GEO-HEAT CENTER

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EXECUTIVE SUMMARY

The Geo-Heat Center conducted a preliminary assessment of the feasibility of a geothermal heat pump (GHP) system at the new planned Schitsu'umsh Cultural Center, located in Plummer, ID. This work has been funded and completed under Midwest Research Institute, National Renewable Energy Laboratory (NREL) Task Order No. KLDJ-5-55052-05, "*Feasibility Studies for Projects in Utah, Nevada, and Idaho*". In summary, 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.

<u>Estimation of the Heating and Cooling Loads and the HVAC System</u>
The heating and cooling loads at this preliminary stage were estimated using software tools. The peak cooling load is estimated at about 1.164 million Btu/hr (97 tons) and the peak heating load is estimated at about 1.138 million Btu/hr.

A conventional heating, ventilating, and air-conditioning (HVAC) system has not been designed at this time. It is the Geo-Heat Center's opinion, due to the aesthetics of the planned building that the lowest cost type of system would be a series of split systems with natural gas heating and DX cooling. Typical installed costs for these types of systems range from $\$10/ft^2$ to $\$12/ft^2$ of floor space.

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.

<u>Geological Conditions</u>
Review of well logs in the vicinity of the Plummer, ID area shows that the area is underlain by approximately 10 ft of clay, and then alternating layers of hard and broken basalt rock. Groundwater occurs in broken rock layers in varying quantities and reported temperatures of 50-56^{o}F. Wells drilled to depths less than 500 ft report total yields on the order of 100 to 200 gpm, except for a well owned by the Coeur d'Alene Tribe, which is a 545-ft deep well yielding only 2 gpm Thus, the site geology would be more suitable for either an open-loop or horizontal closed-loop geothermal heat exchange system. Vertical closed-loops are generally difficult and costly to install in hard and broken rock conditions.

<u>Open-Loop Geothermal Option</u>
This type of system would consist of a production well and an injection well. The groundwater loop would be isolated from the building loop with a plate heat exchanger. Assuming 55^{o}F groundwater, it is estimated that a well yielding 175 gpm could handle the peak loads.

<u>Vertical Closed-Loop Geothermal Option</u>
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 60 vertical boreholes, each 250 ft deep. At 20-ft lateral spacing, this would take up just under half an acre of land area. 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 6-8 ft. The estimated size of a horizontal loop for the new building would take up about 1 acre of land area.

Economic Comparison of Alternatives

The following table summarizes the economics of the proposed geothermal project. The energy savings are based on electricity rates from Kootenai Electric Cooperative.

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	$11.00	-	$462,000	-	-
Open-Loop Geothermal	$11.00	$750	$534,750	$10,400	7
Vertical Closed-Loop Geothermal	$11.00	$1,750	$631,750	$10,500	16
Horizontal Closed-Loop Geothermal	$11.00	$1,250	$583,250	$10,200	12

The most economically-attractive geothermal options are 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 report, show that the worst case cost scenarios increase the payback period to 14 years for an open-loop system, 18 years for a horizontal closed-loop system, and 23 years for a vertical closed-loop system.

Greenhouse Gas Analysis

The reduction in greenhouse gas emissions in using a GHP system over a conventional HVAC system is estimated at 68 tons of equivalent CO_2 per year. This is equivalent to removing about 14 cars and light trucks from the road or planting about 80 acres of new forest.

Recommendations

The Geo-Heat Center recommends that this is a good time to engage an architect/engineer with geothermal heat pump design qualifications so that the mechanical design can be integrated into the whole building design. More site-specific geologic information is needed such as depth to bedrock, drilling difficulties, and groundwater availability. Ideally, a 500 ft test well could be planned to gather more geologic data in order to make a more informed design decision. Other issues of concern might include timing or constraints of water rights and acceptable land area taken up by a closed-loop heat exchanger.

INTRODUCTION

The Geo-Heat Center conducted a preliminary assessment of the feasibility of a geothermal heat pump (GHP) system at the new planned Schitsu'umsh Cultural Center, located in Plummer, ID. This work has been funded and completed under Midwest Research Institute, National Renewable Energy Laboratory (NREL) Task Order No. KLDJ-5-55052-05, "*Feasibility Studies for Projects in Utah, Nevada, and Idaho*". This assessment is considered preliminary because the building design has not been finalized at this time.

PURPOSE AND SCOPE

The purpose of this study is to determine the feasibility of using geothermal heat pumps for space heating, ventilating, and air conditioning for the proposed Coeur d'Alene Tribe Schitsu'umsh Cultural Center.

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.

METHOD OF STUDY

The methods and approach conducted by the Geo-Heat Center to accomplish the project objectives are summarized as follows:

- Visited with some members of the design team at the Coeur d'Alene Tribal Headquarters in Plummer, ID and obtained conceptual drawings and preliminary design details of the new cultural center,
- Reviewed water well logs of the area,
- Developed a computer model of the building using eQuest (J.J. Hirsch, 2005) graphical user interface,
- Computed peak hourly and annual heating and cooling loads of the building using the DOE-2 simulation engine (York and Cappiello, 1981),
- Simulated annual energy use of the HVAC system using the DOE-2 building simulation software.
- Conducted an economic analysis of the alternative GHP system, along with an associated sensitivity analysis of cost assumptions,
- Conducted a greenhouse gas analysis to estimate the possible reduction in greenhouse gas emissions by using geothermal heat pumps. This analysis was done using RetScreen software (NRC, 2005).

HEATING AND COOLING LOADS ANALYSIS

A computer model of the building was developed in order to estimate design loads, but more importantly to estimate annual energy consumption of the HVAC system.

