	
	million Btu	3,543.2	*Return to Energy Model sheet*

Version 3.1 © Minister of Natural Resources Canada 1997-2005. NRCan/CETC - Varennes

Figure 1. *Results of the heating and cooling load analysis with associated input assumptions.*

CONVENTIONAL HVAC SYSTEM

In order to evaluate the economic feasibility of a geothermal heat pump system, a *base* conventional heating, ventilating, and air-conditioning (HVAC) system needs to be established. Given the size and layout of the planned building, a water-based system (Figure 2) would be most practical. This system could be one of two types: (i) a 4-pipe boiler/chiller system with hot and chilled water piped to either central air handlers or terminal fan coil units as depicted in Figure 2, or (ii) a water-source heat pump system with boiler and cooling tower. Another possible conventional HVAC system might be multi-zone rooftop units, but these would be difficult to install, and would likely result in excessive ductwork.

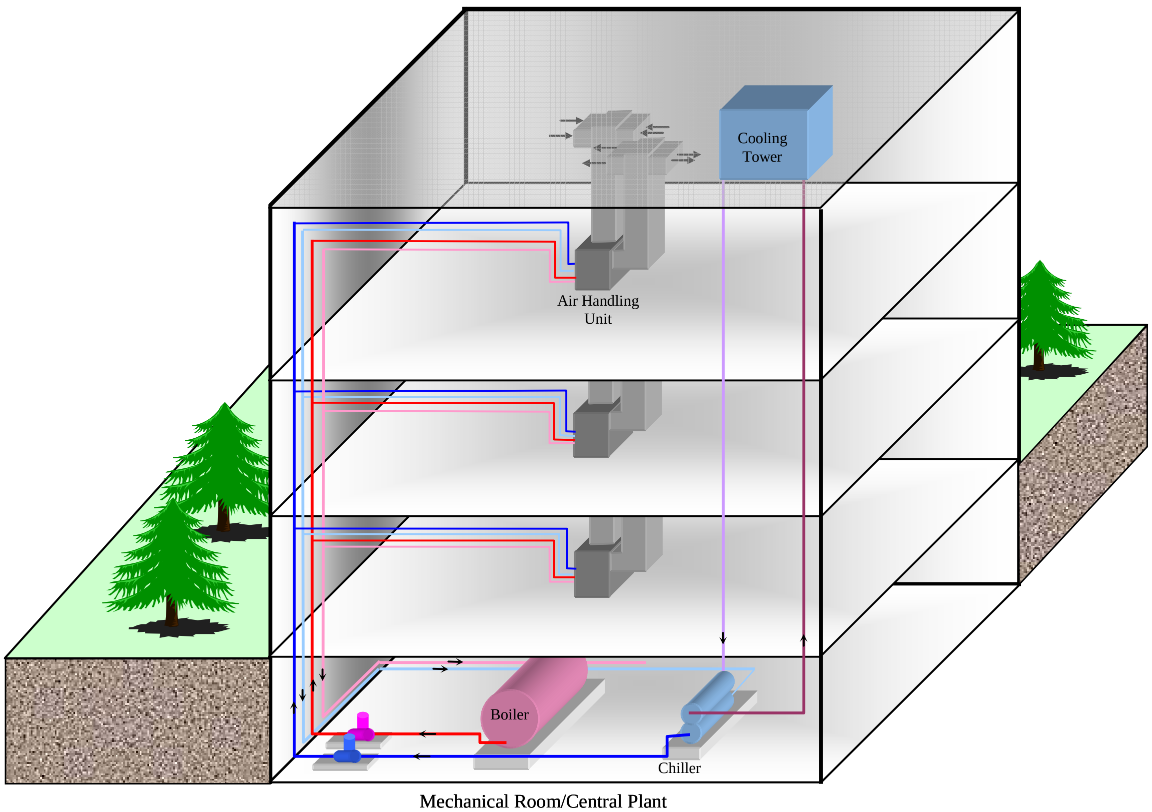

Figure 2. *Conceptual drawing of a conventional 4-pipe HVAC system.*

OUTDOOR AIR HANDLING

Current mechanical codes call for fresh ventilation air to be brought in to all buildings. Fresh outdoor air improves occupant comfort and indoor air quality. On extreme weather days, introducing very cold or very hot air to the HVAC equipment can compromise capacity. Rather than grossly over-sizing equipment to handle these extra outdoor air loads, an energy-efficient way of introducing outdoor air is with heat recovery units as shown in Figure 3.

