

City of Boise Geothermal District Heating System

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ABSTRACT

The City of Boise (City) operates one of the four geothermal district heating systems in the downtown Boise area. The City's system, which has been in operation since the early 1980s, withdraws 175° Fahrenheit (F) water from its wellfield located along the toe of the Boise Foothills, and currently delivers it to about 50 customers throughout the downtown area on the north side of the Boise River. The increase in net withdrawals from the Boise geothermal aquifer in the 1980s resulted in declining water levels. In 1987, the Idaho Department of Water Resources (IDWR) established the Boise Front Low Temperature Geothermal Resource Ground Water Management Area. Additional restrictions were put in place in 1988 when a moratorium on further development was issued by IDWR.

In the late 1990s, the City sought to increase withdrawals above its moratorium-based ceiling of 200 million gallons a year because of a growing customer base. In 1999, the City completed a 3,213-foot injection well. Water levels in nearby wells began to recover shortly after the injection well went on-line and continued to rise for the next several years. Currently, about 75% of the City's withdrawals are returned to the aquifer; the remainder is discharged into the Boise River. In 2002, an agreement between the City and the other local geothermal users was reached that allowed the City to raise its production ceiling to 230 million gallons per year, with the conditions that the City would conduct an aquifer study, and would not ask for an additional increase until January 2005.

The City will soon be bringing two new large commercial buildings on-line in the downtown area. As the City continues to expand its system, including a proposed extension across the

Boise River to provide service to Boise State University, there will undoubtedly be a request in the near future to raise the production ceiling. Although geological studies and computer modeling have provided a basic understanding of the Boise Front geothermal system, the following question will surface again: Can additional withdrawals from the Boise Front geothermal system be incurred with minimal effects on water levels and water temperatures?

Purpose and Objectives

The purpose of this paper is to describe the development of the City of Boise's Geothermal District Heating System. The four specific objectives of this paper will:

1. Describe the development of the four geothermal district heating systems in the Boise area, and the problems that occurred because of these developments.
2. Explain how the City overcame regulatory restrictions imposed by the Idaho Department of Water Resources (IDWR), and protests from other geothermal users in order to get a request to increase its production ceiling granted.
3. Describe how a potential customer determines whether or not to connect to the City's geothermal system.
4. Describe the plans that the City has for additional expansions to its district heating system, including a goal to provide service to the Boise State University campus.

Boise has Been in Hot Water for a Long Time

In 1890 and 1891, the Boise Water Works Company completed two geothermal wells on the east side of Boise. Within a couple years, the nation's first district heating system was birthed in a geological and geographical region known as the Boise Front. Geothermal water was put to use along Warm Springs Avenue to heat over 200 buildings, including homes, businesses, and the Boise Natatorium, which was a 65 by 125 foot enclosed swimming pool. Owners of the heating district

over the next 110+ years have included the Artesian Hot and Cold Water Company, Natatorium Company, Boise Water Corporation, and the Boise Warm Springs Water District (Worbois, 1982). Although this system has provided geothermal water for many homes and businesses over the years, an associated cost to the reservoir system became apparent in the early 20th century when Kelly Hot Springs, located about two and half miles to southeast of the production wells, ceased to flow.

With the exception of development in an area known as Stewart Gulch, which is about five miles northwest of the Boise Warm Springs Water District, no additional expansion of the Boise Front geothermal system occurred until the energy crisis of the 1970s. In 1975 and 1976, two test wells were drilled along the Boise Front, northeast of downtown Boise, in an area known as Military Reserve Park; the wells were successful, hitting 165° - 170° F water.

