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# A LOW TEMPERATURE GEOTHERMAL SPACE HEATING DEMONSTRATION PROJECT

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ABSTRACT

A demonstration project for the State of Idaho utilizes 170°F geothermal water from well sources established in 1892. The project is a retrofitted gas-fired system serving three buildings. Two separate water loops are interfaced through a primary heat exchanger. The geothermal loop is capable of delivering up to 400 gpm at 166°F to the exchanger which transfers about eight million Btuh to the space heating loop. The spent geothermal water is cooled and aerated, then discharged to the Boise River. The second loop is a closed system including the existing boiler, pumps, and piping retrofitted to the new heat exchanger. In addition to demonstrating the technology to utilize low temperature sources for space heating, the project examines economic feasibility, environmental impacts, and materials effects.

## History

The State of Idaho is taking advantage of a natural energy source that may significantly reduce its use of fossil fuels and substantially cut costs of heating state office buildings.

Boise homeowners and business entrepreneurs pioneered geothermal space heating in 1892 at the time of emerging statehood. The historic heating district survives today as the Warm Springs Water District (WSWD) which operates two geothermal wells normally producing 600 gallons per minute (gpm) of 170°F water. It is this source which serves the modern space heating project.

The need for a State of Idaho demonstration project was realized in March 1974 by then-Governor Cecil Andrus. Following several feasibility studies, the governor carried a funding request to the Pacific Northwest Regional Commission which approved $355,000 for design, construction, and management of the experimental project.

The project demonstrates the feasibility of geothermal space heating for state agency buildings. In addition, it demonstrates technology for retrofitting existing systems for use with a geothermal source. Previously the laboratory-office complex was heated by a gas-fired boiler. These are now heated by geothermal energy. The laboratory-office building has a gross area of approximately 35,000 square feet and is heated by two multizone air handling units. The laboratory areas require 100 percent outside air, while the office can recycle up to 90 percent of the air supply. The smaller buildings in the complex use a system similar to the laboratory-office system.

## System Interface

The project contains two separate water loops, the geothermal loop and the space heating loop; these systems or loops are interfaced through a primary heat exchanger. No actual mixing of the geothermal water and the space heating water occurs. The Boise geothermal water is selectively corrosive to some copper alloys, brasses, and aluminum; and if used directly possibly could damage the air handling coils and the boiler, which remain in the system.

## Geothermal Loop

The 170°F geothermal water is delivered from the WSWD 10-inch cast-iron main by a 6-inch asbestos cement (AC) line which extends to the central boiler plant. Approximately 4°F are lost in transmission at 60 gpm from the main to the heating plant. A water meter records actual water usage for billing purposes. The state purchases the water from WSWD at $4 per 1,000 cubic feet for flows not to exceed 400 gpm. Normal water use averaged 9,000 cubic feet per day (47 gpm) for the winter of 1977-78.

The geothermal water enters the boiler plant at approximately 20 pounds per square inch (psi) pressure and is boosted to 80 psi by a centrifugal pump. A second in-pipe measuring device indicates and records the geothermal flow for analyzing energy use in the buildings.

From the flow measuring device, water enters the stainless steel plate heat exchanger at 166°F. Within the reverse flow exchanger, about eight million Btuh of geothermal energy are transferred to the space heating loop at maximum flow. Under design conditions the geothermal water leaves the exchanger at approximately 127°F. This water temperature will vary depending upon building heat load.