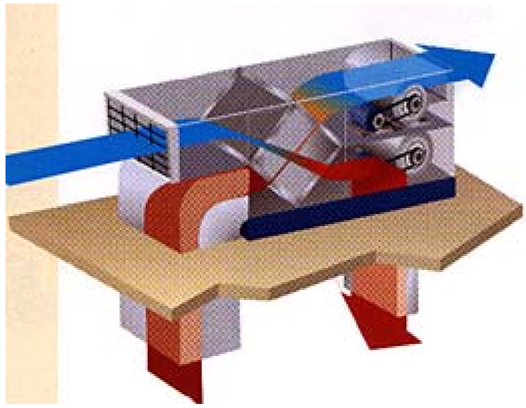

Figure 3. *Example rooftop heat recovery unit for outdoor air handling*.

Heat recovery units are almost essential in most geothermal heat pump systems, since they can considerably reduce heat pump capacity as well as earth loop size, which significantly reduces capital cost. In a pitched-roof design such as that being planned for the new Idaho Fish and Game Headquarters, heat recovery units can be installed in attic spaces and draw in and exhaust outdoor air through louvers.

SITE GEOLOGICAL CONDITIONS

In order to assess the feasibility of a geothermal heat pump system, some knowledge of the subsurface geological conditions is required. There have been two documented wells drilled at the site. Logs of these wells have been provided by the Idaho Department of Water Resources (Appendix A), and show that the site is underlain by alternating layers of sands and clays. A significant amount of groundwater is also present. A 500-ft deep well drilled in 1964 had been previously used for heating, and was flow-tested at 700 gpm. A shallower well, drilled to 83 ft, is currently used for irrigation purposes and produces about 150 gpm. Thus, the site geology would be suitable for either an open-loop or closed-loop geothermal heat exchange system.

POSSIBLE GEOTHERMAL HEAT PUMP SYSTEM DESIGNS

A conceptual drawing of a geothermal heat pump system is shown in Figure 4. In addition to energy savings, geothermal heat pump systems have several architectural advantages over conventional systems as illustrated in Figure 4. Geothermal heat pumps require little to no floor space and require smaller mechanical rooms and no outdoor equipment The heat pump itself can be placed closer to the zone it serves, thereby reducing long duct runs.

In addition to the “inside the building” equipment, geothermal heat pump systems require some type of earth heat exchange system. In this study, we examine the feasibility of (i) an open-loop system, (ii) a vertical bore closed-loop system, and (iii) a horizontal closed-loop system.

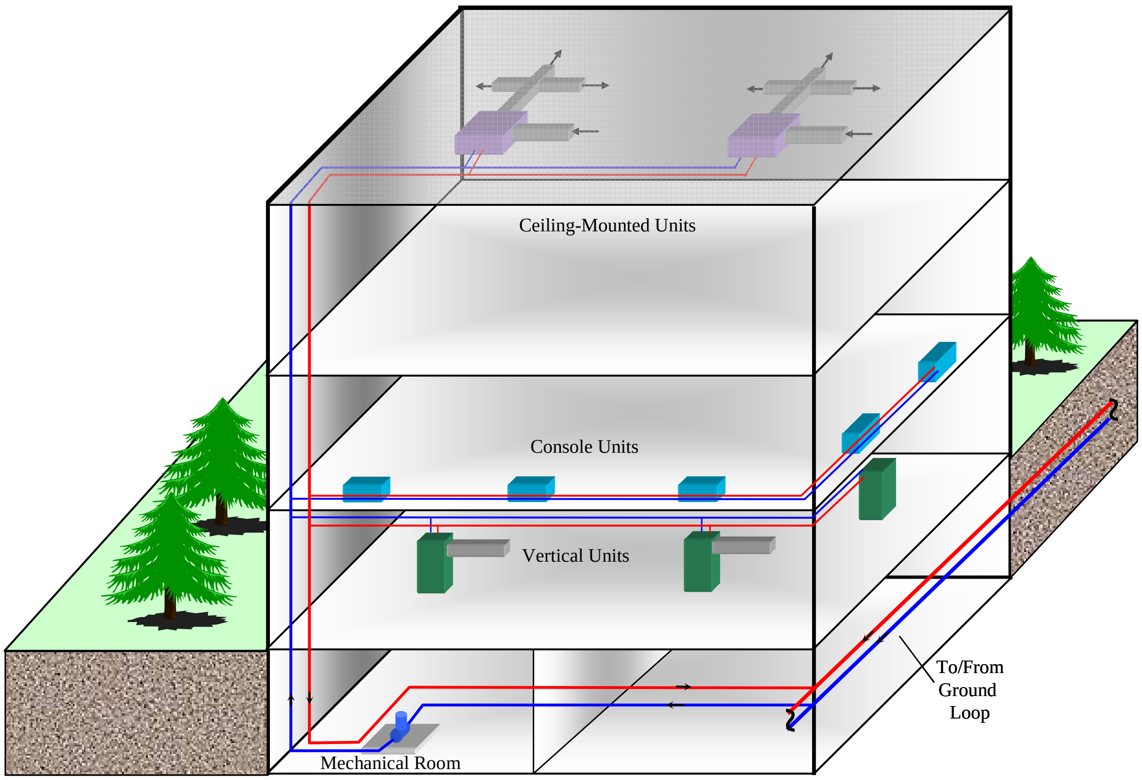

Figure 4. *Conceptual drawing of a geothermal heat pump system showing different heat pump types.*