The discovery of these resources and the frightening energy crisis prompted researchers to refine the geological model for the area. In brief, Boise is on the northern edge of a large basin-filled structure known as the Western Snake River Plain. The geomorphology of the plain is generally flat with some topographic features related to alluvial erosion and local volcanism. The northeast edge of the plain, where Boise is located, is bordered by the Boise Foothills, which become the Boise Mountains further to the north and northeast. The stratigraphy directly underneath Boise is a complex mixture of rhyolite and basalt flows, and interbedded sedimentary rocks that dip gently to the southwest. Like the topography, the geological setting changes abruptly to the northeast because of a series of normal faults located in the Boise Foothills. These faults strike to the northwest/southeast, dip to the southwest, and have displacements up to 800 feet (Wood and Burnham, 1983). The Boise Foothills fault zone contains a mixture of igneous and sedimentary rock units. Further to the northeast, the granites of the Idaho Batholith become the predominant geologic unit. A downdip extension of the Boise Foothills fault zone occurs at least 5,500 feet to the southwest of the edge of the Boise Foothills and almost directly underneath the Boise River, as indicated by geophysical data and well drilling results.

At the same time as the drilling of the exploration wells in Military Reserve Park, the State of Idaho decided to take a serious look at energy options for the Capitol Mall complex, which was beginning to expand. Cecil Andrus, the governor at the time, requested a federal study to determine the feasibility of using geothermal heat for the state's buildings in Boise. In 1977, the State Health Laboratory on the east side of town was retrofitted for geothermal heat as a pilot project and supplied with geothermal water from the Boise Warm Springs Water District. The project was considered a success. As a result, in the early 1980s, the State of Idaho drilled production and injection wells in the vicinity of the Capitol building. By 1982, the State of Idaho's geothermal district heating system was supplying hot water to nine buildings in the Capitol Mall complex, including the State Capitol (Neely, 1995), which is the only state capitol building in the U.S. that utilizes low temperature geothermal for

heating. Currently, the system is used to heat about 1.5 million square feet.

In 1981, the City of Boise and a company known as Boise Geothermal Limited (BGL) entered into a joint venture to supply geothermal water to the downtown area. BGL drilled four wells, ranging from 880 feet to 2008 feet, northeast of downtown Boise and along the edge of the Boise Foothills (Figure 1). Three of these wells are available for production and one is used for monitoring. The City constructed the distribution system. By 1983, BGL and the City were supplying geothermal heat to customers in downtown Boise. In 1988, the City purchased BGL's interests in the wells. The current City system supplies geothermal water to about 50 commercial and public buildings, and heats approximately 3.3 million square feet. Examples of some of the City's customers are the Boise High School, the Ada County Courthouse, the Idaho Water Center, the Public Library, and the YMCA.

The Veterans Administration drilled three wells in the 1980s and now heats a large portion of its campus with geothermal. Together, the four district heating systems in the Boise area currently provide geothermal heat to about 350 commercial, public, and residential buildings (Figure 2). The total annual gross withdrawal is about 775 million gallons, but because of injection, the net withdrawal from the aquifer is less than 300 million gallons (Neely, 2006).

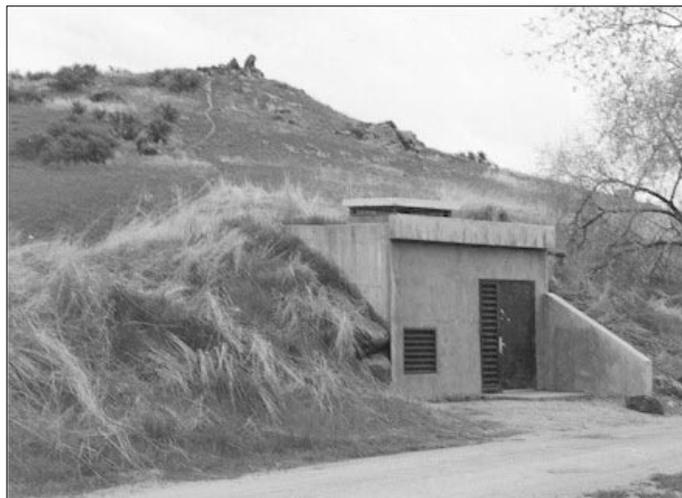


Figure 1. A wellhouse for one of the City of Boise's four geothermal production wells.