A single-story community center with a total floor area of 42,000 ft^2 was modeled with the eQuest/DOE-2 software using weather data for Spokane, Washington. Occupancy schedules for people, lighting, and equipment usage for a typical community center building were assumed. Heat recovery of outdoor ventilation air was also modeled, assuming a 75% heat exchanger effectiveness at peak design conditions. Outdoor air handling is explained in further detail below.

The peak and total annual heating and cooling loads for the building as determined from the DOE-2 software were entered into RETScreen, a simple tool developed by Natural Resources Canada (2005) for subsequent economic and greenhouse gas analyses of a geothermal heat pump system (Figure 1). As shown in Figure 1, the peak cooling load is estimated at 1.164 million Btu/hr (97 tons) and the peak heating load is estimated at 1.138 million Btu/hr. The annual heating and cooling demands are estimated at 917.3 million Btu and 858.6 million Btu, respectively.

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

Site Conditions		Estimate	Notes/Range
Nearest location for weather data		Spokane, WA	*See Weather Database*
Heating design temperature	°C	-13.6	-40.0 to 15.0
Cooling design temperature	°C	31.1	10.0 to 40.0
Average summer daily temperature range	°C	14.1	5.0 to 15.0
Cooling humidity level	-	Medium	
Latitude of project location	°N	47.6	-90.0 to 90.0
Mean earth temperature	°C	12.0	*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	-	Energy use data	
Design heating load	kW	333.5	
	million Btu/h	1.138	
Annual heating energy demand	MWh	268.8	
	million Btu	917.3	
Design cooling load	kW	341.2	
	ton (cooling)	97.0	
Annual cooling energy demand	MWh	251.6	
	million Btu	858.6	*Return to Energy Model sheet*

Version 3.1 NRCan/CETC - Varennes

Figure 1. *Summary of peak and annual heating and cooling loads, along with design weather data.*

OUTDOOR AIR HANDLING

It was mentioned above that the computer model of the building included a heat recovery system for outdoor air. Current mechanical codes call for fresh ventilation air to be brought in to all buildings, and ventilation rates were described in the Pre-Design Report by ALSC Architects (March 2006). 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 results in the necessity of very large-capacity equipment to handle extra the loads. Rather than grossly oversizing 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 2.

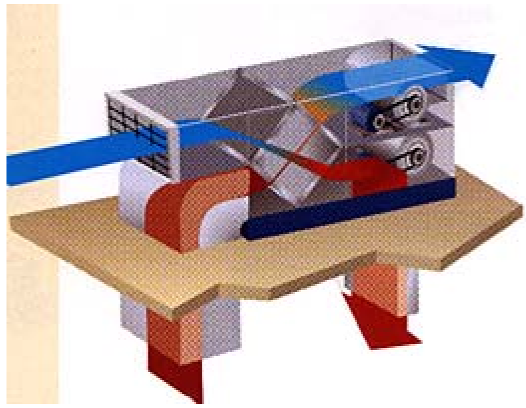

Figure 2. *Example rooftop heat recovery unit for outdoor air handling*.

Heat recovery units are almost essential in commercial geothermal heat pump systems, since they can considerably reduce heat pump capacity as well as earth loop size, which significantly reduces capital cost. These units can be installed in attic spaces or closets, and draw in and exhaust outdoor air through decorative louvers.

CONVENTIONAL HVAC SYSTEM

In order to evaluate the economic feasibility of a geothermal heat pump system, a *base* conventional HVAC system needs to be established. Given the size and layout of the planned building, split systems with natural gas heating and direct-expansion (DX) cooling with remote condenser units would likely be the most practical, lowest-cost option. Another possible conventional HVAC system might be single-zone and multi-zone rooftop units, but these would be difficult to install on a building with a pitched roof.

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 are a number of documented water wells drilled in the Plummer area, and logs of these wells have been obtained from the Idaho Department of Water Resources, some of which are included in Appendix A.

Review of water well logs in the area shows that the site is underlain by clay and basalt. A surficial layer of clay is present to a depth of approximately 10 ft, underlain by layers of basalt rocks that are described in the logs as hard or broken rock. A modest amount of groundwater is also present in the fractured layers of basalt. Reported well yields range from 100 to 200 gpm, except for a well owned by the Coeur d'Alene Tribe, which was drilled to a depth of 545 ft and only produced 2 gpm.

Based on the site geological conditions, the most favorable type of earth coupling for a geothermal heat pump system is either a horizontal closed-loop or an open-loop with groundwater wells. Vertical closed-loops are generally difficult and costly to install in hard and broken rock conditions.

POSSIBLE GEOTHERMAL HEAT PUMP SYSTEM DESIGNS

A conceptual drawing of a geothermal heat pump system is shown in Figure 3. In addition to energy savings, geothermal heat pump systems have several architectural advantages over conventional systems. Geothermal heat pumps require little to no floor space and require smaller mechanical rooms and no outdoor equipment. The absence of outdoor equipment is a good aesthetic advantage for a building like the Schitsu'umsh Cultural Center. The heat pump itself can be placed closer to the zone it serves, thereby reducing long duct runs. Coupled with heat recovery units, the heat pump capacity can be more closely matched with actual zone loads.

