FINAL REPORT
GEOTHERMAL HEATING FEASIBILITY STUDY OF THE UTAH TRANSIT AUTHORITY, SALT LAKE CITY, UT

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DISCLAIMER STATEMENT

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EXECUTIVE SUMMARY

The Geo-Heat Center conducted a feasibility study for the Utah Transit Authority (UTA) to install a supplemental heating system supplied by geothermal energy at their recently acquired Warm Springs Facility in Salt Lake City, UT. The thermal energy is proposed to be distributed through piping under service platforms, which will act as an overhead radiant heating panel for maintenance workers. 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*", Task 2: "*Geothermal Heating Feasibility Study of the Utah Transit Authority, Salt Lake City, UT*".

Hourly heating loads were first computed for a typical year for the UTA Facility using computer software. This allowed estimation of annual energy savings for the part-load geothermal system.

Two basic geothermal resource utilization scenarios were identified: (1) construct a pipeline from the UTA Facility to Wasatch Warm Springs, which is located approximately 0.4 miles east of the building or (2) drill a new well on the UTA property. Within *Scenario 1*, two options were considered: (a) utilize geothermal water directly for heating purposes or (b) utilize geothermal water as source water for geothermal heat pumps. In *Scenario 2,* drilling a new well on the UTA property would likely result in encountering low temperature groundwater, so only geothermal heat pump applications were considered. To compare alternatives, two economic indicators were computed: simple payback period and return on investment.

Geothermal Resource

Geothermal water issues from the Wasatch Warm Spring at a reported flow rate of 60 gpm and a temperature of about 100^{o}F. Two conceptual models of the geothermal reservoir exist, and there has unfortunately been no new addition of data to refine these models. Therefore, the origin of the geothermal water remains uncertain, and this uncertainty has implications for existence of hot water at feasible depths under the UTA site. The geothermal water may either originate from below the Becks Warm Spring (some 3 miles north) and flow laterally along the Warm Springs fault zone, or it may originate from under the entire fault zone and flow vertically upward, mixing with colder water. Given that hotter water exists at the Becks spring, the first model (or a combination of the two) appears to be the more likely.

The uncertain nature of the geothermal water origin makes drilling for hot water at the UTA property a risky proposition. To drill down the fault zone would entail drilling to depths of approximately 5,500 ft, and there would be no guarantee that hotter water could be found. The drilling cost of such a venture would be on the order of $1.5 million.

Geothermal Energy Utilization and Economic Comparison of Alternatives

Results of the economic comparison of alternatives are summarized in the following table. The simple payback period is based on energy savings only, while return on investment considers 30-year life-cycle costs, including maintenance costs, period replacement costs, and debt service.

Scenario		Capital Cost (includes 20% contingency)	Net Annual Energy Savings	Simple Payback on Energy Savings (years)	Return on Investment (30-year project life)
1(a).	Construct pipeline from UTA facility to Wasatch Warm Springs - Direct-use heating using geothermal water	$192,000	$17,000	11.3	8.7%
1(b).	Construct pipeline from UTA facility to Wasatch Warm Springs - Use geothermal water as source water for geothermal heat pumps	$384,000	$31,000	12.4	6.3%
2.	Drill supply and injection well on UTA property - Use groundwater as source water for geothermal heat pumps	$275,400	$28,500	9.7	11.1%

It should be noted that although *Scenario 2* appears to be the most economically attractive, there are considerable uncertainties in the geologic conditions under the UTA property, both natural and as a result of the industrial history of the site. For cost estimating purposes, it was assumed, based on well logs from surrounding properties, that a well drilled to 250 ft could yield 150 gpm at 55^{o}F, and thus geothermal heat pumps would be required. A test well would have to be drilled on the UTA site to verify these assumptions. One additional benefit of heat pump applications as proposed in *Scenario 2* is that they could also be used for radiant cooling in summer, provided pipe surfaces are kept above the dew-point temperature to prevent condensation.

In addition, there are uncertainties in the cost estimates of the pipeline construction in *Scenario 1*. Although a 20% contingency was included, no other allowances were made for encountering contaminated soils or other unknown underground structures.

Recommendations

The Geo-Heat Center recommends that additional field investigation be undertaken prior to serious consideration of either *Scenario 1* or *2*. Regarding *Scenario 1*, actual spring temperatures and flow rates should be verified and ideally measured over the period of a cold month. In addition, a more detailed field inspection should be done to verify the proposed pipeline route. Property access and/or groundwater contamination plumes may preclude this option. Regarding *Scenario 2*, a test hole needs to be drilled prior to making any firm design plans. If the geothermal gradient does not appear to increase significantly as drilling proceeds, the test hole should be converted into a supply well at the first occurrence of usable groundwater.

INTRODUCTION AND BACKGROUND

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*”, Task 2: “*Geothermal Heating Feasibility Study of the Utah Transit Authority, Salt Lake City, UT”*.

Utah Transit Authority (UTA) is a quasi-governmental organization that serves the most densely populated areas of Utah along the Wasatch Front in the Salt Lake City metropolitan area. UTA acquired the Warm Springs Service Center building (Figure 1) in 2003 for commuter rail maintenance. The building has a footprint of 165,000 ft^2 of which 120,000 ft^2 will require heating. The building also has approximately 30 to 40 ft high ceilings, resulting in a very large volume of space to be heated.

***Figure 1.** Overview of Wasatch Warm Springs and the Utah Transit Authority Building.*

The UTA facility is located in a known geothermal resource area (Figure 1). About 0.4 miles east of the facility is the Wasatch Warm Springs, which is one of a series of springs that occurs on a north-south trending fault system lying at the base of the Wasatch Range. This Warm Springs fault geothermal system extends about 3 mi. in length and 0.75 mi. in width. The Warm Springs and Hobo faults associated with these springs are local names for segments of the Wasatch fault zone, which forms the boundary between the Salt Lake Valley and the Wasatch Range (Basin and Range and Middle Rocky Mountains Provinces). Becks Hot Spring, Wasatch Warm Springs, Hobo Warm Springs, and Clark Warm Springs occur along this segment of the fault as well as two, shallow, warm water wells used by local quarry operators. Discharge temperatures in this system appear to cool from north to south, ranging from 131°F at Becks Hot Spring to 100° F at Wasatch Warm Springs.