The City of Boise Takes on Management Area Restrictions and a Moratorium

The addition of three new district heating systems in the Boise area brought about changes to the aquifer equilibrium. Two of these systems (State and VA) had injection wells from the onset. However, the City system did not, and the result was declining water levels in some of the local production and monitoring wells in the mid 1980s (Figure 3). Because of these declines, the IDWR established the Boise Front Low Temperature Geothermal Resource Ground Water Management Area in north-central Ada County in 1987 (Figure 4).

In 1988, the IDWR issued a moratorium to further limit geothermal developments. The difference between the two types of orders is that a ground water management area allows for new appropriations if there is adequate supply and prior water rights will not be injured; a moratorium contains specific restrictions, such as in the case of the Boise Front Moratorium, where further development or additional use related to undeveloped or partially development permits is prohibited unless it is shown that three measurable conditions would not be impacted (pumping levels, water levels, and water supply temperatures).

During the late 1980s and early 1990s, several aquifer studies were completed in an effort to better understand the Boise geothermal resource (Waag and Wood, 1987; Berkeley Group, 1990; Montgomery, 1992). Throughout the 1990s, the City of Boise continued to acquire new customers. Montgomery Watson (1994) completed a modeling study for the Boise geothermal system to evaluate future potential stresses to the aquifer and to predict the effectiveness of, and the optimal location for, an injection well. The study predicted that injection would be “an effective means of maintaining water levels in the aquifer” and that “some temperature declines will occur under current pumping levels and for all injection scenarios.”

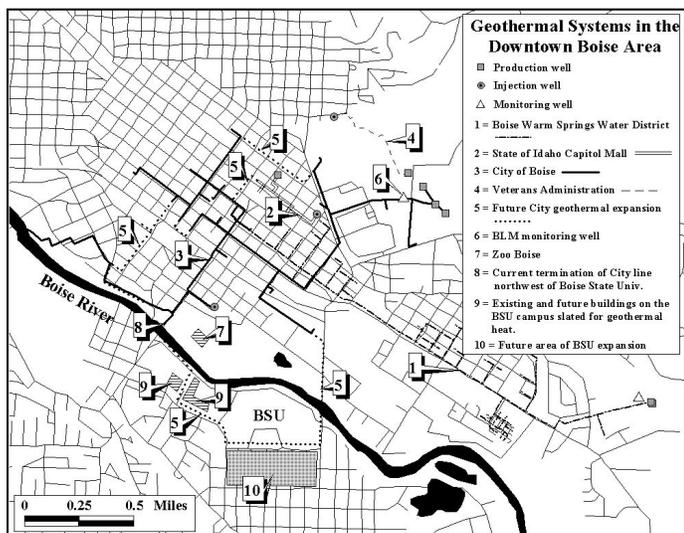


Figure 2. Map of the four geothermal district heating systems within the City of Boise (source is the City of Boise Public Works Department).

As a result of the modeling study, the City completed a 3,213-foot injection well in 1999. The well is located in the extension fault zone about 5,500 feet southwest of the Boise Foothills fault zone. Interestingly, the well produced 160°F water under artesian flowing conditions.

Since 1999, water levels in the BLM monitoring well have risen significantly and in a manner similar to the modeling predictions (Figure 3). In 2001, the City requested an increase in production from 200 million gallons per year, which was the ceiling imposed by the moratorium, to 310 million gallons per year by October, 2003. The application was protested by several of the other Boise geothermal users. The application was brought to a hearing at IDWR, but was suspended when