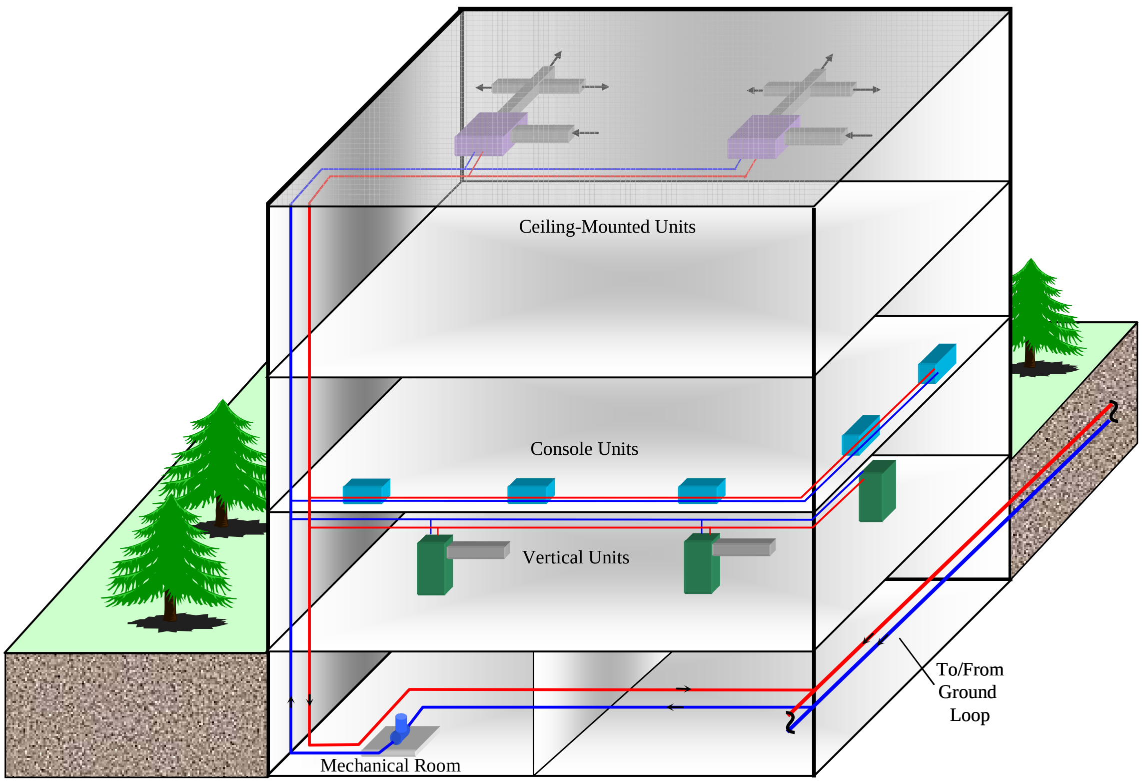

Figure 3. *Conceptual drawing of a geothermal heat pump system in a low-rise office building showing different heat pump types.*

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.

Option (i): Open-Loop System

A conceptual diagram of an open-loop system is shown in Figure 4. 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 55^oF, for the conceptual design of the Schitsu'umsh Cultural Center, about 150 gpm of groundwater would be required for peak cooling and about 175 gpm of groundwater would be required for peak heating. For energy efficiency, the building loop circulating pump should be variable speed.

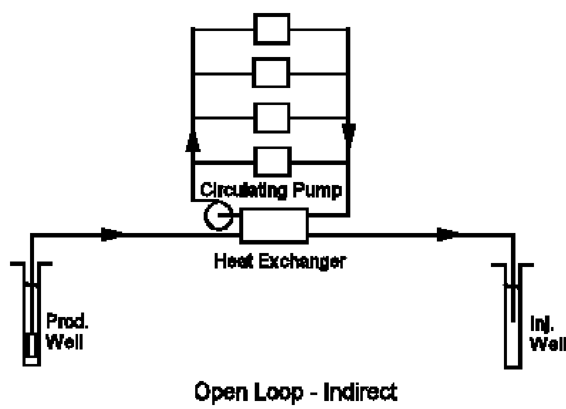

Figure 4. *Conceptual diagram of an open-loop geothermal heat pump system.*

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 in the Plummer, ID area. In general, only two drill holes are required: one for the supply well and one for the injection well. The Coeur d'Alene Tribe would be required to secure a water right for non-consumptive use, in addition to a subsurface injection permit.

Option (ii): Horizontal Closed-Loop System

A conceptual diagram of a horizontal closed-loop system is shown in Figure 5. The closed-loop heat exchanger consists of a network of high-density polyethylene (HDPE) plastic pipe. Different configurations are possible; the "slinky" type is a more compact arrangement, but requires more pipe due to increased thermal interference between adjacent loops. 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 6-8 ft. However, since specialized drilling is not required, horizontal systems can be installed at lower cost than vertical systems in many cases. Their advantage over an open-loop systems is that pumping of groundwater and dealing with associated regulations are avoided.

For this preliminary study, a very compact "slinky" horizontal loop would be necessary in order to fit it within a reasonable space. The estimated size of the horizontal loop would take up about one acre.