<u>Option (i): Open-Loop System</u>

A conceptual diagram of an open-loop system is shown in Figure 5. The system consists of two "loops" separated by a stainless steel plate heat exchanger, which isolates groundwater from the heat pump equipment. This configuration reduces any scale or corrosion to the heat exchanger. Routine maintenance and cleaning of the stainless steel plates usually results a trouble-free system. The building piping loop would be filled with an antifreeze solution, typically a mixture of water and about 15% propylene glycol.

The use of an isolation heat exchanger also allows for energy-efficient control of the well pump. The building loop temperature is allowed to "float" between a heating and cooling setpoint, and when the building loop temperature reaches either of these setpoints, the well pump is energized and moderates the building loop temperature. With this type of control, the required groundwater flow rate is a function of its temperature. Assuming an average groundwater temperature of 60^{o}F, about 250 gpm of groundwater would be required for peak cooling. For energy efficiency, the building loop circulating pump should be variable speed.

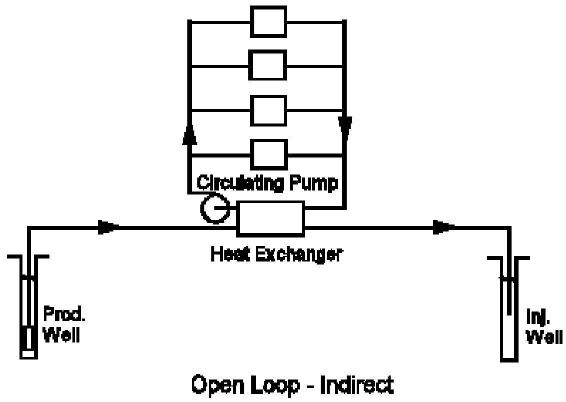

Figure 5. *Conceptual diagram of an open-loop geothermal heat pump system.*

The main advantage of this type of system over the closed-loop systems is that they can be the lowest cost option if enough groundwater is available, which there appears to be at the Idaho Fish and Game Headquarters site. In general, only two drill holes are required: one for the supply well and one for the injection well. However, in the case of the new Idaho Fish and Game Headquarters, the existing irrigation well may be suitable as an injection well, and irrigation water can be supplied by the same well supplying the geothermal heat pump system. Regardless, the water right currently held for the property would need modification.

Option (ii): Vertical Closed-Loop System

A conceptual diagram of a vertical closed-loop system is shown in Figure 6. The closed-loop heat exchanger consists of a network of high-density polyethylene (HDPE) plastic u-tubes installed in vertical boreholes at typical depths of 200 to 500 ft deep. The entire ground loop is filled with an antifreeze solution, typically a water + 15% propylene glycol mixture, which circulates through both the building and ground loops. For energy efficiency, the circulating pump should be variable speed.

The length of the borehole heat exchanger system is a function mainly of the building thermal loads profile and the thermal properties of the ground. In systems of the size that would be anticipated at the new office building, it is recommended that an in-situ thermal conductivity test be done to determine these thermal properties to aid in the proper design of the borehole network. For this preliminary study, the drilling requirements are estimated at 140 vertical boreholes, each 250 ft deep. This would take up about 40% of the parking lot area (i.e. approximately 33,000 ft^2).

The main advantage of the vertical closed-loop system over open-loop systems is that handling of groundwater and dealing with associated regulations are avoided. The advantage over horizontal closed-loop systems is that less pipe is required and considerably less land area is taken up. The main disadvantage of vertical closed-loop systems is the high cost of drilling multiple vertical boreholes.