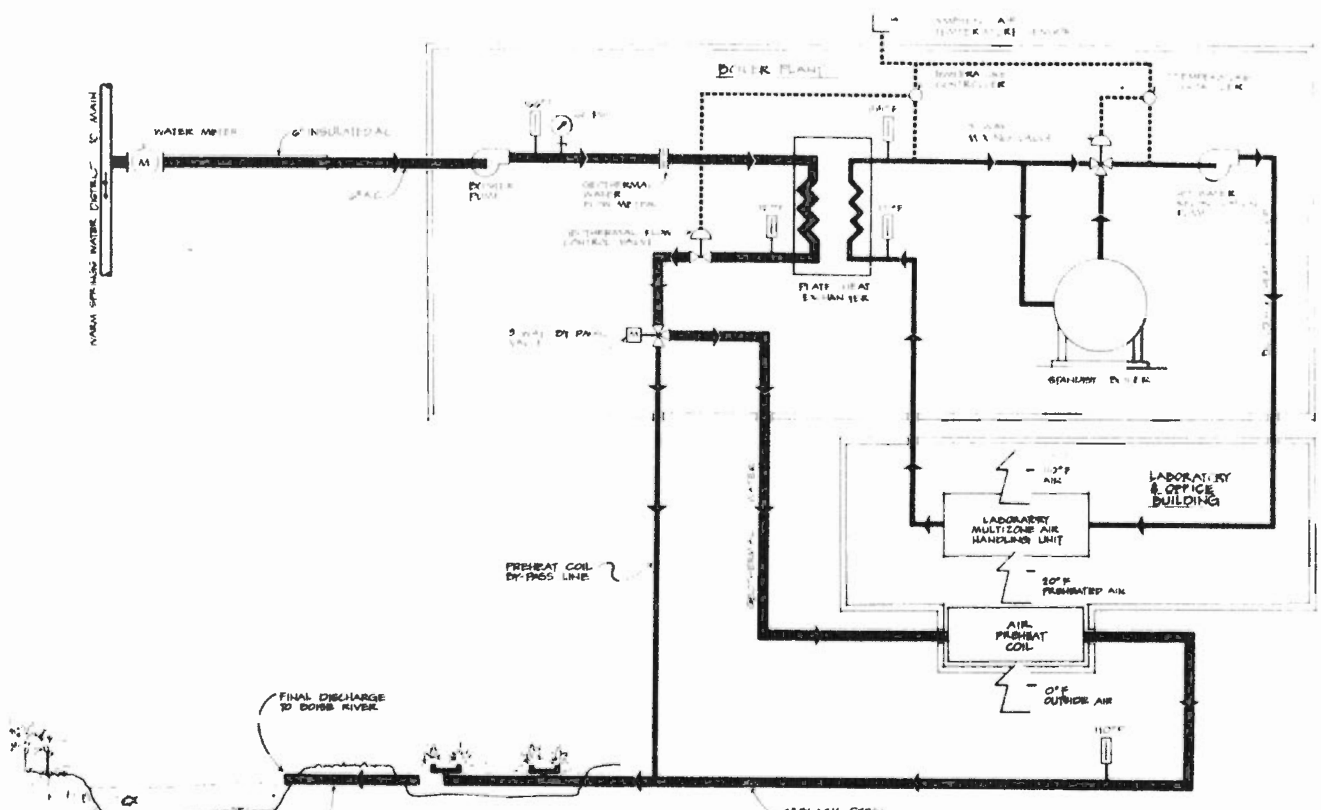
The geothermal water flow rate is regulated by a pneumatic control valve on the discharge side of the heat exchanger. The pneumatic valve is positioned in response to a temperature sensor, which monitors space heating water temperature leaving the exchanger. As more energy is required to raise the heating water temperature, the control valve opens, increasing the geothermal water flow through the system.

Under normal operations, the discharged geothermal water flows through a three-way diverting valve to an air preheat coil. The geothermal water entering the coil tempers the make-up air for the laboratory prior to entering the main multizone heating unit. From the preheat coil, the geothermal water flows to a spray pond for further cooling, and aeration before discharge.

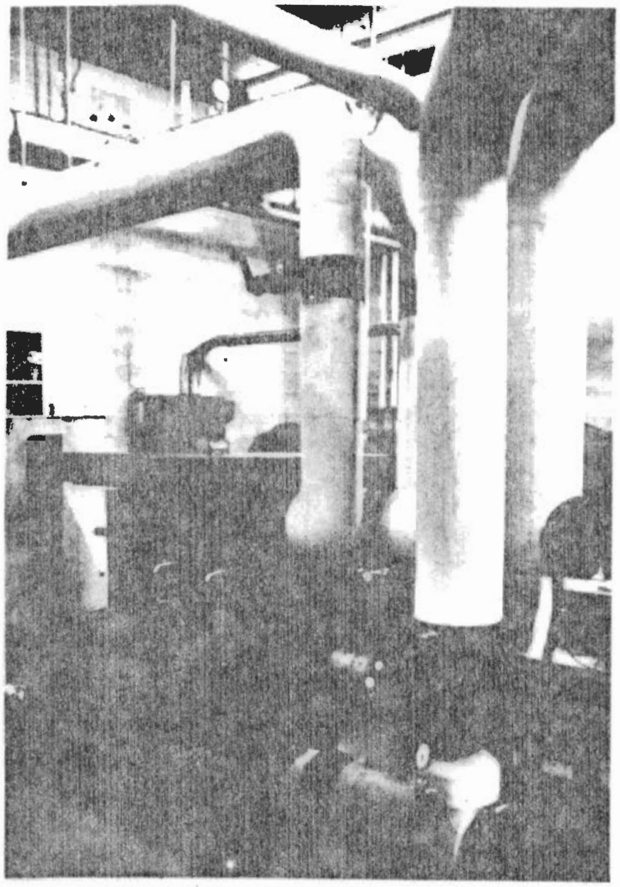
During the warmer months when the additional heating is not necessary, the three-way valve can divert the water directly to the spray pond, bypassing the air preheat coil. Operation of the valve may be either manual or automatic. In the automatic mode, the preheat coil water temperature controls flow through the valve. If the geothermal temperature approaches 40°F, the valve bypasses the preheat coil and a solenoid valve automatically drains the preheat coil to prevent freezing.