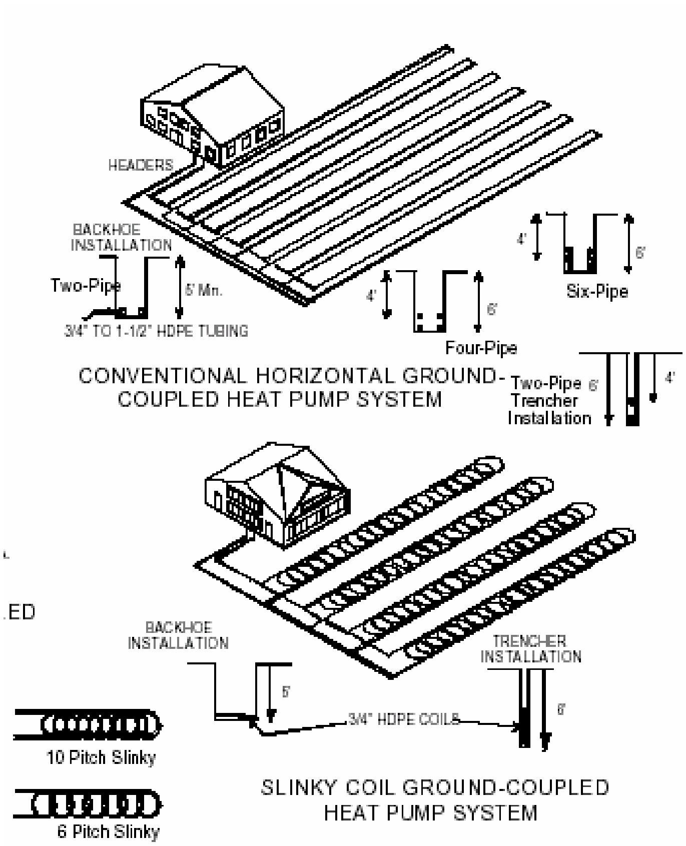

Figure 5. *Conceptual diagram of a horizontal closed-loop geothermal heat exchanger.*

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

A conceptual diagram of a vertical closed-loop system is shown in Figure 6. The closed-loop heat exchanger consists of a network of HDPE plastic u-tubes installed in vertical boreholes at typical depths of 200 to 300 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 Schitsu'umsh Cultural Center, it is recommended that an in-situ thermal conductivity test be done to determine the soil/rock thermal properties to aid in the proper design of the borehole network. More importantly, it would give information on the geology and difficulty of drilling at the site. For this preliminary study, the drilling requirements are estimated at 60 vertical boreholes, each 250 ft deep at 20 ft lateral spacing. This would take up about 18,000 ft^2 of land area (i.e. just less than half an acre).

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, particularly in difficult geological environments.

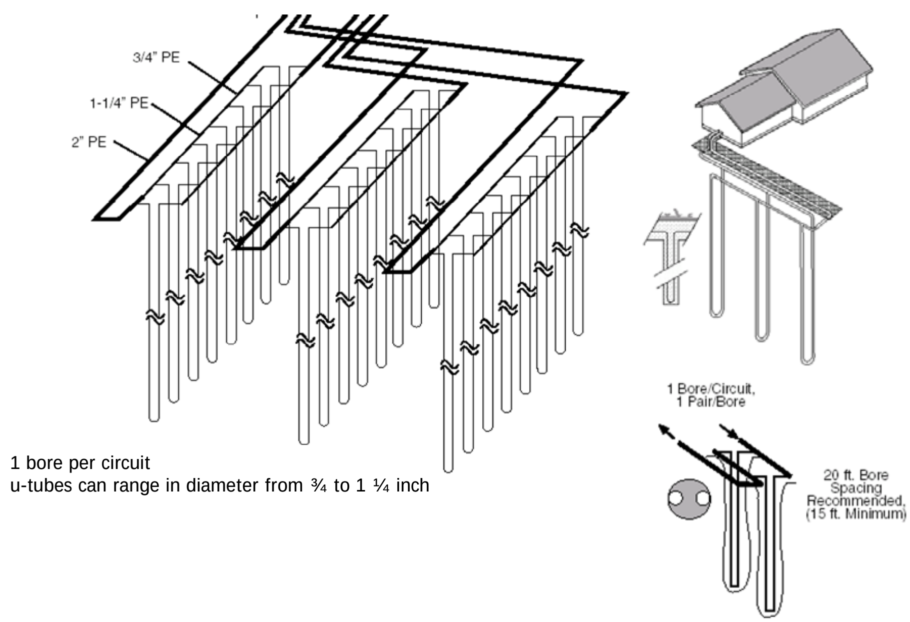

Figure 6. *Conceptual diagram of a vertical closed-loop geothermal heat exchanger*.

ECONOMIC COMPARISON OF ALTERNATIVES

As previously mentioned, the lowest cost conventional HVAC system, and thus the one assumed for this study would be a number of single-zone split system with natural gas heat and DX cooling. Typical installed costs for these types of systems range from $10/ft^2 to 12/ft^2 of floor space. This does not include the cost of a natural gas pipeline, which would need to be brought to the site.

Energy costs used for this feasibility study were based on electricity rate schedules from Kootenai Electric Cooperative. Electricity rates are $0.042/kWh with a demand charge of $200 for the first 50 kW of demand or less, and $2.50 per kW of demand thereafter. Natural gas rates were estimated at $1.20/therm.

Based on recent case studies done by the Geo-Heat Center (GHC, 2005), the following estimates were made for possible geothermal heat pump systems at the Schitsu'umsh Cultural Center:

- $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:
    - $10,400 for the open-loop system,
    - $10,500 for the vertical closed-loop system, and
    - $10,200 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. A summary of results of the economic comparison are shown in Table 1. The simple payback periods on energy savings for the open-loop, vertical closed-loop, and horizontal closed-loop are 7, 16, and 12 years respectively.

Table 1.
Summary of Economic Comparison of Geothermal Alternatives

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	$11.00	-	$462,000	-	-
Open-Loop Geothermal	$11.00	$750	$534,750	$10,400	7
Vertical Closed-Loop Geothermal	$11.00	$1,750	$631,750	$10,500	16
Horizontal Closed-Loop Geothermal	$11.00	$1,250	$583,250	$10,200	12

Operating and maintenance (O&M) costs were not considered. O&M costs of closed-loop geothermal heat pump systems are generally lower than conventional systems, mainly because of the fact that geothermal heat pump systems have no outdoor equipment. On the contrary, O&M costs of open-loop geothermal heat pump systems can be higher than conventional systems due to periodic cleaning of the plate heat exchanger and maintenance of the well pump.