OBJECTIVES AND SCOPE

The main objective of this project is to assess the feasibility of utilizing geothermal energy to provide supplemental heat to the UTA Service Center. There are currently unused distribution pipes that run overhead of work areas that have been suggested for retrofit to provide overhead radiant heat. This feasibility study examines means for accessing geothermal resources and distributing the heat to end uses, and evaluates options on an economic basis. Two basic geothermal resource utilization scenarios were identified and evaluated: (1) build a pipeline to utilize thermal energy from a known resource at the Wasatch Warm Springs or (2) drill a well and utilize geothermal resources on the UTA property.

METHODOLOGY AND REPORT ORGANIZATION

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

- Visited the UTA site and met with the project team in addition to research scientists from the University of Utah and the Utah Geological Survey,
- Compiled and reviewed data and information on the local geology and geothermal resources,
- Conducted a heating load analysis of the UTA facility, and
- Conducted an economic analysis of alternatives.

Design aspects for a geothermal application of this type consist of a number of geological, mechanical, and economic considerations. Thus, these topics are addressed in this report in the following subsections (which follow this section):

- *Warm Springs Geothermal Resources:* describes the known geothermal resource from regional and local (i.e. at the UTA property) perspectives in the context of direct-use heating applications,
- *Heating Load Calculations and Annual Energy Consumption:* summarizes results of computer calculations to estimate peak heating loads and annual heating energy consumption. These estimates are necessary in order to determine energy savings from the proposed supplemental overhead radiant system,
- *Geothermal Retrofit Description and Economic Comparison of Alternatives:* describes work required to retrofit the facility to geothermal heat, presents cost estimates, and compares alternatives based on simple payback period and return on investment,
- *Concluding Summary and Recommendations:* summarizes the findings of this study and presents recommendations for further action.

WARM SPRINGS AREA GEOTHERMAL RESOURCES

Regional Geothermal Resource

The Warm Springs Fault geothermal area is a strip approximately three miles long by 4,000 feet wide that parallels the western edge of the Salt Lake Salient to the northwest of the Utah State Capital Building (Murphy and Gwynn, 1979). The observed occurrences of warm water along the Warm Springs Fault are bound on the north by Becks Hot springs and on the south by Wasatch Warm Springs.

Figure 2 shows a conceptual model of the geothermal reservoir at Warm Springs Fault Geothermal Area. The Warm Springs Fault has a minimum displacement of approximately 600 ft, and the down thrown block is buried beneath approximately 400 ft of valley fill. A second fault referred to as the Hobo Springs Fault lies to the west and has a total displacement of approximately 4,000 ft. Major thermal springs appear to be located near intersections of these major normal faults with each other and with relatively minor pre-Basin and Range structures of the Salient. Recharge to the system is believed to be from an undefined source area in the Wasatch Range, and the water is heated in the normal geothermal gradient by circulation to depths of 5,000 to 6,500 ft (Murphy and Gwynn, 1979).

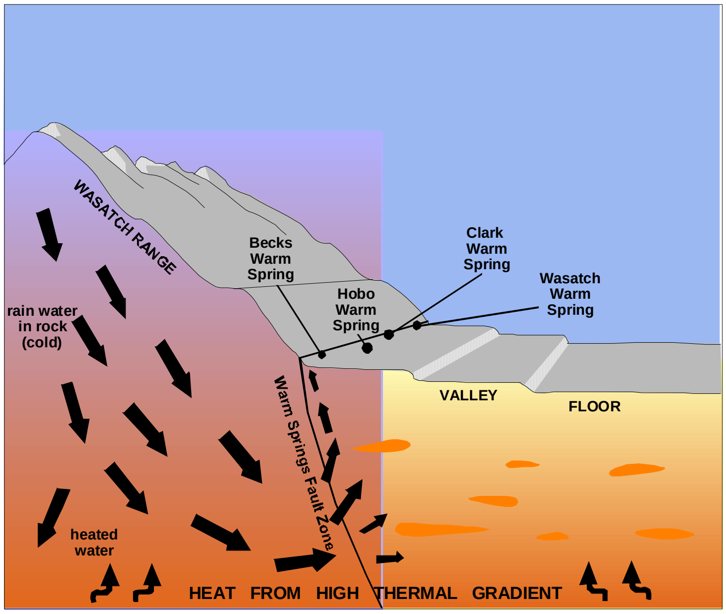

Figure 2. *Conceptual model of the geothermal resource for the Warm Springs Fault system.*

Wasatch Warm Springs are about one mile north-northwest of Temple Square in Salt Lake City, Salt Lake County. The springs, like Becks Hot Springs, issue along the Warm Springs Fault at the contact between rocks of Quaternary and Paleozoic age. During the past 45 years, several short tunnels have been constructed in an effort to increase spring discharge; and other construction in the immediate vicinity of the springs has affected spring discharge. Therefore, comparisons of variations in spring discharge and in chemical characteristics of the water may not be valid. Taylor and Leggette (1949, p. 40) show that observed flow from the springs at "Wasacth Springs Plunge" ranged from 310 to 1,020 gpm during the period 1920-36. Milligan and others (1966, table 1) reported a discharge of 314 gpm during the summer of 1964. Concurrent observations of discharge and chemical characteristics of the springs are inadequate for establishment of the relation between discharge and chemistry of the water, but the dissolved-solids content appears to increase as spring discharge decreases. Dissolved-solids content was nearly 13,000 ppm at very low discharges during the severe drought in 1934. Since then, the data available show dissolved-solids content ranging from about 5,600 to about 8,600 ppm. The data suggest that fairly constant amounts of deep, highly mineralized water mixes with variable amounts of shallower, less mineralized water (Mundoff, 1970).

Ground-water movement in the principal aquifer is generally northward toward the Great Salt Lake. Ground water migrates laterally toward the Jordan Valley from both the east and west sides of the valley and, subsequently, migrates to the north.