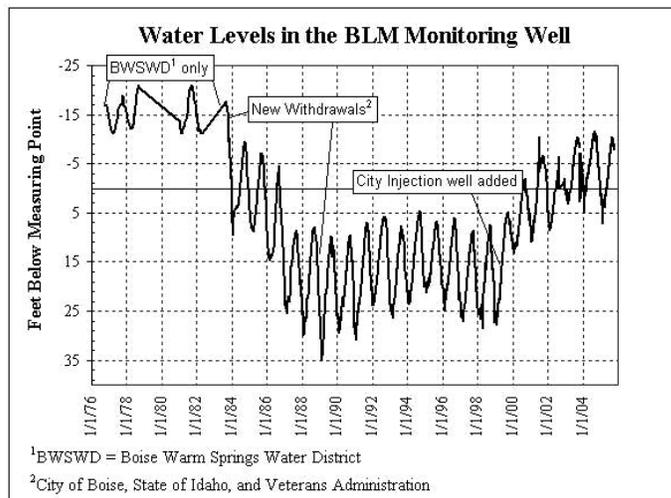


Figure 3. Hydrograph for the BLM monitoring well in the downtown Boise area.

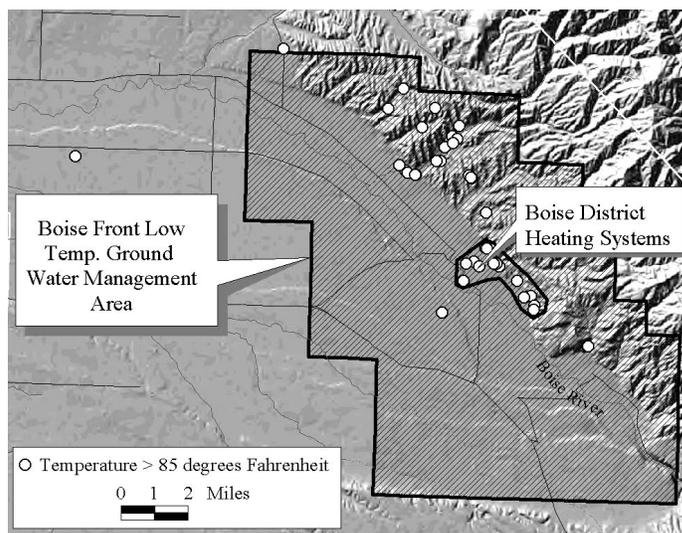


Figure 4. Map showing the Boise Front Low Temperature Geothermal Resource Ground Water Management Area.

the parties reached a tentative interim agreement. The interim agreement allowed the City to increase its production up to 230 million gallons per year (a 15% increase), with the following stipulations:

1. The City would complete a technical modeling study.
2. The City would not make a request for additional increases in withdrawals until January 2005.
3. An improved monitoring plan would be put into place for most of the downtown and Stewart Gulch geothermal users.
4. The IDWR would manage the monitoring data and produce semi-annual reports. The requirement was later modified to an annual report.

At present, all four stipulations have been met: Petrich (2003) completed a technical analyses of the Boise Front

geothermal system for the City; the City has not asked for an increase; a comprehensive monitoring plan was developed and has been followed faithfully for the last couple years; and IDWR has complete five summary reports since 2003. So far, temperature declines have only been observed in the State production well, despite the prediction of the original model results that also anticipated declines in the VA and City production wells (Montgomery Watson, 1994).

It should also be mentioned that the City has developed a unique rate structure for its customers which promotes conservation of the resource. Unlike many other heating districts in the world that use a BTU (energy) approach for billing customers, the City's billing is based on gallons used (flow). The cost of the water is such that if the customer removes 50 degrees F from the water, the customer's energy cost will be 30% less than if they used a natural gas-fired system. If customers' systems are not that efficient, they use more water and their savings are reduced. Of course, if they can extract more than 50 degrees F, they will save more than 30%. Another aspect of this pricing system is that it is dynamic. As the price of natural gas goes up or down, the price of the geothermal water delivered to the customer tracks it in order to maintain the 30% savings in energy costs. As natural gas prices climb like they have in the recent few years, geothermal deliveries to existing customers become more profitable for the City.