SENSITIVITY ANALYSIS

In this pre-design stage, there are obviously uncertainties in the actual project costs. Therefore, based on the above economic estimates, a sensitivity analysis of the simple payback period to capital costs of the various scenarios was conducted. Results of the sensitivity analysis are shown in Figures 7, 8, and 9 in the form of contour maps.

A review of Figures 7-9 shows that there can be a wide range of payback periods, depending on the capital cost of both the conventional and the geothermal system. The most attractive economics exist for an open-loop geothermal heat pump system, where the simple payback period can range from less than 1 year to 14 years. The next most economically attractive option is the horizontal closed-loop geothermal heat pump system, where the simple payback period can range from less than 6 years to about 18 years. The simple payback period for a closed-loop vertical system can conceivably range from just under 11 years to over 23 years.

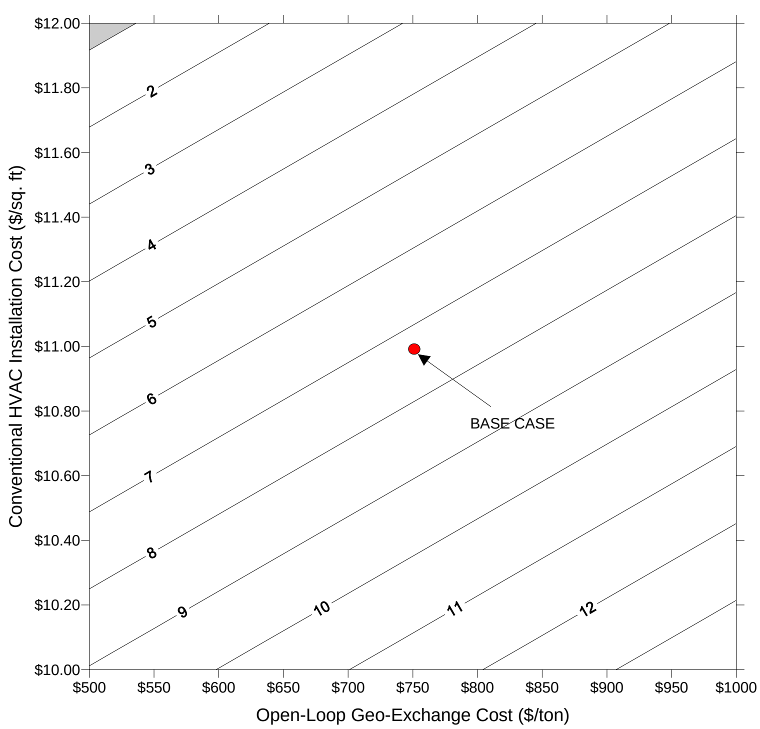

Figure 7. *Contour map of simple payback period on energy savings of an open-loop geothermal heat exchange system.*

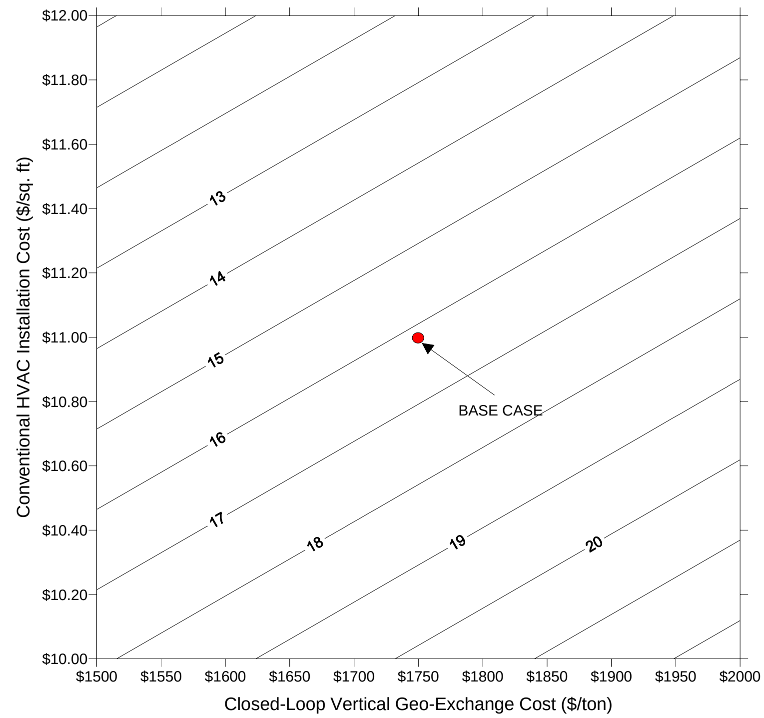

Figure 8. *Contour map of simple payback period on energy savings of a closed-loop vertical geothermal heat exchange system.*