The Jordan Valley is an area of highly convective heat flow due to the influx of cool water from the mountainous recharge areas. Stable, conductive thermal gradients are difficult to obtain in such areas, and results must be considered local rather than regional. The occurrence of the warm water in the area appears to be controlled by two main Basin and Range structures: a) the Warm Springs Fault striking northwest and dipping 65 to 70 degrees to the southwest, and b) the Hobo Springs Fault striking subparallel to the Warm Springs Fault and dipping slightly to the southwest, close to 90 degrees.

Geothermal Potential on the UTA Property

The Wasatch Warm Springs constitutes the southernmost observed occurrence of warm water along the Warm Springs Fault. The Wasatch Warm Springs is approximately one mile northwest of the Utah State Capital Building between Victory Road and Beck Street and east of the Utah Transit Authority building (Figure 1). The spring at one time supplied water to a popular bathing resort; over the years a series of 6 tunnels have been driven northeastward into cemented alluvium and tufa deposits in attempts to increase spring flow but discharge eventually decreased with time (Milligan, et. al., 1966). The spring discharge also varies with seasonal and climatic variations. Temperatures ranging from 100.4° to 107.6°F have been reported and the average discharge is 63.4 gpm (Karlsson, 1984). The flow from the springs is not presently used, and the water drains away from the site in a number of buried pipes. Much of the water is discharged into the storm sewer; eventually discharging into the Jordan River. The water rights for the springs are owned by the City of Salt Lake (Murphy and Gywnn, 1979).

The temperature of Wasatch Warm Springs was 105°F on July 26, 1967 and was 132°F at the nearby Becks Hot Springs on the same date. Dissolved solids were 6,000 and 13,900 ppm, respectively. The water is of the sodium chloride type at both springs, and sulfate concentrations are similar. The lower temperature and lower dissolved-solids content of water from the Wasatch Warm Springs probably results from a proportionately greater amount of less deeply circulated ground water that enters the system in the vicinity of these springs. Although a small area of volcanic rocks is about one mile east of the Wasatch Warm Springs, the source of the heat is believed to be the geothermal gradient (Mundorff, 1970).

A limited number of wells have been drilled in the vicinity of the Warm Spring Fault with most of them 1 to 1.5 miles to the west. None of the wells were available for temperature gradient measurements during the Murphy and Gwynn 1979 study. One well, (B-1-1) 15dbd, is located near the radio towers and was drilled to 732 ft and encountered alternating layers of sand and clay. Another deep water test hole to the south of the area encountered sands and clays to a depth of over 1,000 ft. During the same study there were five temperature gradient holes drilled which were located along the Warm Springs Fault. The depths drilled ranged from 250 – 300 ft. There was only one drilled in the vicinity of Wasatch Warm Springs Hole E (B-1-1) 25bcc was located about 246 ft west of the Wasatch Warm Spring outlet. The hole was drilled through a series of sands and gravels containing varying percentages of clay. The generally elevated temperatures measured below five meters are the result of lateral flow of warm water through the sands and gravels from the spring system located to the east. The temperature profiles for the temperature gradient holes are shown in Figure 3 with Hole E show as a heavier line (Murphy and Gwynn, 1979).

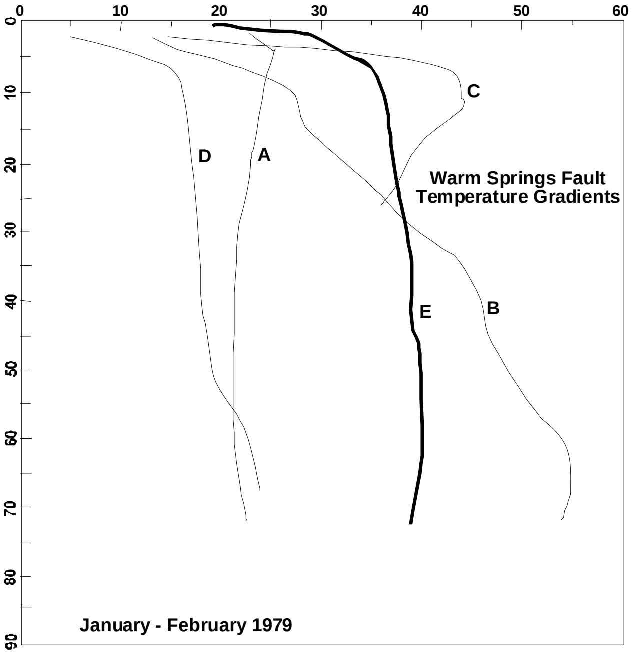

Figure 3. *Temperature gradient wells drilled along Warm Springs Fault*

There are two different possibilities for the geothermal flow:

1. The thermal water which is circulated to depth and heated in the deep layers of the Basin and Range province flows laterally at depth and ascends along the faults such as Warm Springs Fault. As it nears the surface, it is mixed with the cool water which has traveled laterally from the mountains through the surface layers. This appears to be the model described in the papers by Murphy and Gwynn and Cole.

2. The thermal water rises under the Range where it is mixed with the cool surface water. From there it flows laterally to its outlets along the faults such as Warm Springs Fault. Some Investigators have expressed the opinion that this is no less likely than the first.

It is clear that the first model offers a good chance of producing considerably warmer water than is flowing from the Wasatch Warm Springs. If the thermal waters follow the path of the second model, no temperature increase of water is produced by drilling in the area.

The UTA building is approximately 0.4 miles from Wasatch Warm Springs. If a well was drilled to intersect the fault in hopes of getting hotter water they would need to drill down to approximately 5,500 to 7,100 feet as shown in Figure 4.

The report *"Utah Geological and Mineral Survey – Report of Investigation No. 185 Low-Temperature Geothermal Assessment of the Jordan Valley Salt Lake County, Utah" by Robert H. Klauk* collected and analyzed 199 water samples in the Jordan Valley area including the springs along the Warm Springs Fault system. The chemical geothermometry results are listed below for Wasatch Warm springs.

Temp 39°C (102.2°F)
Qtz (Cond) 42
Chalcedony10
Na-K-Ca – 119
Na-K-Ca (Mg – Correction) – 70

The report states that reasonable results have been achieved for Becks and Wasatch Warm Springs. It states that the Wasatch Warm Springs mixing model provided a temperature of 122°F to be expected at depth and a 30 percent cold water component. The second confirmation mixing model from Truesdell and Fournier, 1977 indicates quartz equilibrium and not chalcedony with a maximum temperature of 129°F.