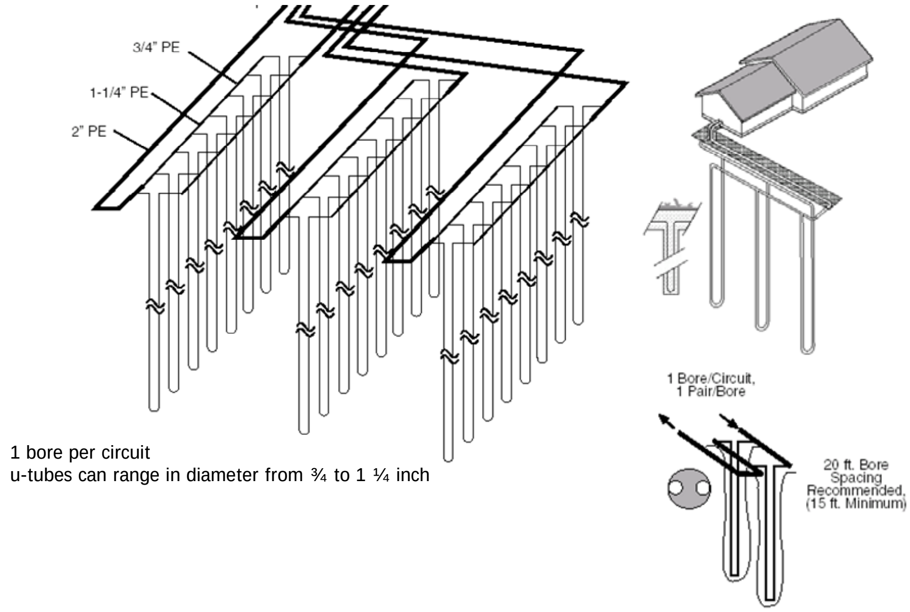

Figure 6. *Conceptual diagram of a vertical closed-loop geothermal heat exchanger*.

<u>Option (iii): Horizontal Closed-Loop System</u>

A conceptual diagram of a horizontal closed-loop system is shown in Figure 7. Different configurations are possible; the "slinky" type is a more compact arrangement, but requires more pipe due to increased thermal interference between adjacent loops. As with the vertical systems described previously, the entire ground loop is filled with an antifreeze solution, typically a water + 15% propylene glycol mixture, which circulates through both the building and ground loops. For energy efficiency, the circulating pump should be variable speed.

Horizontal loops require much more buried pipe than vertical loops because they are buried at depths that still experience some seasonal temperature fluctuations, and this is their main disadvantage with respect to vertical closed-loop systems. To minimize these fluctuations, especially with a commercial building, the loop should be buried at depths no shallower than 6 ft. However, since specialized drilling is not required, horizontal systems can be installed at lower cost than vertical systems in many cases.

For this preliminary study, a very compact "slinky" horizontal loop would be necessary in order to fit it within the parking lot space. The estimated size of the horizontal loop would take up about 70% of the parking lot area (i.e. approximately 58,000 ft^2).

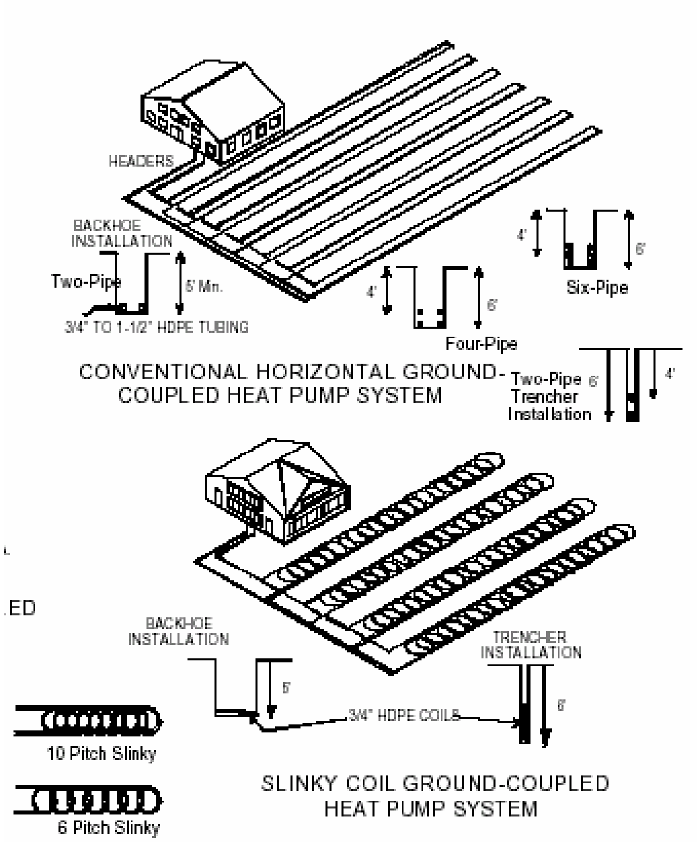

Figure 7. *Conceptual diagram of a horizontal closed-loop geothermal heat exchanger*.

ECONOMIC COMPARISON OF ALTERNATIVES

As previously mentioned, a conventional HVAC system has not been designed, and it is assumed for this study that the most appropriate type of system would be a water-based system as described above, but a multi-zone rooftop system might also be an option. Typical installed costs for these types of systems range from $\$12/ft^2$ to $15/ft^2$, with multi-zone rooftop systems at the lower end and water-based systems at the upper end of the range. A recent case study by the Geo-Heat Center revealed installed costs of 4-pipe systems at new two new schools as high as $\$19/ft^2$.

Energy costs used for this feasibility study were based on current utility bills for the existing office building. Electricity rates average $0.048/kWh and natural gas rates average $1.12/therm.