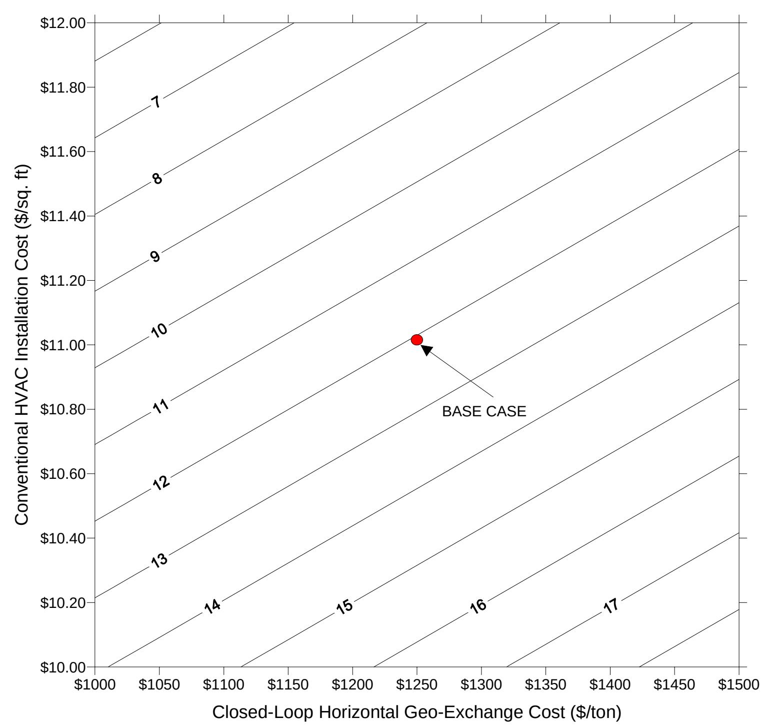

Figure 9. *Contour map of simple payback period on energy savings of a closed-loop horizontal geothermal heat exchange system.*

GREENHOUSE GAS ANALYSIS

Greenhouse gas emissions have been attributed to various negative impacts on air quality and global weather patterns. As a result, carbon emissions have become regulated in some locations throughout the world. Heating and cooling of buildings is responsible for greenhouse gas emissions through the use of electricity generated by fossil-fuel fired power plants, and by combustion of fossil-fuels directly for heat.

RetScreen software (NRC, 2005) was used to estimate the reduction in greenhouse gas emissions through the use of a GHP system at the Schitsu'umsh Cultural Center. The greenhouse gases considered included carbon dioxide (CO_2), methane (CH_4), and nitrous oxides (N_2O). Carbon emission factors from various electrical power generating methods, along with emission factors from natural gas combustion for heating are used in the software. Kootenai Electric Cooperative purchases electricity from Bonneville Power Administration, which is primarily generated by hydro sources. Therefore, a GHP system will be approximately 100% renewable.

The reduction in greenhouse gas emissions is estimated at 68 tons of equivalent CO_2 per year in using a GHP system over a conventional system. This is equivalent to removing about 14 cars and light trucks from the road or planting about 80 acres of new forest.

CONCLUDING SUMMARY AND RECOMMENDATIONS

This preliminary feasibility assessment of installing a geothermal heat pump (GHP) system at the new planned Schitsu'umsh Cultural Center in Plummer, 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 Schitsu'umsh Cultural Center has not been designed, but the most likely type of system would be number of split systems with natural gas heating and direct-expansion (DX) cooling. A typical installed cost for this type of system is about $11/ft^2 of floor space.
- All three geothermal configurations considered are technically possible for the new building, but each has some associated risks. Well logs indicate inter-layered hard and broken basalt, making a vertical closed-loop system potentially cost prohibitive. Likewise, unexpectedly shallow bedrock can hamper excavating for a horizontal closed-loop. The risks involved with choosing an open-loop groundwater system, are that adequate groundwater supply may not be found.
- Existing well logs indicate a good chance of adequate groundwater 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. Irrigation water can optionally be supplied by the geothermal well. An open-loop system would require a water right and an injection permit.
- A vertical closed-loop system is estimated to require 60 vertical boreholes, each 250 ft deep with 20-ft lateral spacing, which would take up just less than half an acre of land area. 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 building, it is recommended that an in-situ thermal conductivity test be done to determine the soil/rock thermal properties, in addition to gaining some insight into the drilling conditions.

- 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 require about one acre of land area.
- 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 of simple payback on energy savings shows the following approximate payback periods:
  - 7 years an open-loop system,
  - 12 years for a horizontal closed-loop system, and
  - 16 years for a vertical closed-loop system.

The Geo-Heat Center recommends that this is a good time to engage an architect/engineer with geothermal heat pump design qualifications so that the mechanical design can be integrated into the whole building design. 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. More site-specific geologic information is needed such as depth to bedrock, drilling difficulties, and groundwater availability. Ideally, a 500 ft test well could be planned to gather more geologic data in order to make a more informed design decision. Other issues of concern might include timing or constraints of water rights and acceptable land area taken up by a closed-loop heat exchanger.

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APPENDIX A

WATER WELL LOGS IN THE PLUMMER, ID VICINITY

Form 238-7
7/93
Starships Consulting and Management Services

IDAHO DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

Office Use Only
Inspected by ____
Twp ____ Rge ____ Sec ____
1/4 ____ 1/4 ____ 1/4
Lat : : Long. : :

1. WELL TAG NO. D0040122
Drilling Permit No: 832463
Other IDWR No. 96-8044

2. OWNER **Well Number:** 938
Name Plummer, City of C/O USKH INC
Address 621 W Mallon Ave STE 309
City Spokane State WA Zip 99201

3. LOCATION OF WELL by legal description
sketch map location must agree with written location.

Twp. 46 ☑ North or ☐ South
Rge. 4 ☐ East or ☑ West
Sec. 18 NE 1/4 NE 1/4 1/4
Gov't Lot ____ County BENEWAH
Lat: : : Long: : :
Address of Well Site 3rd & "D" Street
City Plummer
Lt. 1 Blk. 31 Sub. Name ____

4. USE:
☐ Domestic ☑ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other ____

5. TYPE OF WORK check all that apply (Replacement, etc.)
☐ New Well ☑ Modify ☐ Abandonment ☐ Other Deepened

6. DRILL METHOD
☑ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other ____

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD

Was drive shoe used? ☐ Y ☑ N Shoe Depth(s)
Was drive shoe seal tested? ☐ Y ☑ N How?