How a Potential Customer Evaluates the Geothermal Option

There are a number of factors that a potential customer considers when determining whether or not to connect to the City of Boise's geothermal district heating system. The following list contains some of the items that might be evaluated:

1. Where is the location of the building in relation to the existing distribution system? The cost of extending the two-line system (supply and return), which is about \$50,000 per city block, can be prohibitive. For example, the owners of a large building are currently considering connecting to the City system, but an extension of the lines will cost \$85,000. Since the building will be using a heat pump system, they will be able to take about 80 degrees F of heat from the water. This efficiency means that the building will require less geothermal water, which makes it even harder for the City to justify the cost of the extension. The owner and the City are negotiating in order to find a "middle ground" for the payment of the extension.
2. How easily can an existing building be made compatible for geothermal heating? How much will the cost be? Is the owner willing to pay for these costs?
3. Does the type of building cause challenges for billing occupants? In a condominium complex, geothermal heat will not be very feasible because occupants (and building managers) typically will want units to be metered individually. This will be expensive and complicated from an engineering perspective. In a large office building, geothermal heat can be run through a central air handler (or a heat pump system), and heating costs are included in the rental or lease

rates, thus eliminating the need for individual metering.

4. Do the owners think that the system will be reliable? Do they want or need a backup system? If the answer to the second question is "yes", how much will this add to the cost? The majority of the City's 50 customers have backups; some have them because the buildings were retrofitted and the previous systems were simply left in place. The recent trend is that most new buildings are not installing a backup. Some buildings, such as an office center like the new Idaho Water Center, don't require a backup because in the case of a heating/cooling system problem, the office could simply shut down until it is fixed. But others, like the Elks Rehabilitation Hospital, must have a backup in order to stay in operation if the geothermal supply is temporarily unavailable.

New Developments are on the Horizon for the City of Boise's Geothermal System

Downtown Boise north of the Boise River continues to be the City's target area for new customers. Two large buildings currently under construction in this area will be added to the City's geothermal system. The City would like to bring on more new customers in the downtown area; however, they face two challenges. First, the City will soon reach its ceiling of 230 million of gallons of annual withdrawal. Second, new customers are often not interested in geothermal heat despite the 30% discount compared to natural gas because geothermal is sometimes labeled as "too different" than conventional heating methods. Even though the City has a proven track record of delivering geothermal for space heating, some developers would rather stick with fossil fuel heating because it is the norm. Another challenge that the City and new customers must overcome is the cost of extending the supply and return lines, which runs about \$50,000 per city block.

In addition to the customers north of the Boise River, the City and Boise State University (BSU) have been discussing plans for heating several new and existing buildings on the college campus (Figure 2). If successful, this effort could serve as a ground-breaker for future geothermal expansions at BSU. The university campus, which is on the south side of the Boise River, has an enrollment of about 18,600 students and is home to at least 80 buildings. Currently, the City has supply and return lines that terminate on the north side of the river, and on the east side of the Capitol Boulevard bridge (Figure 2). The City's system was originally designed for a future extension to BSU; hence the geothermal water lines currently terminating at the Boise River are of adequate size for handling the campus requirements. BSU has additional plans to expand to the south of its existing campus, which will create new heating needs and will result in more opportunities for the City to provide geothermal water (Figure 2).

Zoo Boise, another possible customer close to the existing pipeline, has shown an interest in heating two proposed buildings. About 1,000 feet of new water lines would have to be installed to service these future buildings. A recently-completed study by the Geo-Heat Center indicated that the payback time would be less than 10 years for installations in

the two new buildings (GeoHeat Center, 2005). The study also showed that the payback time for providing geothermal to existing buildings requiring retrofitting is over 15 years; that analysis does not include the cost of landscape restoration. Some additional possible applications that could be serviced by the City's system are a geothermal-themed street plaza and a Boise River soaking pool (GeoEngineers 2004).

In conclusion, the City of Boise has undertaken a variety of creative and expensive efforts in order to mitigate for past effects on the water levels, to understand the aquifer system better, to avoid future deleterious impacts, and to promote efficient use of the resources. These measures allow the Boise Front geothermal resources to be utilized to the maximum and to accommodate new customers.

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