Based on recent case studies done by the Geo-Heat Center, the following estimates were made for possible geothermal heat pump systems at the Idaho Fish and Game Headquarters:

- $\$11/ft^2$ for installed cost “inside the building” mechanical and plumbing work,
- $500 to $1,000/ton cost range for open-loop geothermal systems,
- $1,500 to $2,000/ton cost range for vertical closed-loop heat exchanger,

- $1,000 to $1,500/ton cost range for horizontal closed-loop heat exchanger,
- Annual energy savings estimated from the RETScreen model are:
    - $11,800 for the open-loop system,
    - $12,500 for the vertical closed-loop system, and
    - $10,000 for the horizontal closed-loop system.

The vertical closed-loop system has the greatest energy savings. Open-loop systems have a slightly greater operating cost due to well pump energy. Horizontal closed-loop systems typically have higher energy costs than vertical closed-loop systems due to fluctuating seasonal temperatures at their burial depth.

Based on the above economic estimates, the following contour maps were prepared, showing simple payback on energy savings for the three possible options (Figures 8, 9, and 10). A review of these figures shows that any of the geothermal options appear quite economically attractive. Assuming the mid-point value on each axis to be a good average cost estimate (that is, $13.50/sq. ft installed cost of a conventional HVAC system, $750/ton for an open-loop heat exchange system, $1,750/ton for a vertical closed-loop heat exchange system, and $1,250/ton for a horizontal closed-loop heat exchange system), the simple payback period on energy savings alone is immediate for the open-loop system, about 7 years for the vertical closed-loop system, and less than 1 yr for the horizontal closed-loop system.

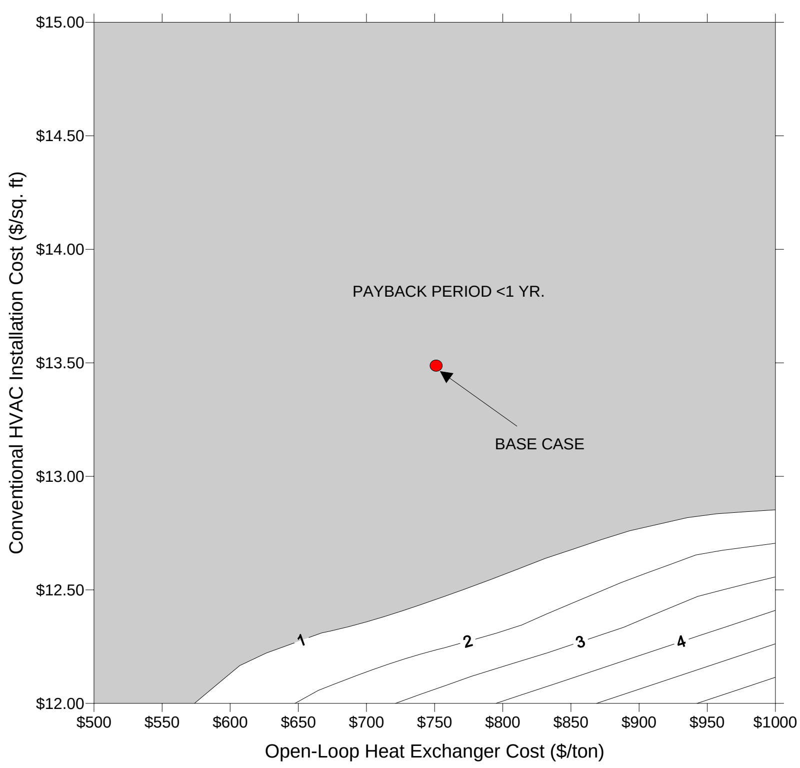

Figure 8. *Contour map of simple payback period on energy savings of an open-loop geothermal heat exchange system.*