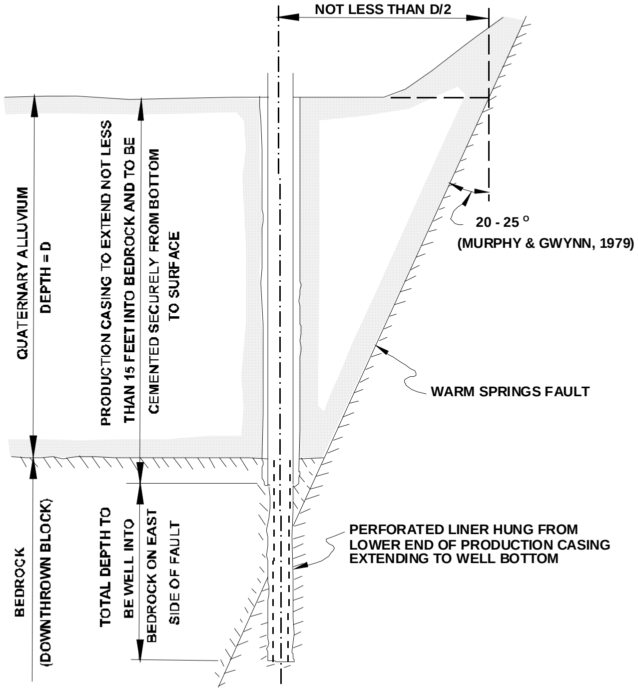

Figure 4. *Design of well if drilled to intersect Warm Springs Fault on UTA property.*

HEATING LOAD CALCULATIONS AND ANNUAL ENERGY CONSUMPTION

This section presents an overview of radiant heating methods and results of the heating load estimates at the UTA facility.

Overview of Radiant Heating

Radiant heating and cooling are described in the ASHRAE Applications Handbook (2003). The main benefit of radiant heating is that the radiant appliance directly heats objects, occupants, and surfaces, not air (although some heating of water vapor in air occurs, but is negligibly small). These attributes of radiation heat transfer are especially important in heating a voluminous space such as the UTA facility, where occupants only work in concentrated areas. Once objects in a space begin to warm as a result of a radiator, objects store this energy creating a thermal storage reservoir, and then begin to warm surrounding air near the object due to convection, and re-radiate heat to other objects or occupants.

With radiant heating systems, ambient air temperatures do not need to be kept as high as with forced-air-heating systems. This concept has led to development of the well-known ASHRAE comfort chart (re-drawn in Figure 5), originally published in ASHRAE Standard 55-1992. Note that the ASHRAE comfort chart uses the concept of the *operative temperature* (T_{op}), which is defined as the average of the ambient air temperature (T_a) and the mean radiant temperature (T_{mrt}):

$$T_{op} = \frac{T_a + T_{mrt}}{2} \qquad (1)$$

The mean radiant temperature is loosely defined as the temperature felt by an occupant or object due to the radiant energy received from the surroundings. It is also roughly defined as the average temperature of walls and floors in a space.

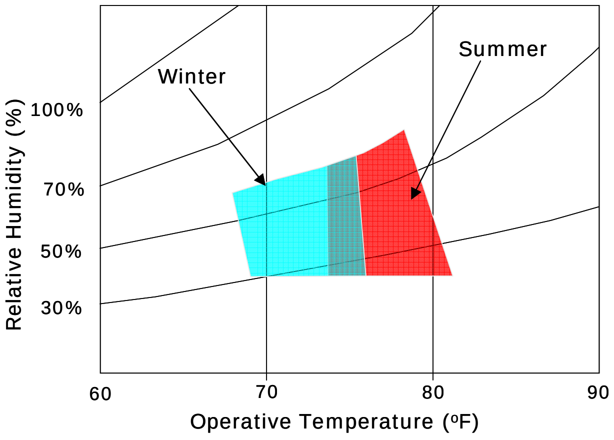

***Figure 5.** ASHRAE comfort chart.*

As seen in Figure 5, occupants of a space will feel comfortable at operative temperatures of about 68°F, depending on the relative humidity. Combining this with Equation 1, it can be seen that the comfort level of an occupant can be kept constant with decreasing ambient space temperature, as long as the mean radiant temperature is correspondingly increased.

Heating Load Calculations

From the previous discussion, an operative temperature of 70°F is considered a comfortable temperature in winter, and this temperature was assumed in the heating load calculations. To maintain this space temperature, it was also assumed that the mean radiant temperature of the surrounding objects could be kept at 75°F from the radiant heating system, meaning that the air temperature in the space could be kept at 65°F.

To perform the heating load analysis, we constructed a computer model of the UTA building using eQuest (J.J. Hirsch, 2005) graphical user interface. The model only included the 120,000 ft^2 maintenance area of the building to be heated with geothermal energy. Loads were computed on an hourly basis for a typical year using the so-called DOE-2 simulation engine (York and Cappiello, 1981). This allowed the annual heating energy consumption to be determined.

Results of the hourly loads analysis are shown in Figure 6. The peak hour load is estimated at approximately 5.3 million Btu/hr and the annual heating requirements are approximately $7.17x10^9$ Btu. At UTA's current natural gas charge of $1.00/therm and assuming 80% efficiency, the annual cost of heating with natural gas would be about $90,000.