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded

Length of Headpipe ____ Length of Tailpipe ____

9. PERFORATIONS/SCREENS
☐ Perforations Method ____
☐ Screens Screen Type ____

From	To	Slot Size	Number	Diameter	Material	Casing	Liner

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
40 ft. below ground Artesian pressure ____ lb.
Depth flow encountered ____ ft. Describe access port or control devices: ____

4.6 N 4 W 18

11. WELL TESTS:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
120			

Water Temp. Bottom Hole Temp
Water Quality test or comments: ____
Depth first Water encountered 145

12. LITHOLOGIC LOG:(Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality, Temperature	Water Y	Water N
6	150	150	Basalt Hard	☑	☐

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Completed Depth 150 (Measurable)
Date: Started 4/13/2005 Completed 4/13/2005

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

Firm Name H2O WellService, Inc. Firm No. 448
Firm Official [signature] Date 4-18-05
and
Supervisor or Operator [signature] Date 024/13/05
Louie Henner
(Sign once if Firm Official and Operator)

Form 238-7
6/02

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

Office Use Only
Well ID No.
Inspected by
Twp. Rge. Sec.
1/4 1/4 1/4
Lat: Long:

1. WELL TAG NO. D D00 40865
DRILLING PERMIT NO. 836166
Water Right or Injection Well No.

2. OWNER:
Name Plummer Forest Products, Inc.
Address P.O Box 259
City Plummer State ID Zip 83851

3. LOCATION OF WELL by legal description:
You must provide address or Lot, Blk, Sub. or Directions to well.
Twp. 46 North X or South
Rge. 4 East or West X
Sec. 18, NW 1/4 SW 1/4
Gov't Lot County Benewah
Lat: Long:
Address of Well Site Hwy 95 City Plummer
Lt. Blk. Sub. Name

4. USE:
Domestic, Municipal, Monitor, Irrigation, Thermal, Injection, X Other Log Yard

5. TYPE OF WORK check all that apply (Replacement, etc.)
(X) New Well, Modify, Abandonment, Other

6. DRILL METHOD:
X Air Rotary, Cable, Mud Rotary, Other

7. SEALING PROCEDURES

Seal Material	From	To	Weight/Volume	Seal Placement Method
Bentonite	0	58	12 sk	Pour Around Pipe

Was drive shoe used? X Y N Shoe Depth(s) 58'
Was drive shoe seal tested? X Y N How? Air

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
8"	+2	-58	.250	Steel	X		X	
6"	-8	-462	.200	PVC		X		

Length of Headpipe Length of Tailpipe
Packer Y X N Type

9. PERFORATIONS/SCREENS PACKER TYPE
Perforation Method Drill
Screen Type & Method of Installation

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
-322	-462	3/4	.220	6"	PVC		X

10. FILTER PACK

Filter Material	From	To	Weight/Volume	Placement Method
none				

11. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
146 ft. below ground Artesian pressure lb.
Depth flow encountered 302 ft. Describe access port or control devices.
Well Cap
46N 4W 18

12. WELL TESTS:
Pump, Bailer, X Air, Flowing Artesian

Yield gal/min.	Drawdown	Pumping Level	Time
100 gpm	Airlift from		462

Water Temp. 50° Bottom hole temp.
Water Quality test or comments: Clear no odor
Depth first Water encountered 63'

13. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temperature	Water Y	Water N
10	0	4	fill		
	4	12	Clay - Tan		
	12	22	Basalt - Broken		
	22	58	Basalt - Gray		
6"	58	63	Basalt - Gray		
	63	66	Basalt Broken w/water 25 gpm Dryed up while drlg.	✓	
	66	302	Basalt Gray		
	302	305	Basalt - Broken w/water 22 gpm	✓	
	305	310	Clay - Brown		
	310	315	Clay - Light Green		
	315	320	Basalt - Black & Brown 50 gpm	✓	
	320	402	Basalt - Gray		
	402	410	Clay - Gray w/water 25 gpm	✓	
	410	420	Clay - Gray		
	420	462	Basalt - Black		

100 gpm total

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Completed Depth 462' (Measurable)
Date: Started 9-21-05 Completed 9-26-05

14. DRILLER'S CERTIFICATION
We certify that all minimum well construction standards were complied with at the time the rig was removed.
Company Name Action Drilling INC. Firm No. 618
Principal Driller Alvin Carris Date 10-15-05
and
Driller or Operator II Date
Operator I [signature] Date 10-15-05
Principal Driller and Rig Operator Required.
Operator I must have signature of Driller/Operator II.

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Form 238-7 6/02

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

Office Use Only
Well ID No.
Inspected by
Twp Rge Sec
1/4 1/4 1/4
Lat : : Long : :

1. WELL TAG NO. D 0040657
DRILLING PERMIT NO. 836349
Water Right or Injection Well No.

2. OWNER:
Name Mel Doyle
Address Milwaukee Rd
City St. Maries State ID Zip 83861

3. LOCATION OF WELL by legal description:
You must provide address or Lot, Blk, Sub. or Directions to well.
Twp. 46 North X or South
Rge. 4 East or West X
Sec. 9 1/4 N/W 1/4 S/E 1/4
Gov't Lot County Benewah
Lat: : : Long: : :
Address of Well Site 405 Ellis Lane City Plummer
Lt. Blk. Sub. Name

4. USE:
X Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other

5. TYPE OF WORK check all that apply (Replacement etc.)
X New Well ☐ Modify ☐ Abandonment ☐ Other

6. DRILL METHOD:
X Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other

7. SEALING PROCEDURES

Seal Material	From	To	Weight / Volume	Seal Placement Method
Bentonite	0	39	8 sx	Pour Around Pipe

Was drive shoe used? X Y ☐ N Shoe Depth(s) 39'
Was drive shoe seal tested? X Y ☐ N How? Air

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
6"	+1	-39	250	Steel	X		X	
4"	-18	-200	160	PVC		X		

Length of Headpipe Length of Tailpipe
Packer ☐ Y X N Type

9. PERFORATIONS/SCREENS PACKER TYPE
Perforation Method Drill
Screen Type & Method of Installation

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
-140	-200	3/4"	72	4"	PVC	☐	X

10. FILTER PACK

Filter Material	From	To	Weight / Volume	Placement Method
none				

11. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
38' ft. below ground Artesian pressure lb.
Depth flow encountered 172 ft. Describe access port or control devices: Well Cap

46N 4W 9

12. WELL TESTS:
☐ Pump ☐ Bailer X Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
50 gpm	Airlift	from 200	

Water Temp. 50 gpm Bottom hole temp.
Water Quality test or comments: Clear no odor
Depth first Water Encounter 172'

13. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temperature	Water Y	Water N
8	0	12	Clay - Tan		
	12	28	Basalt Broken		
	28	39	Basalt Gray		
6"	39	72	Basalt Gray		
	72	78	Basalt Broken - Brown		
	78	163	Basalt - Gray		
	163	168	Basalt - Broken Brown		
	168	172	Basalt - Gray - Hard		
	172	182	Basalt - Broken Water 22 gpm	X	
	182	200	Basalt - Broken Water 28 gpm	X	
	200	202	Basalt - Broken W/Red clay		
			50 gpm totatel @ 200'		

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Completed Depth 200' (Measurable)
Date: Started 9-27-05 Completed 9-28-05

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

Company Name Action Drilling Inc. Firm No. 618
Principal Driller Alvin Carris Date 10-15-05
and
Driller or Operator II Date
Operator Alvin Carris Date 10-15-05
Principal Driller and Rig Operator Required.
Operator I must have signature of Driller/Operator II.

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Form 238-7
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IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

Office Use Only
Well ID No.
Inspected by
Twp ___ Rge ___ Sec ___
___ 1/4 ___ 1/4 ___ 1/4
Lat: : : Long: : :

1. WELL TAG NO. D D0039888
DRILLING PERMIT NO. 830757
Water Right or Injection Well No.

2. OWNER:
Name Coeur d'Alene Tribe
Address PO Box 408
City Plummer State ID Zip 83851

3. LOCATION OF WELL by legal description:
You must provide address or Lot, Blk, Sub. or Directions to well.
Twp. 46 North ☒ or South ☐
Rge. 4 East ☐ or West ☒
Sec. 22, ___ 1/4 (10 acres) ___ 1/4 (40 acres) ___ 1/4 (160 acres)
Gov't Lot ___ County ___
Lat: : : Long: : :
Address of Well Site 230 Agency Loop Rd. City Plummer
(Give at least name of road + Distance to Road or Landmark)
Lt. ___ Blk. ___ Sub. Name ___

4. USE:
☐ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other ___

5. TYPE OF WORK check all that apply (Replacement etc.)
☒ New Well ☐ Modify ☐ Abandonment ☐ Other

6. DRILL METHOD:
☒ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other

7. SEALING PROCEDURES

Seal Material	From	To	Weight / Volume	Seal Placement Method
Bentonite	0	80	33sx	Pour Around Pipe

Was drive shoe used? ☒Y ☐N Shoe Depth(s) 185
Was drive shoe seal tested? ☒Y ☐N How? Air

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
8"	+2	-185	250	Steel	☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐

Length of Headpipe ___ Length of Tailpipe ___
Packer ☐Y ☒N Type ___

9. PERFORATIONS/SCREENS PACKER TYPE
Perforation Method none
Screen Type & Method of Installation

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
	none					☐	☐
						☐	☐
						☐	☐

10. FILTER PACK

Filter Material	From	To	Weight / Volume	Placement Method
none				

11. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
350 ft. below ground Artesian pressure ___ lb.
Depth flow encountered 368 ft. Describe access port or control devices: welded Steel plate

46N 4W 22

12. WELL TESTS:
☐ Pump ☐ Bailer ☒ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
2 g.p.m. Air lift from			545'

Water Temp. 56° Bottom hole temp. ___
Water Quality test or comments: Clear no odor
Depth first Water Encounter 90'

13. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temperature	Water Y	Water N
12"	0	16	Clay - Brown		
	16	25	Clay - Tan		
10"	25	60	Clay - Tan		
	60	90	Clay - Red		
	90	91	Clay - Red Sandy w/water 1gpm - dirty	✓	
	91	120	Clay - Red		
	120	180	Clay - Tan w/some shale		
8"	180	260	Shale - Tan w/ clay		
	260	280	Shale - Multi-color - soft		
	280	300	Shale - Multi color		
	300	368	Granite - Pink + Gray		
	368	369	Granite - Pink + Gray w/water 1gpm	✓	
	369	482	Granite - Pink + Gray		
	482	483	Granite - Pink + Gray w/water 1gpm	✓	
	483	545	Granite Pink + Gray		
			2 gpm. Total @ 545		

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Completed Depth 545 (Measurable)
Date: Started 1-18-05 Completed 1-27-05

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

Company Name Action Drilling Inc. Firm No. 618
Principal Driller Alvin Carris Date 2-18-05
and
Driller or Operator II ___ Date ___
Operator I Alvin Carris Date 2-18-05
Principal Driller and Rig Operator *Required.*
Operator I must have signature of Driller/Operator II.

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