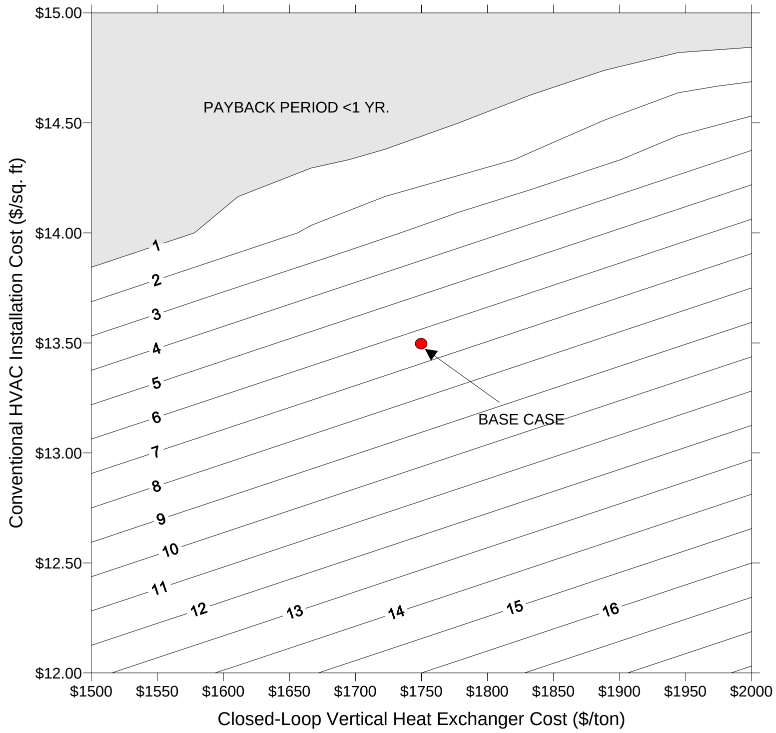

Figure 9. *Contour map of simple payback period on energy savings of a closed-loop vertical geothermal heat exchange system.*

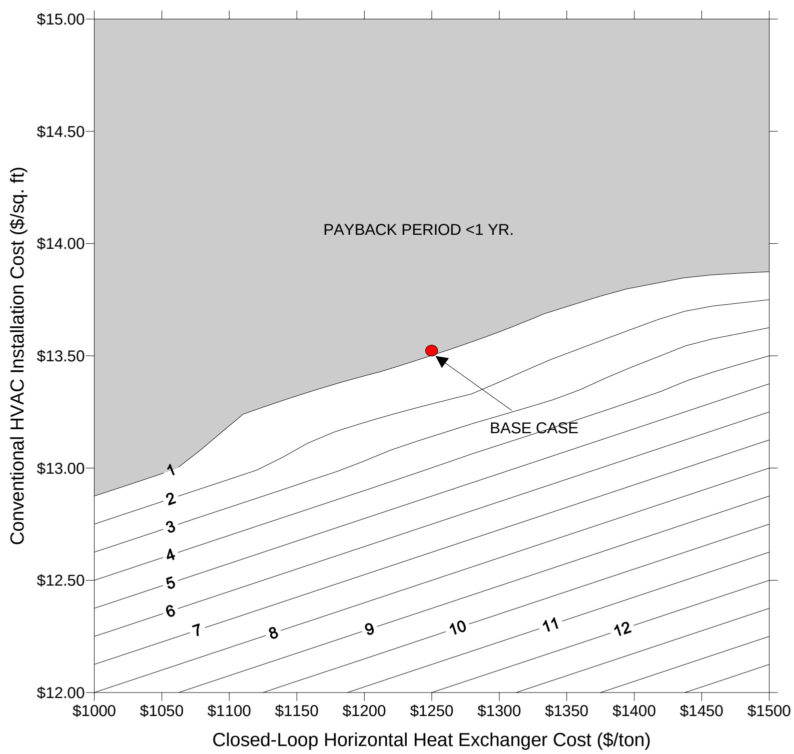

Figure 10. *Contour map of simple payback period on energy savings of a closed-loop horizontal geothermal heat exchange system.*

Operating and maintenance (O&M) costs were not considered here in order to be conservative. Consideration of O&M costs will only improve the economics of geothermal heat pump systems, as limited studies of these costs show geothermal heat pump systems to be lower than conventional systems. This is mainly attributed to the fact that geothermal heat pump systems have no outdoor equipment.

CONCLUDING SUMMARY AND RECOMMENDATIONS

This preliminary feasibility assessment of installing a geothermal heat pump system at the new planned Idaho Fish and Game Headquarters in Boise, ID has included an estimate of peak hour and total annual heating and cooling loads, and a simple payback analysis of open- and closed-loop geothermal heat pump system options.

Some specific conclusions of this study are as follows:

- A conventional HVAC system for the new Idaho Fish and Game Headquarters has not been designed, but the most appropriate type of system would be a water-based system. A multi-zone rooftop system might also be an option. Typical installed costs for these types of systems range from $12/ft^2 to $15/ft^2 of floor space, with multi-zone rooftop systems at the lower end and 4-pipe systems at the upper end of the range.
- All three geothermal configurations considered are technically possible for the new building.
- Ample groundwater is available at the site for an open-loop system, and this type of system would be the lowest cost option and least intrusive to the site. To reduce costs, it may be possible to use the existing irrigation well as an injection well, and only drill one new well for geothermal supply. Irrigation water can be supplied by this same geothermal well. Regardless, the water right currently held for the property would need modification.
- A vertical closed-loop system is estimated to require 140 vertical boreholes, each 250 ft deep with 20-ft lateral spacing, which would take up about 40% of the parking lot area (i.e. approximately 33,000 ft^2). The actual length of the borehole heat exchanger system is a function mainly of the building thermal loads profile and the thermal properties of the ground. In systems of the size that would be anticipated at the new office building, it is recommended that an in-situ thermal conductivity test be done to determine these thermal properties to aid in a proper design of the borehole network.
- A horizontal closed-loop system would require much more buried pipe than vertical loops because they are buried at depths that still experience some seasonal temperature fluctuations, and this is their main disadvantage with respect to vertical closed-loop systems. A very compact horizontal loop would be necessary in order to fit it within the parking lot space. The estimated size of the horizontal loop would take up about 70% of the parking lot area (i.e. approximately 58,000 ft^2).
- Assuming that the "inside the building" mechanical and plumbing work of a geothermal heat pump system could be done for $11/ft^2, an analysis simple payback on energy savings shows the following payback periods:
    - Immediate for an open-loop system,
    - About 7 years for a vertical closed-loop system, and
    - Less than 1 year for a horizontal closed-loop system.