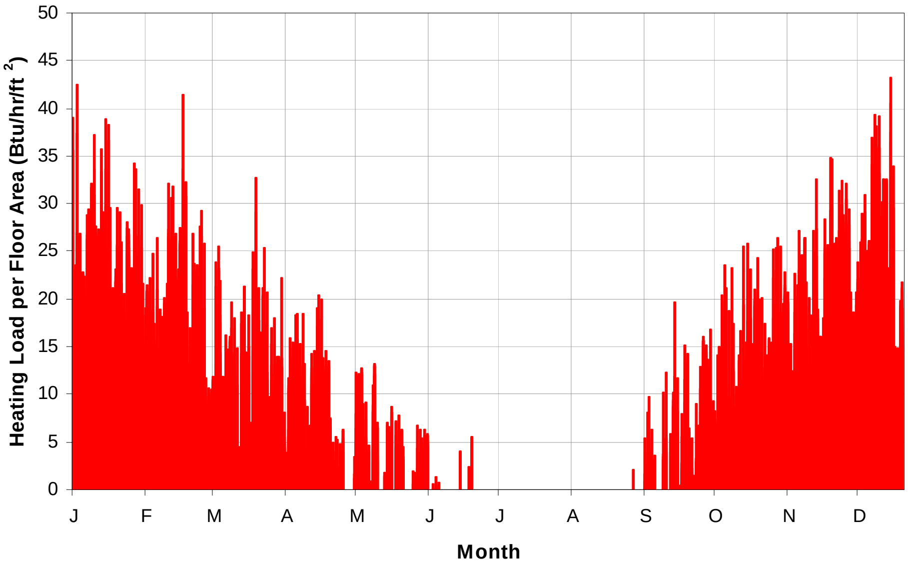

Figure 6. *Hourly heating loads for a typical year for the maintenance area of the UTA facility.*

GEOTHERMAL RETROFIT DESCRIPTION AND ECONOMIC COMPARISON OF ALTERNATIVES

This section describes work required and costs associated with the retrofit scenarios of the UTA building. First, the building retrofit is described, and then scenarios are presented to access the geothermal resource along with associated construction costs and energy savings. The geothermal scenarios considered are:

1. Construct a pipeline to directly access geothermal water from Wasatch Warm Springs, or
2. Drill a new well on UTA property

The advantage of *Scenario 1* is that there is no risk assumed in finding geothermal water. Under *Scenario 2,* as described previously, it is unknown what groundwater temperatures and flow rates exist under the UTA property.

Retrofit of the UTA Building

UTA personnel have proposed to distribute heat in the maintenance area of the UTA facility via radiant methods. The radiators will consist of hot water piping, routed under service rail platforms where train cars are parked for maintenance. A photograph of some of the old service piping is shown in Figure 7. The piping is located about 7 ft above the floor where occupants work. Consequently, this low of a radiant mounting height should lend itself well to low radiant temperatures.

Figure 7. *Photograph of old service piping to be retrofitted for overhead radiant heating.*

Piping under a total of seven platforms is planned for geothermal retrofit. The Geo-Heat Center field-inspected each of these, and the platforms are designated in the UTA facility by column labels *C* through *I*. Not all platforms are identical; platforms *F*, *G*, and *H* are full tee-shaped while platforms *C*, *D*, *E*, and *I* are half-tees. Also, not all old service piping is identical under each platform, and some old piping does not run the full length of the platform (i.e. platforms *D*, *F*, and *G*). In general, 3 to 4 pipe runs of pipe sizes ranging from 1¼-in. to 2-in. are available per platform for geothermal retrofit. Also, common to each platform is a space in the center of the I-beam for a 3-inch diameter pipe, which could be used as a return pipeline.

Scenario 1: Construct a Pipeline to Wasatch Warm Springs

Under this Scenario, two possibilities emerged: *Scenario 1(a)* – utilize the geothermal water directly for heating, or *Scenario 1(b)* – use the geothermal water as a source for heat pumps.

Geothermal Resource Development: The numerous small springs that comprise Wasatch Warm Springs are channeled through culverts as shown in Figure 8 to a single outfall that runs under Beck Street. From there, the spring water is routed to a storm sewer whose exact route is unknown, but based on construction drawings provided by UTA, appears to cross the south end of the UTA property, approximately 1,200 ft south of the UTA building. Regardless, the storm sewer collects runoff from other sources, necessitating the construction of a pipeline to the main outfall of the springs in order to collect the hottest available water.

Figure 8. *Photograph of one spring comprising the Wasatch Warm Springs.*

A proposed route for the pipeline is shown in Figure 9. The pipeline length is about 2,000 ft, and with the expected temperature of 100^{o}F and flow rate of 60 gpm, it could be constructed of 4-in. diameter, pre-insulated PVC pipe with a PVC jacket. This type of construction would result in a temperature loss in the water of about 1.5^{o}F over the pipeline length. The geothermal water would be transmitted to the UTA facility under gravity flow. The used water could be diverted to the existing UTA storm sewer system.

Geothermal Energy Utilization and Distribution in the UTA Facility: With the expected temperature and flow rate of water from the Wasatch Warm Springs, some usable heat could be extracted from the water for direct-use purposes. The actual amount can be estimated by considering an energy balance on the geothermal fluid stream.

Figure 9. *Possible pipeline route to the UTA facility from the Wasatch Warm Springs.*

First, it should be noted that low-temperature, hydronic radiant panel systems are typically designed with a temperature drop of the water of 10°F across the radiant heating system in order to provide a relatively even heat distribution. If this were the design criteria for the UTA Facility, at 98°F entering geothermal water temperature, the geothermal fluid would leave at 88°F, meaning that the bulk average fluid temperature would be on the order of 93°F. Under these conditions, 300,000 Btu/hr of thermal energy would be transferred, or about 6% of the peak load, which translates to about 19% of the annual load. Figure 10 shows graphically the fraction of the hourly heating load handled under this scenario.

One way to extract more heat from the geothermal fluid stream is through the use of heat pumping technology. Heat pumps provide two advantages for greater heat extraction rates: (1) a greater allowable temperature drop across the source geothermal fluid side, and (2) higher fluid temperatures of up to 140°F on the radiant heating loop. A schematic of how a heat pump system could be configured is shown in Figure 11, assuming a radiant heating supply temperature of 130°F. Staged heat pumps allow some units to be shut down when not needed. Under this scenario, a peak heating load of 1 million Btu/hr, or about 19% of the peak load could be supplied, which translates to about 58% of the annual load. The hourly heating load fraction met by the heat pump system is shown graphically in Figure 12.