Spray Pond

The spray pond is 100 by 120 by four feet deep. Water enters nominally at 110°F and is reduced to 80°F through the spray unit. A fixed gravity overflow standpipe in the pond controls the water level. The spent geothermal water flows to the Boise River via a 2,800-foot long 10-inch AC gravity main. A 15-foot perforated discharge header on the river bed disperses the geothermal water in the main river channel.




*Heating System Schematic*



*The heat exchanger in place at the central boiler plant. Note the pneumatic geothermal control valve in the lower right corner.*

## Space Heating Loop

The space heating water loop is a closed system including the boiler, pumps, and piping with the new heat exchanger. The multizone air handling units are located in the laboratory-office building basement mechanical room. To take full advantage of the geothermal water, the original 180°F air handling unit water coils were replaced with larger coils designed to operate at 155°F. With this minor modification and the installation of the heat exchanger in series with the boiler the system was converted to total geothermal heat.

Under design conditions of 0°F ambient air the space heating water enters the plate heat exchanger at 100°F and the energy given up by the geothermal water raises the space heating water to 155°F. As the ambient air temperature increases, less energy is needed to maintain the building zones at their specified temperatures. With this condition, the return building water temperature rises causing a rise in the leaving geothermal water temperature; with less energy being extracted, the system efficiency drops. System efficiency is greatly improved by lowering the space heating outlet water temperature as the ambient temperature rises. This is accomplished by varying the outlet water temperature setpoint as a function of the ambient air temperature. As the ambient air temperature approaches 30°F the outlet water setpoint is lowered to 130°F by a linear temperature compensator. The setpoint temperature is maintained by regulating the incoming amount of geothermal water with the pneumatic valve.

From the exchanger, the space heating water flows through a three-way mixing valve which is positioned in response to the mixed water temperature. When this temperature drops below the preset temperature, the valve diverts a portion of the water through the standby natural gas-fired boiler system which will boost the temperature as required to maintain the setpoint temperature. Under normal operating conditions, this diversion will not be necessary. It is available in the event of a loss of geothermal water or under extreme conditions of extended cold weather. From this three-way valve, the space heating water continues through parallel circulating pumps rated at 230 gpm to the multizone air handling units.

Laboratory activities require that the building environment be maintained at a constant 72°F temperature, and that the air not be recirculated. The system operates on once-through, 100 percent outside air; creating an abnormally high heat load for a building of this size. Operations data indicate the summer months have a significant load due to low night-time temperatures which range downward to 55°F.

## Testing and Instrumentation

One of the purposes of the demonstration project is to evaluate and test various types of materials and systems for use in future geothermal heating projects. Two types of asbestos pipe were used, transite and temptite; in addition, black steel, coated steel, cast-iron, and in limited areas, some copper piping were used.

The system has been instrumented with flow recorders and temperature monitors to track precisely overall system performance. These data are recorded on magnetic tape and sent to the University of Idaho Department of Chemical Engineering for reduction and analysis. Based upon the results of these data, modifications to the system operations are made to improve efficiencies of both the geothermal system and the overall building heating system.

Water Quality

The Boise geothermal water is of high quality. Total dissolved solids range from 250 to 270 milligrams per liter (mg/l). Fluoride appears to be the main element found in the water which exceeds the national standards set forth in the Safe Drinking Water Act. From the WSWD predecessor's first use through the present time, however, the geothermal water has been used for domestic purposes providing drinking water, showers, baths, and hot water for domestic chores. The water also contains trace amounts of $H_2S$ giving the water a slight odor under some circumstances.

During this demonstration project, the Boise State University Biology Department has been involved monitoring environmental impacts posed by the discharge of the geothermal water. This work includes evaluating the effect spent geothermal water may have on the spray pond area and the stretch of the Boise River receiving the final discharge. Initial indications are that no adverse effects will result from the discharge. The formal environmental study will continue for approximately one year.

Economic Analysis

The total new construction for the entire project was less than $109,000. This included a spray pond, piping, and the heat exchanger. Based on the computer program model of the system and actual calculations, an initial fuel cost savings of $10,000 is anticipated annually. Actual geothermal water costs for winter months of 1978 averaged $35 per day. This represents a 50 percent reduction for fuel costs during the first year of operation. As natural gas rates continue to rise, greater fuel cost savings are anticipated.

Future Utilization

One of the objectives of this research project was to gain knowledge useful in future designs using geothermal water. The objective is being fulfilled. A 30,000-square foot office building utilizing a geothermal space heating system is being constructed by the State of Idaho adjacent to the demonstration project. While the demonstration project was a retrofit, the new building is designed entirely around geothermal energy.

The project was also implemented to utilize a natural resource and reduce the use of fossil fuels. The economics of low temperature geothermal utilization for space heating are promising. The necessary technology is available as demonstrated in projects like the State of Idaho laboratory-office building.

*The cooling-spray pond with the State of Idaho Health-Agriculture building in the background.*