The Geo-Heat Center recommends that this is a good time to engage in an architect/engineer with geothermal heat pump design qualifications. In fact, the sooner the better, so that the design can proceed without having to go back and re-design the mechanical systems. In order to make economic evaluation a bit easier, the base HVAC design could be a water-source heat pump loop with a boiler and cooling tower. Therefore, the base mechanical system and geothermal "in the building" system would essentially be the same, and economic comparisons would be that of the boiler and cooling tower relative to an earth heat exchanger. In this way, alternate bids could be solicited if desired.

It is also recommended that the owner/operators of the new building meet with the design team and other interested parties to establish the best geothermal option. Issues of concern might include timing or constraints of water rights and acceptable land area taken up by a closed-loop heat exchanger among others.

APPENDIX A

WATER WELL LOGS FOR THE IDAHO FISH AND GAME SITE

Well Log Form 1
3M

047967

RECEIVED
SEP 10 1964
Department of Reclamation

WELL LOG AND REPORT TO THE STATE RECLAMATION ENGINEER OF IDAHO

SUBMIT WITHIN 30 DAYS AFTER COMPLETION OF WELL: SEE IDAHO STATUTES 42-238

Permit No. G 23064 Well No. ____ County ADA

Owner FISH & GAME (STATE OF IDAHO)

Address ____

Driller LUKEHART DRILLING & PUMP CO.

Address 1819 FEDERAL WAY BOISE

Well location NE ¼ NW ¼ Sec. 14, T. 3 N/S R. 2 E/W

Size of drilled hole 12"

Total depth of well 500'

Locate well in section: NW ¼ | NE ¼ (X) | Sec. | SW ¼ | SE ¼

Give depth to standing water from the ground 7 Water temp. 63 °Fahr.

Test delivery was 700 g.p.m. or ____ c.f.s. Drawdown was 19 feet. Pump? ____ Bail? Air Compressor

Size of pump and motor used to make test ____

Length of time of test 20 hours ____ minutes.

If flowing well, give flow No c.f.s. or ____ g.p.m. and of shut off pressure ____

If flowing well, described control works ____ (TYPE AND SIZE OF VALVE, ETC.)

Water will be used for [illegible] Weight of casing per lineal foot 44.33

Thickness of casing .250 Casing material STEEL (STEEL, CONCRETE, WOOD, ETC.)

Diameter, length and location of casing 12" 123'6" – 12"
(CASING 12" IN DIAMETER OR LESS, GIVE INSIDE DIAMETER; CASING OVER 12" IN DIAMETER, GIVE OUTSIDE DIAMETER)

CASING RECORD

Diam. Casing	From Feet	To Feet	Length	Remarks—seals, grouting, etc.
12	0	123'6"	123'6	CASING SEALED IN BLUE CLAY

Number and size of perforations None located ____ feet to ____ feet from ground

Date of commencement of well May 28' 1964 Date of completion of well JUNE 28, 1964

NENW S.14 3N 2E

G3304

WELL LOG

From Feet	To Feet	Type of Material	Water-bearing Formation Ans. Yes or No	Casing Perforated Ans. Yes or No
0'	2'	Top Soil	No	No
2'	49'	Sand + Gravel	Yes	No
49'	54'	Sandy Clay	No	No
54'	67'	Muddy Sand (Blue)	No	No
67'	95'	Sand + Clay (Blue)	No	No
95'	110'	Blue Clay	No	No
110'	128'	Brown Clay + Sand	No	No
128'	191"	Blue Clay - Sandy	No	No
191'	214'	Blue Shale	No	No
214'	234'	Brown Shale (Very Stickie) (Made Seal for Shoe)	No	No
234'	272'	Green Shale	No	No
272'	294	Green Shale with Some Gravel (Some Water	Yes	No
294'	296'	Green Sandy Shale	No	No
296'	316'	Course Sand + Blue Clay	Yes	No
316'	341'	Brown Sand + Clay	Yes	No
341'	343'	Blue Clay	No	No
343'	410'	Sand + Clay (Blue)	Yes	No
		If more space is required use Sheet No. 2		

WELL DRILLER'S STATEMENT

This well was drilled under my supervision and the above information is complete, true and correct to the best of my knowledge and belief.