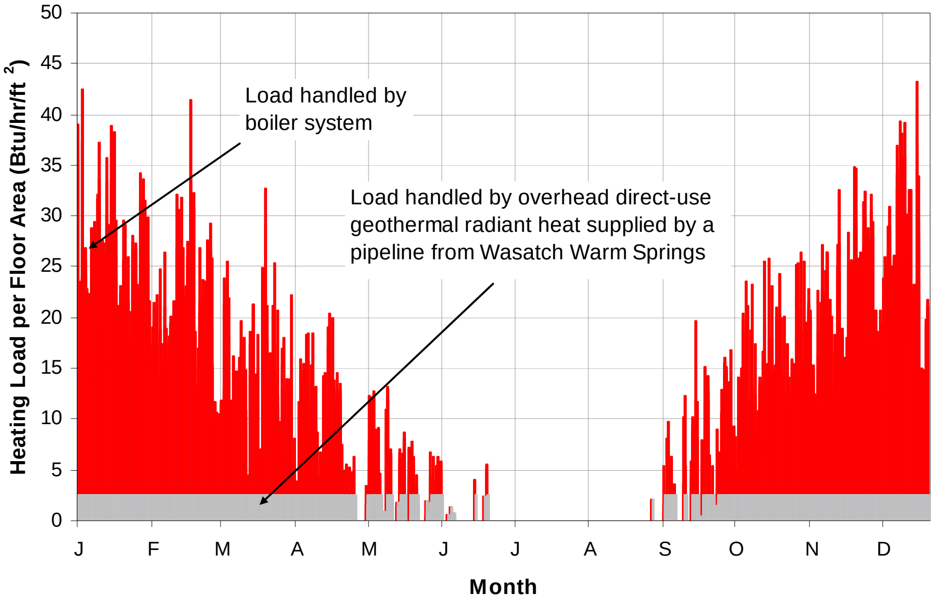

Figure 10. *Fraction of hourly heating load handled by direct-use geothermal energy supplied by a pipeline from Wasatch Warm Springs (Scenario 1(a)).*

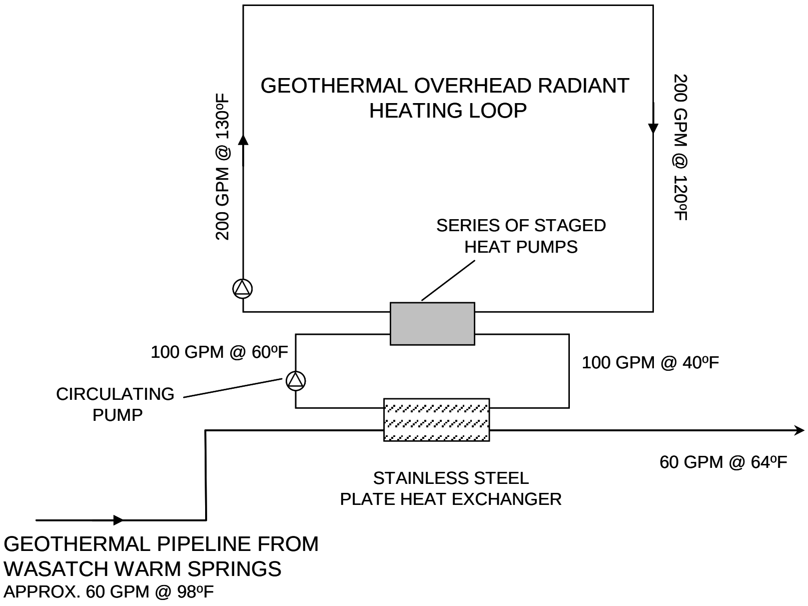

Figure 11. *Process schematic of heat pump configuration with source water from a pipeline to Wasatch Warm Springs (Scenario 1(b)).*

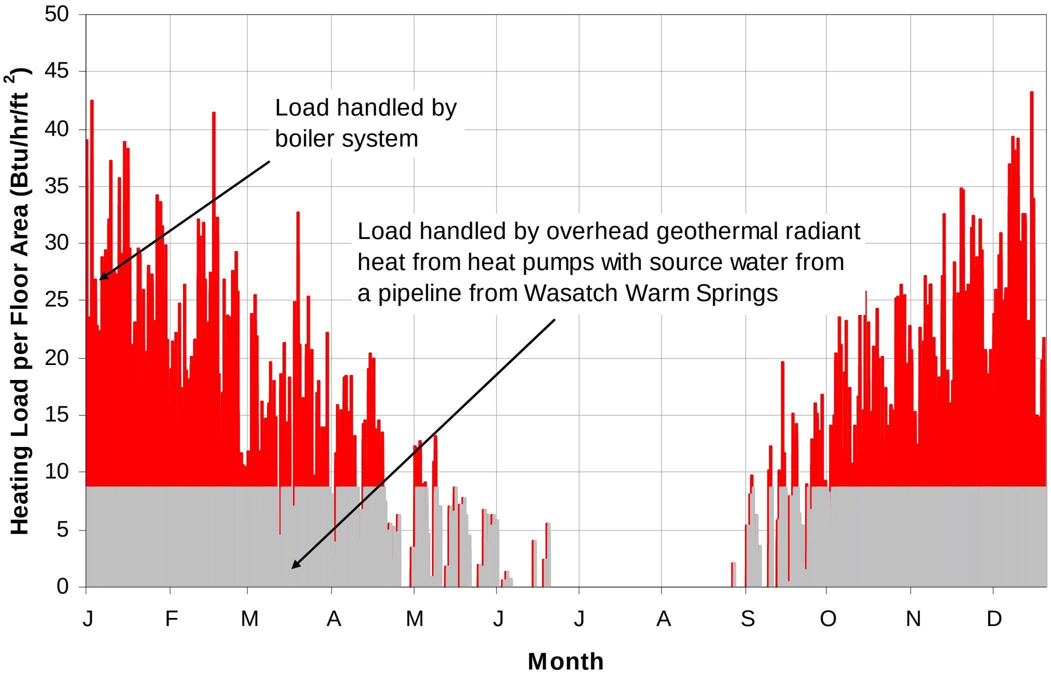

Figure 12. *Fraction of hourly heating load handled by geothermal energy from heat pumps supplied by a pipeline from Wasatch Warm Springs (Scenario 1(b)).*

Scenario 1 Geothermal Heating System Economics: For this cost estimate, permit and other fees for acquisition of easements for the pipeline were not considered. Old service piping removal and retrofitting to a radiant heating system were also not considered, as it was assumed that this would all be done by UTA personnel.

Scenario 1(a):

• Pipeline construction (2,000 ft) including the cutting and repairing of surface materials, trenching to 4-ft depth and backfilling, 4-in. pre-insulated PVC pipe material and installation, fittings and valves, associated traffic control, horizontal boring under railway (approx. 50 ft):	$150,000
• Heat exchanger, circulating pump, and associated plumbing:	$ 10,000
• TOTAL (including 20% contingency)	$192,000

Scenario 1(b):

In addition to the costs of Scenario 1(a):

• Heat pumps including circulating pump and associated plumbing and controls:	$160,000
• TOTAL (including 20% contingency)	$384,000

In *Scenario 1(a)*, the avoided annual cost of natural gas at $1.00/therm is about $17,000, giving a simple payback period of 11.3 years. In Scenario 1(b), the avoided annual cost of natural gas at

$1.00/therm is about $51,000, but this comes at the expense of about 305,000 kWh of electrical energy consumption of heat pumps and circulating pumps. Thus, the net annual energy savings under *Scenario 1(b)* is about $31,000, resulting in a simple payback period of approximately 12.4 years.

Scenario 2: Drill a Well on UTA Property

Under this Scenario, only the use of geothermal water as a source for geothermal heat pumps is considered. This is due to the fact that there is an unfortunate lack of information regarding both the groundwater temperature and well yields under the UTA property. As described in earlier sections of this report, existing geologic information does not support the existence of warm groundwater at shallow depths under the UTA property. With the steep dip angle of the Warm Springs fault zone, a well would have to be drilled to at least 5,500 ft on the UTA property to intersect this fault zone. Also, as mentioned previously, depending on the actual flowpath of geothermal waters (i.e. vertically upward along the fault zone or horizontally from Becks Hot Springs), water at this depth may or may not be significantly warmer than that of the Wasatch Warm Springs. Therefore, there would be considerable risk and cost (i.e. on the order of $1.5 million based on recent drilling quotes received by the Geo-Heat Center) to drill to this target. Consequently, drilling on the UTA property would most likely result in encountering low-temperature aquifers.

Geothermal Resource Development: Based on well logs from surrounding properties, well yields on the order of 100 to 200 gpm at 55°F can be expected at the UTA property. Given the industrial history and storage and usage of chemicals and fuels at the site and surrounding properties, undertaking this scenario will surely result in the necessity of a groundwater modeling study to demonstrate that existing contaminant plumes will not be exacerbated. Therefore, a supply well would likely need to pump groundwater from below a confining clay layer, and an injection well would be a prudent choice so as not to suppress the groundwater table excessively. Ideally, the supply well would be located on the south side of the building, as close as possible to the building. The injection well could be located on the north side of the building.

Geothermal Energy Utilization and Distribution in the UTA Facility: Geothermal energy utilization under *Scenario 2* is much the same as *Scenario 1(b)*, except with lower source water temperatures supplied by a well as shown in Figure 13. The peak and annual heating load fractions would be the same as in *Scenario 1(b)*.

Scenario 2 Geothermal Heating System Economics: For this cost estimate, it was assumed that supply and injection wells would be drilled to a depth of 250 ft and yield adequate groundwater supply.

Scenario 2:

• Mud-rotary drilling, 2 wells x 250 ft deep:	$ 40,000
• Well flow testing:	$ 2,000
• Horizontal transfer piping to/from building:	$ 5,000
• Stainless steel submersible well pump and controls:	$ 7,500

• Heat exchanger and associated plumbing:	$ 15,000
• Heat pumps including circulating pumps and associated plumbing and controls:	$160,000
• TOTAL (including 20% contingency)	$275,400

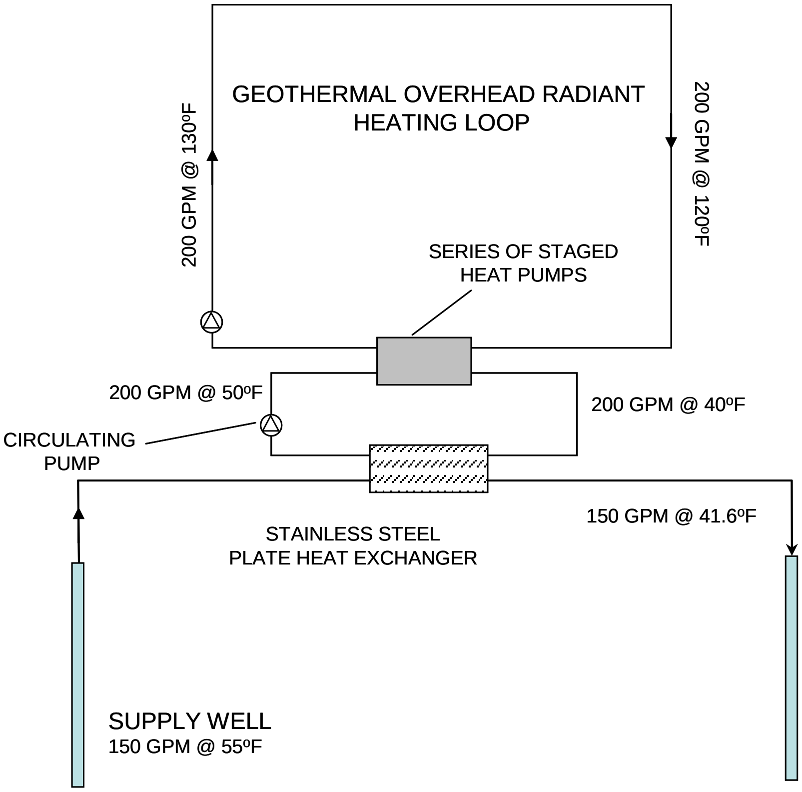

Figure 13. *Process schematic of heat pump configuration with source water from a supply well on the UTA property (Scenario 2).*

Under *Scenario 2*, the avoided annual cost of natural gas is the same as *Scenario 1(b)* at approximately $51,000, but at slightly higher annual electrical energy consumption due to increased pumping requirements and lower heat pump coefficient of performance due to lower source water temperature. Thus, the net annual energy savings under *Scenario 2* is about $28,500, resulting in a simple payback period of roughly 10 years.

<u>Economic Comparison of Alternatives</u>

This section summarizes the results of the economic analysis. In addition to simple payback period, alternatives are compared using a 30-year life-cycle cost analysis. Alternatives are compared using return on investment. Assumptions included in the life-cycle cost analysis were:

- 30-year project life,
- Project capital is borrowed at 6% interest rate with a 10-year debt term,

- Annual heat pump maintenance costs are estimated at 1% of capital cost,
- Annual heat exchanger maintenance cost is estimated at $1,000, and
- Submersible well pump replacement is conservatively assumed every 10 years

Results of the economic analysis are shown in Table 1.

Table 1. Economic Analysis Results

Scenario		Capital Cost (includes 20% contingency)	Net Annual Energy Savings	Simple Payback on Energy Savings (years)	Return on Investment (30-year project life)
1(a).	Construct pipeline from UTA facility to Wasatch Warm Springs - Direct-use heating using geothermal water	$192,000	$17,000	11.3	8.7%
1(b).	Construct pipeline from UTA facility to Wasatch Warm Springs - Use geothermal water as source water for geothermal heat pumps	$384,000	$31,000	12.4	6.3%
2.	Drill supply and injection well on UTA property - Use groundwater as source water for geothermal heat pumps	$275,400	$28,500	9.7	11.1%

A review of the results presented in Table 1 indicate that *Scenario 2*, drilling on the UTA property for groundwater for a geothermal heat pump application, is the most economically attractive. Scenario 2 has a simple payback on energy savings of just under 10 years with a return on investment of 11.1% for a 30-year project life.

It should be noted that although *Scenario 2* appears to be the most economically attractive, there are considerable uncertainties in the geologic conditions under the UTA property, both natural and as a result of the industrial history at the site. A test well would have to be drilled on the UTA site to verify the assumptions made here. One additional benefit of heat pump applications as proposed in *Scenario 2* is that they could also be used for radiant cooling in summer, provided pipe surfaces are kept above the dew-point temperature to prevent condensation.

In addition, there are uncertainties in the cost estimates of the pipeline construction in *Scenario 1*. Although a 20% contingency was included, no other allowances were made for encountering contaminated soils or other unknown underground structures.

CONCLUDING SUMMARY AND RECOMMENDATIONS

The Geo-Heat Center has conducted a feasibility study of utilizing geothermal energy for supplemental heating at the UTA Warm Springs Facility in Salt Lake City, UT. The thermal energy is proposed to be distributed through piping under service platforms, which will act as an overhead radiant heating panel for maintenance workers.

Two basic geothermal resource utilization scenarios were identified: (1) construct a pipeline to directly access geothermal water from Wasatch Warm Springs, or (2) drill a well on the UTA property. Within *Scenario 1*, two options were considered: *(a)* utilize geothermal water directly for heating purposes or *(b)* utilize geothermal water as source water for geothermal heat pumps. In *Scenario 2*, drilling a new well on the UTA property would likely result in encountering low temperature groundwater, so only geothermal heat pump applications were considered. To compare alternatives, two economic indicators were computed: simple payback period and return on investment.

Some specific conclusions of this study are as follows:

- There has been no recent (i.e. since the early 1980s) significant addition of data or information to refine or improve the hydrogeologic models of geothermal water occurrence at the Warm Springs area. Therefore, groundwater flow paths remain uncertain; predominant flowpaths could be vertically upward along the entire fault zone or horizontally from Becks Hot Springs.
- The uncertain nature of the geothermal water origin makes drilling for hot water at the UTA property a risky proposition. To drill down the fault zone would entail drilling to depths of approximately 5,500 ft, and there would be no guarantee that hotter water could be found. The drilling cost of such a venture would be on the order of $1.5 million.
- Constructing a pipeline from the UTA facility to Wasatch Warm Springs (*Scenario 1*) involves much lower risk than drilling for hot water on the UTA property, but geothermal water flow rate and temperature are somewhat limited (i.e. 60 gpm @ 100^{o}F).
- Under *Scenario 1(a)* (constructing a pipeline to Wasatch Warm Springs and using the geothermal water directly), it is estimated that UTA could avoid about $17,000 annually in natural gas costs, resulting in a simple payback of 11.3 years on energy savings alone. Given the uncertainty of soil conditions that might be encountered in such an undertaking, a 20% contingency has been included in the capital cost estimate.
- Under *Scenario 1(b)* (constructing a pipeline to Wasatch Warm Springs and using the geothermal water as a source for heat pumps), it is estimated that UTA could avoid much more in natural gas costs than in *Scenario 1a* but at the expense of electrical energy consumption for heat pumps. Thus, this scenario results in a net annual energy savings of about $31,000, giving a simple payback of 12.4 years.
- Under *Scenario 2* (drilling a well on the UTA property), there is uncertainty regarding the geologic conditions that would be encountered. For cost estimating purposes, based on well logs from surrounding properties, it was assumed that a well drilled to 250 ft could yield 150 gpm at 55^{o}F. Therefore geothermal heat pumps would be required. The cost estimate also included an injection well and a 20% contingency. Annual energy savings to UTA would be similar to *Scenario 1(b)*, but slightly less at $28,500, giving a simple payback on energy savings of 9.7 years.

- In considering a 30-year life-cycle, which includes annual maintenance and periodic replacement costs, the return on investment was greatest for *Scenario 2* at 11.1%, followed by *Scenario 1a* at 8.7%, and then *Scenario 1b* at 6.3%.
- The Geo-Heat Center recommends that additional field investigation be undertaken prior to serious consideration of either *Scenario 1* or *2*:
  - Regarding *Scenario 1*, actual spring temperatures and flow rates should be verified and ideally measured over the period of a cold month. In addition, a more detailed field inspection should be done to verify the proposed pipeline route. Property access and/or groundwater contamination plumes may preclude this option.
  - Regarding *Scenario 2*, a test hole needs to be drilled prior to making any firm design plans. If the geothermal gradient does not appear to increase significantly as drilling proceeds, the test hole should be converted into a supply well at the first occurrence of usable groundwater.

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