Signed [signature]

By__________

License No. 122

Dated Sept. 9, 1964

Well Driller's Helper__________

047968 Fish & Game Dept
Lubert
3N 2E S.14 NE NW

WELL LOG

From Feet	To Feet	Type of Material	Water-bearing Formation Ans. Yes or No	Casing Perforated Ans. Yes or No
410'	416'	BLUE CLAY	No	No
416'	427'	BLUE SAND	Yes	No
427'	500'	BLUE CLAY	No	No
500	—	VERY COURSE GRAVEL	Yes	—
		u448		
		If more space is required use Sheet No. 2		

WELL DRILLER'S STATEMENT

This well was drilled under my supervision and the above information is complete, true and correct to the best of my knowledge and belief.

Signed Billie M. Lubert

By

Dated Sept. 9, 1964

License No. 122

Well Driller's Helper

NENW S.14 3N2E

USGS

Form 238-7
6/89

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

USE TYPEWRITER OR BALLPOINT PEN

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name IDAHO FISH & GAME
Address P.O. BOX 35 BOISE, ID.
Owner's Permit No. 63-91-Z-100

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement
☐ Well diameter increase
☐ Abandoned (describe abandonment procedures such as materials, plug depths, etc. in lithologic log)

3. PROPOSED USE

☐ Domestic ☒ Irrigation ☐ Test ☐ Municipal
☐ Industrial ☐ Stock ☐ Waste Disposal or Injection
☐ Other ______ (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other ______

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other ______

Thickness	Diameter	From	To
.250 inches	8 inches	+ 1.5 feet	59 feet
.250 inches	6 inches	57 feet	66 feet
.250 inches	6 inches	80 feet	76 feet
inches	inches	feet	feet

Was casing drive shoe used? ☒ Yes ☐ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☐ Yes ☒ No
How perforated? ☐ Factory ☐ Knife ☐ Torch ☐ Gun
Size of perforation ______ inches by ______ inches

Number	From	To
perforations	feet	feet
perforations	feet	feet
perforations	feet	feet

Well screen installed? ☒ Yes ☐ No
Manufacturer's name HUSTON
Type STAINLESS STEEL Model No. 304
Diameter 6 Slot size .20 Set from 66 feet to 76 feet
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Gravel packed? ☐ Yes ☒ No ☐ Size of gravel ______
Placed from ______ feet to ______ feet
Surface seal depth 31 Material used in seal: ☐ Cement grout
☒ Bentonite ☒ Puddling clay ☐ ______
Sealing procedure used: ☒ Slurry pit ☐ Temp. surface casing
☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☐ Welded ☐ Solvent Weld
☐ Cemented between strata
Describe access port ______

6. LOCATION OF WELL

Sketch map location must agree with written location.

N / W / E / S

Subdivision Name ______
Lot No. ______ Block No. ______
County ADA
NE ¼ NW ¼ Sec. 14, T. 3N ☒N ☐S, R. 2 ☐E ☒W

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7. WATER LEVEL

Static water level 13 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow ______
Artesian closed-in pressure ______ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature ______ °F. Quality ______
Describe artesian or temperature zones below.

8. WELL TEST DATA

☒ Pump ☐ Bailer ☒ Air ☐ Other ______

Discharge G.P.M.	Pumping Level	Hours Pumped
150	60	4

9. LITHOLOGIC LOG 71194

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
10	0	18	GRAVEL		X
10	18	31	GRAVEL		X
8	31	35	SAND & GRAVEL	X	
8	35	38	LARGE GRAVEL & SAND	X	
8	38	46	GRAVEL & SAND	X	
8	46	49	1" TO 2" ROCK & SAND	X	
8	49	53	FINE COURSE SAND & GRAVEL	X	
8	53	58	COURSE SAND & 3/8 GRAVEL	X	
8	58	69	COURSE SAND & ROCK	X	
8	69	73	BROWN CLAY/GRAVEL/SAND	X	
8	73	83	SAND	X	

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Western Regional Office

BILL DOTY DRILLING CO.,INC. 42
106 CALLOWAY
CALDWELL, ID. 83605

10. Work started 6-14-91 finished 6-18-91

11. DRILLERS CERTIFICATION

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name BILL DOTY DRILLING CO.,INC. Firm No. 42
Address 106 CALLOWAY CALDWELL, ID. 83605 Date ______
Signed by (Firm Official) [signature]
and
(Operator) [signature]

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT