



Report

**Downtown Boise Geothermal Feasibility Study
Boise, Idaho**

May 14, 2004

**For
Capital City Development Corporation**

May 14, 2004

Capital City Development Corporation
805 West Idaho Street, Suite 403
Boise, Idaho 83702

Attention: Ms. Betsy Lloyd

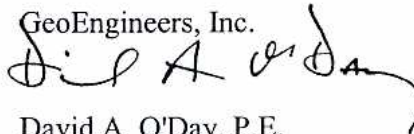
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Capital City Development Corporation
GEI File No. 10788-001-00

This letter transmits our final report entitled "Downtown Boise Geothermal Feasibility Study", performed in general accordance with our proposal to the Capital City Development Corporation (CCDC) of July 9, 2003, which was authorized by Dennis Clark on July 17, 2003.

As envisioned during the formulation of our approach to this project, the background information presented in Sections I through III is largely the work of GeoEngineers. The contributions by Kent Johnson of the City of Boise; Christian Petrich, then of the Idaho Water Resources Research Institute; and Dave Musgrove of Musgrove Engineering PA are gratefully acknowledged. A draft issued on October 29, 2003 was reviewed by these contributors as well as CCDC staff. Section IV, "CCDC's Role in Geothermal Resource Utilization to Foster Downtown Redevelopment" has been a collaborative effort with CCDC staff. Section IV is intended to present some "strawman" ideas and potential concepts for use by CCDC staff and others to increase the awareness and utilization of the valuable geothermal resource available to the City of Boise and its citizens.

GeoEngineers sincerely appreciates this opportunity to be of service to CCDC and to participate in a very interesting project. If there is anything else that we can do for CCDC, please contact me.

Respectfully submitted,

GeoEngineers, Inc.

David A. O'Day, P.E.

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**REPORT
DOWNTOWN BOISE GEOTHERMAL FEASIBILITY STUDY
BOISE, IDAHO
FOR
CAPITAL CITY DEVELOPMENT CORPORATION**

EXECUTIVE SUMMARY

A study has been performed to develop a “layman’s” understanding of the origin, location, features and capacity of the natural, low-temperature geothermal system in the vicinity of downtown Boise, Idaho and, in particular, of the Boise City geothermal production, distribution and disposal system. The present utilization of this renewable natural resource is examined and its potential and constraints for expansion are presented and discussed. Lastly, recommendations are made for improvements to the system and for activities that can be undertaken by the Capital City Development Corporation and others to use the geothermal resource to foster the redevelopment of downtown Boise.

INTRODUCTION

This report presents the findings and recommendations of the Downtown Boise Geothermal Feasibility Study prepared for the Capital City Development Corporation (CCDC) by GeoEngineers, Inc. (GEI). The objective of this study is to describe in relatively nontechnical terms the City of Boise’s geothermal system, its relationship to the geologic setting of the City, how this resource is used, how much remaining capacity exists, and some ideas as to how its use might be expanded to foster the redevelopment of downtown Boise.

SECTION I - DESCRIPTION OF THE EXISTING SYSTEM

A. THE GEOTHERMAL RESOURCE

Geology

The Treasure Valley is a component part of the Western Snake River Plain, the latter extending approximately from Twin Falls, Idaho to Vale, Oregon. This plain appears as a northwest-southeast running depression formed by the movement of continental masses on either side of the plain (Petrich, 2003; Maley, 1987). The driving force of this movement is the “seafloor spreading” along the mid-Atlantic Rift, a discontinuity in the earth’s mantle that discharges molten rock, or magma, and forces the North American plate westward away from the European plate. This movement has caused the North American plate to override the Pacific Ocean plate. An ancient plate boundary was located in the approximate location of today’s Wasatch Front. As the North American Plate overrode the Pacific Ocean Plate, portions of the latter became attached, or “accreted”, to the North American Plate. The two masses that represent southern and central Idaho have moved apart as they have moved past each other, and the terrain between them has dropped, creating a basin, or graben. Some geologists attribute this depression to the cooling contraction of a magma chamber beneath the Snake River Plain. This basin was subsequently filled with sediments eroded from the mountains to the north and south and with relatively recent basalt flows, some of which are very prominent in the Treasure Valley landscape. The details are extremely complex and remain the subject of debate in the geological community. What is important for the present

discussion is that there are mountains to the north and to the south, and that the intervening basin has been filled with sediments that slope toward the center of the basin from both sides. The mountains to the south are volcanic, i.e., rhyolite and basalt, while the mountains to the north are predominantly granitic. The basin, i.e., the Treasure Valley, is the site of many geologic faults that run generally parallel with the basin, i.e., northwest-southeast. Perhaps the best-known of these faults is the Foothills Fault that generally runs parallel to and at the toe of the Boise Foothills, though this is only one of a family of faults that are roughly parallel to each other.

Origin Of Geothermal Water

To the north of the Treasure Valley, the granitic formation mentioned above is called the Idaho Batholith, and it forms a significant portion of central Idaho. Though the origin and behavior of the geothermal waters in the Boise area are not well understood, it is generally believed that precipitation falling on the Idaho Batholith enters fracture zones and seeps deep below the ground surface. There, this water is heated by the decay of radioactive minerals (Petrich, 2003). This water flows to the south through the rock fractures until it encounters the faults of the Treasure Valley. The relatively high temperature water is less dense than the cooler waters in the sediments of the Treasure Valley, so it tends to rise toward the surface along the faults and manifest itself as hot springs at the ground surface. Today, wells drilled into the fault system intercept this water before it reaches the ground surface. It is worth noting that this mechanism cannot fully explain all the geothermal waters in the Treasure Valley.

These geothermal waters are encountered in three principal areas in the vicinity of Boise: Stewart Gulch (generally, the extension of 36th Street northeastward to Cartwright Road), downtown Boise (extending eastward to the old penitentiary area), and the old Barber area, today better known as the site of the Harris Ranch development.

Geothermal Water Systems

Four different systems of wells, pumps and distribution piping have been constructed to utilize the geothermal resources of the downtown Boise area (Petrich, 2003, p. 17):

1. By far the oldest system is the Boise Warm Springs Water District (BWSWD). First developed in 1891, this is the nation's oldest geothermal heating district (GeoHeat Center) and the best known of the geothermal systems in Boise. This system consists of three wells in the vicinity of the old Penitentiary; two are used as production wells and the third is used to monitor water levels. The two production wells are approximately 400 feet deep (Johnson, 2004). The BWSWD system serves the homes on either side of Warm Springs Avenue, hence the street name. The warm water is distributed to the users and, after use, is discharged either to shallow injection wells at the location of use, a system of collection ditches that drains to the Boise River, or to the City's sanitary sewer. Some of the water is used as domestic hot water and is discharged to the sanitary sewer, but some of the water used for space heating is also discharged to the sewer system. The BWSWD system has no reinjection system to return the used water to the aquifer. This system had virtually exclusive use of the Boise geothermal

- resource until the early 1980s, though there were individual users who took advantage of the geothermal resource during this intervening period.
2. The next system to be developed was the State of Idaho's "Capitol Mall" system that, as its name would suggest, is used to heat state buildings throughout the downtown area. This system began operation in 1982 and consists of two wells, one used as a production well and another as an injection well. These wells are 2152 feet and 3030 feet deep, respectively.
 3. The City of Boise's (City) system that is the focus of the present study came on line in 1983. This system consists of four wells, three are used as production wells and the fourth is used as a monitoring well. The City's demand is met during most of the year by one of these wells. The other two can be used during high-demand periods or in the event of a mechanical failure. These wells range in depth from 880 feet to 2008 feet (IDWR website). This system was originally developed by a private firm, Boise Geothermal Limited, and purchased by the City of Boise in 1988 (Geo-Heat Center, 2003). Most of the water produced from this system has been reinjected since 1999 through a 3213-foot deep injection well located in Julia Davis Park. Approximately ten percent of the total system flow is discharged to the Boise River at the present time for operational reasons that will be explained later in this report. This discharge is located near the intersection of 14th Street and Shoreline Drive (Johnson, 2003).
 4. The last geothermal system is the Veterans Administration (VA) system, which commenced operation in 1988. This system consists of one production well and one injection well, with depths of 1666 feet and 2300 feet, respectively. The water is used to heat some of the VA buildings in the Fort Boise vicinity, then returned to the aquifer via the injection well.

Well Interaction

A major issue today regarding the geothermal resource in the Boise area is the interaction of these four and other well systems. In other words, to what extent does pumping one system's wells affect the water levels or production capacity in the other systems' wells? Because of the uncertainty in these interrelationships, the four systems' ability to produce geothermal water from its wells has been capped by a five-year development moratorium first imposed in 1988, following the designation of the Boise Front Low Temperature Geothermal Resource Ground Water Management Area on June 15, 1987. This moratorium was renewed in 1993, 1998, and 2003 (IDWR, 2003). A study was recently completed by the Idaho Water Resources Research Institute (IWRRI, part of the University of Idaho) and the Los Alamos National Laboratory (LANL) (Zyvoloski, Keating and Petrich, 2003) to analyze the existing data and evaluate the potential impact of increases in the allowed annual pumping rate for the City system. On November 25, 2003, the Director of the Idaho Department of Water Resources (IDWR) renewed the moratorium for an additional five years (Dreher, 2003). This is a highly contentious issue that may not be resolved in the near future. At this writing, the City's pumping limit is 230 million gallons per year (MG/yr) (Johnson, 2003). Therefore, for purposes of this study, the production of the City system is considered to be capped at 230 million gallons per year, though the IDWR Director and courts of competent jurisdiction have the ability to modify the terms of the moratorium by stipulated agreements among the parties.

Geothermal Water Temperatures

The other component important to this study is water temperature. Water temperatures in the Boise area range from 80°F to 176°F (IDWR, 2003; Johnson, 2003). Though there are many other warm water wells with lower temperatures, they are not generally considered valuable as geothermal resources and, therefore, are generally excluded from geothermal studies. The water temperature at the City's well that is available approximately 95 percent of the time is 176° F. To put these temperatures into perspective, one classification system (Lund, 1998, p. 35) uses the following classifications:

1. Low Temperature Resources: less than about 190°F
2. Moderate Temperature Resources: about 190°F to 300°F
3. High Temperature Resources: greater than 300°F

According to the IDWR (IDWR, 2003), the Idaho Geothermal Resources Act defines “low temperature geothermal” as 86°F to 212°F and “geothermal” as greater than 212°F. From these classifications, it can be seen that the Boise geothermal resource is not a high temperature geothermal resource. Therefore, the uses to which its waters can be applied are limited (Lienau, Lund, Rafferty and Culver, 1994, p.8). For example, temperatures in excess of 300°F are generally considered the minimum for the generation of electricity (Lund, 1998, p. 40). Nevertheless, the Oregon Institute of Technology Geo-Heat Center's 2003 information indicates that the four Boise heating districts produce the equivalent of about 50 gigawatt-hours (GWh) of energy per year, about 20 GWh of which was produced by the City system. The 20 GWh of energy produced by the City system, at a typical Idaho electric power cost of about \$0.05 per kilowatt-hour, is equivalent to approximately one million dollars worth of electricity per year, or about 2.5 million dollars for the four systems combined. The 20 GWh is also equivalent to approximately 34,000 barrels of fuel oil (Reese and Renner, 1995).

B. EXISTING DISTRIBUTION SYSTEM

The City's existing distribution system consists of the three production wells, the distribution piping throughout downtown Boise, the injection well at Julia Davis Park, and the outfall to the Boise River near the intersection of Shoreline Drive and 14th Street. The distribution system consists of two subsystems: a “supply” piping network that distributes hot (160 to 170°F) water, and a “collection” network that collects and redistributes the water that has already been used by the consumers connected to the supply network. The supply piping is insulated, while the collection piping is not. The pipe sizes vary from 14 inches in diameter for the supply lines closest to the wells to two-inch diameter pipes or smaller for the service connections to some of the customers.

The City system classifies its customers into one of three classes:

1. “X” Customers, who receive water from the supply (“hot”) line and return it to the collection (“cool”) line.
2. “Y” Customers, who receive water from the collection line and return it to the collection line.
3. “Z” Customers, who receive water from an uninsulated collection line and return it to the same collection line, but presently receive supply water. These are the buildings along River Street, and are served by the line that originally discharged all the flow to the Boise

River prior to the construction of the injection well in Julia Davis Park in 1999. This is a special condition for which hot water is delivered through a collection line to deliver adequate heat to the five buildings located along this pipeline. However, these buildings' heating systems are understood to have been designed to use collection system water.

The supply line customers receive water at about 160°F and are assumed to remove about 50°F. Therefore, a downstream user, receiving this water from the collection line would expect water temperatures on the order of 100 to 120°F, from which they are assumed to remove about 20°F.

The original intent of this study was to evaluate the capacity of the system on a node (i.e., a point in the system) temperature basis, then estimate how much heat is available at any particular location in the distribution system. From such estimates, it was hoped to be able to identify existing capacity at a number of desirable locations consistent with the goals and objectives of CCDC. In fact, City staff do measure and record pipe or valve temperatures when they read the meters each month. However, the instantaneous temperature at a node is related to recentness, rate, and duration of flow at the node, which are not known at the time of the temperature observation. The unused hydraulic capacity at the node at the time of the observation is also unknown, so the remaining heat that could be delivered at a node cannot presently be determined with the available data. It is possible to estimate the total amount of energy available in the system simply by multiplying the annual water production limit by the temperature difference between the production well and the injection well. However, this says nothing about the availability of energy at a particular location. Part of this is an artifact of the billing system. Customers are charged on the basis of their volumetric consumption only, rather than consumption *and* the temperature drop through their system, so only monthly flowmeter data is available. This will be discussed further later in this report.

C. PRESENT SYSTEM UTILIZATION

At the present time, the City's geothermal system has about 50 open accounts, though at least one does not actively utilize water from the system. In addition, discussions have been held with a number of additional prospective customers. How many of these potential customers will eventually become users of the system is difficult to determine. The new USGS/BOR Building is finished and occupied, but is listed herein as a prospective customer because operational data is not yet available for this building. Some, like the Veltex Building and the Water Center are under construction at this time. At least one more building, the parking garage at 9th and Bannock Streets, has been connected to the system since the analyses for this study were completed. Others, like the Boise Tower and the new Capital Station Convention Center are less certain. The development community also has plans for additional redevelopment in the near future. Very recently the City has received inquiries regarding connecting the former First Security Bank Building to the system (Johnson, 2003).

The uses to which these customers put the geothermal water varies. The principal uses are for space heat and for heating domestic water. However, whether a building uses the geothermal system for heating hot water is not necessarily known to the system operators except in certain cases; in one such case, there is a separate meter specifically for water heating use. A number of customers use the geothermal water for melting snow on sidewalks. The Downtown YMCA and the new Elks Hospital heat the water in swimming and therapy pools in addition to space heating. A former customer used the system for water

heating for an industrial laundry, but this customer has since relocated the business. A purchaser of the former premises could resume using the system. Several use the geothermal system throughout the year to “temper” the cold air from their air conditioning system. In other words, they have large air conditioning systems that serve all the spaces, then, use the warm geothermal water to warm up the air furnished to spaces that are cooler than desired.

There are essentially two ways that the geothermal water of the City system is used for space heating (Musgrove, 2003). Other systems exist, some in combinations of the components described below, but the discussion is intentionally limited here for simplicity. In addition, today’s geothermal heating systems are generally not considered for new buildings smaller than 30,000 square feet. Some designers prefer geothermal systems for buildings taller than about three stories to economize space. The floor area occupied by geothermal water pipes is much less than air ducts for conventional heating systems. In all cases, the geothermal water itself is not circulated through the building. Instead, the geothermal water passes through a heat exchanger and heats a separate water loop within the building. In most geothermal systems, this is done to prevent the salts present in geothermal waters from precipitating out in the heating system and fouling the system piping. The salts typically found in geothermal waters also make it relatively corrosive, so the heat exchangers are made of relatively inert metals such as stainless steel, and the building heating system can then be constructed of less expensive materials (Rafferty, 2001, p.8). Boise geothermal water, however, is relatively free of corrosive salts. Here, heat exchangers are also used to limit the water losses and damage in case of a piping failure within a building. However, about five to ten degrees of water temperature may be lost in the heat exchangers.

1. **Direct Use Systems:** Direct use systems are used with the relatively high temperature (160 to 170°F) water from the supply system. There are two variants of this arrangement. In one, the water heated by the heat exchanger is circulated to fin-and-tube radiators throughout the building. In the other variant, the high temperature water from the heat exchanger serves a central air handler for each building or for each floor. From these central air handlers, the conditioned air is conveyed throughout the building space by a duct system, i.e., by moving air rather than water. Where a central air handler is provided in a basement mechanical room instead of on each floor, for example, the ductwork to each floor occupies a significant building area when the building height exceeds three or four floors. This is typical of conventional, i.e., non-geothermal heating systems, such as gas-fired boilers or air heaters. For cooling, i.e., air conditioning, a second set of pipes distributes water chilled in a cooling tower or chiller throughout the building, and cools the air by blowing air over tubes located in the same radiator shells or air handlers as the hot water tubes of the heating system.
2. **Hydronic Heat Pump Systems:** In this type of system, the relatively cool water (100 to 120°F) of the collection system exchanges heat with water circulated throughout the building. On each floor, there may be several heat pumps. A heat pump can be thought of as a reversible refrigerator that moves heat from one location to another by absorbing heat in the working fluid, e.g., water, at one location and releasing it in another. The advantage of this type of system is that, not only can the same system provide both heating and cooling (whereas the direct use systems require separate cooling systems as mentioned above), but it can remove

heat from one part of the building and release it in another. An example of this might be a building where the offices on the sunny side heat up and require air conditioning, but another side of the building is shaded and the occupants there desire heat. Under these specific circumstances, no “fuel”, including heat from the City’s geothermal system, is required because the heat is simply being moved from one part of the building to another. This is done in the Washington Mutual Building and, as a result, they have the lowest water utilization rate of all the customers on the City system. On a cold day when the entire building is calling for heat, however, external heat from the City’s geothermal system would be required.

As mentioned previously, the Boise City system has three types of customers: Supply system customers (“X” customers), collection system customers (“Y” customers), and supply system customers whose systems were designed to use collection system water, but actually use supply water because of the way the City system is presently piped (“Z” customers). At the time of the analyses for this study, there were 36 X customers, 4 Y customers, and 5 Z customers. In other words, there are presently 41 customers taking water from the supply side of the system, 5 of which could be switched to the collection side if the City system were modified. There are 4 customers that use only water from the collection side of the system. The details of this demand are presented in the Appendix A to this report. The details of the newest customer, added in late October 2003 are not included. These customer counts only include those with a significant historical record to provide data useful to the present study. These are, in fact, several additional customers utilizing the system but for which their utilization history is too short for the present study. These include the new USGS/BOR building which was recently occupied but for which there is no operating data (therefore, it is not included in the analysis of existing buildings in the Appendix).

In addition to these customers, there are nine other projects to which service commitments have been made, including the Veltex Building at 5th and Main that is presently under construction.

D. AVAILABLE PRESENT CAPACITY

The City’s present pumping limit agreed to under the geothermal system moratorium, and associated stipulated agreements, is 230 million gallons per year (MG/yr). For purposes of this study, the same method was used to project total heating demand during an extremely cold year as is used by the Boise City system. The actual demand is adjusted in direct proportion to the actual number of heating degree days (HDD) as compared to the design HDD value. HDD is calculated as the annual sum of the difference between the actual daily average temperature and 65°F. In other words, the assumption is that occupants will turn on the heating system when the outside air temperature is less than 65°F. For each such day, the average daily temperature is subtracted from 65 degrees and added to the value for all the other days of that year. This is a typical heating demand calculation used for residential structures. It is not typically used for commercial buildings (Musgrove, 2003). The design of heating systems for commercial buildings is based on an extreme low temperature, the statistical basis of which varies with the occupancy of the building. For example, a lower design temperature would be used for a hospital, where the patients could not be evacuated if the heating system could not keep up with the heating demand. On the other hand, a building such as a movie theater might use a higher design temperature on the theory that if the theater’s heating system can’t keep up with the heating demand, the theater might elect to close for the

day rather than incur the cost of a higher capacity system. The design outside air temperature is selected on a statistical basis to ensure that the heating system can heat the space adequately under most conditions. The more important the facility, the greater assurance is needed that the design indoor temperature can be maintained. A typical design criterion for non-critical facilities would be to design the heating system so that there is only a one-percent chance that the outside air temperature would be lower than the design temperature in any given year. This is the 99-percentile temperature, which in Boise is about 9°F; for critical facilities, the 99.6-percentile temperature is used, which is 2°F for Boise. This calculation does not consider the total heating demand throughout the year. Since the pumping limit of the City geothermal system is based on a maximum number of gallons of hot water per year, this method provides no guidance as to the total demand of the heating district system. Therefore, the HDD method, which *does* yield an aggregate annual heating requirement, is used.

The projection method used is as follows. First, it is assumed that all water is used for space heating, though this is not exactly correct because some customers also use it for heating swimming pool and domestic water, and to melt snow from sidewalks. Next, the data available by customer for the most recent three years is averaged. In some cases, the usable period of record is only one or two years because of known problems or changes to the customers' systems that render some of the data no longer meaningful. In others, the systems or their uses have been modified by change in heating strategy or by making the control system more efficient; in these cases, using average historical consumption rates may be misleading. The average annual consumption was then adjusted in proportion to the average HDD value for the years for which data exists and added up to determine the total demand on both the supply pipe network and the collection pipe network. The total demand on the supply network was then compared to the maximum allowable pumping limit under the moratorium and stipulated agreement to determine the remaining capacity. Estimated demand has been included for eight of the projects that the City system operators are aware of and/or have held discussions about providing service to. This has not been done for the collection pipe network because this water is used by several customers, one after another. A collection system customer may take in water discharged by a supply customer, another collection system customer, or a mixture thereof. Therefore, the remaining amount of heat that can be extracted is variable and not known, particularly for the "Z" customers.

A projection of supply water demand, presented in Appendix A, suggests that during a design event (design HDD) year, supply side customers would use 172 million gallons (MG). This may be a low estimate because in 2000, the City pumped 188 MG, in 2001 it pumped 172 MG, and in 2002, it pumped 171 MG (Petrich, 2003, p. 21). These data differ slightly from the City's data: 2000, 177 MG, and 2001, 184 MG (K. Johnson, 2003). However, some users have ceased using the system since the high of 2000. The estimated demand for the nine projects awaiting service (including USGS/BOR) ranges from 52 to 72 MG/yr. This implies a design demand for buildings presently taking service or committed to of 224 to 244 MG/yr. In addition, there are three customers that maintain service connections but have not used geothermal water for several years; and the City's residual obligation to them has not been determined. Though the load on the system could be reduced by 11.5 MG by converting the "Z" customers to the collection side of the system, the demand of the existing buildings plus those to which commitments have been made could still exceed the present pumping limit. There always remains the possibility that not all

the future projects on the City's list will be constructed, e.g., Boise Tower, Capitol Station Convention Center, and two other, lesser known potential projects, but until the commitments are withdrawn, allowance needs to be made to serve them. Though the IWRRRI and the LANL, in their final draft reports, indicate that the pumping limit could be increased substantially, perhaps even doubled (Zyvoloski, Keating and Petrich, 2003), it is unclear whether or when the moratorium pumping limit will be raised. The moratorium was extended for an additional five years at the present pumping rate in 2003 (Dreher, 2003). However, it should be noted that this would not preclude future increases by stipulated agreement among the parties.

On the basis of the foregoing, it should be assumed that all future connections (excluding existing commitments or their replacements) will be to the collection side of the system. It should be noted that converting a "Z" customer to a "Y" customer, i.e., switching from the supply side to the collection side will increase the flow requirement to 250% of the flow from the supply side to obtain equivalent quantities of heat. The present "Y" customers are projected to use 5 MG/yr during a design HDD year. To this one should add 28 MG/yr for the "Z" customers converted to "Y" customers, for a total present collection side demand of about 33 MG/yr. Though this total does not include the demand of the Veltex Building, which will connect to the collection side of the system when it is completed and occupied (Holm, 2003), it is clear that there remains plenty of collection side capacity. Assuming that under these circumstances, the present discharge to the river would be terminated, there should be a total collection capacity available on the order of approximately 200 MG/yr. Additionally, the BWSWD has just begun a study of the feasibility of installing a collection pipe network on their system (Clark, 2003; Baldwin, 2003). At present, they are at the feasibility stage of the project, so the actual work has not yet begun. In recent years, BWSWD has pumped over 200 MG, with a permitted maximum of 300 MG. The study is likely to be relatively complex because some users discharge the water to backyard infiltration basins or shallow ditches that return the water to the Boise River. Some is used directly as domestic hot water and then discharged to the sanitary sewer, so it is unrecoverable. The BWSWD system is an extremely low pressure system that may render collection economically infeasible. The BWSWD's plans for utilizing the recovered water are also presently unknown, as is whether they would consider a partnership that might make the collection water available to the City's system. However, the potential resource may make it worth investigating.

SECTION II - GEOTHERMAL RESOURCE UTILIZATION METHODS AND USES

A. TRADITIONAL USES

General

As mentioned previously, the City's geothermal system is used predominantly for space heating. It is also used for heating the pools at the downtown YMCA and the new Elks Hospital, heating domestic water at the Federal Building, and for snow melting for two relatively new office buildings along River Street and others.

Consumption Rate Analysis

In an attempt to estimate typical geothermal water usage rates, we contacted a number of geothermal research and advocacy groups. None were aware of typical annual usage rates and one, in fact, indicated

interest in obtaining such data were we to encounter any. We also discussed this problem with a local mechanical engineer who designs such systems (Musgrove, 2003).

As discussed above, heating, ventilation and air conditioning (HVAC) systems for commercial buildings are designed on the basis of an extreme daily temperature, so designers do not concern themselves with the total amount of energy consumed to heat a building for a year. Lastly, we analyzed the City's data which generally covers fiscal years 2000 to 2002 (beginning in October); the data for the 2003 fiscal year were not available at the time that the analyses for this study were completed. Data was found to vary wildly between otherwise apparently similar buildings and for a given building from year to year. Some of the variations can be explained by faulty meters, defective valves, and the like. However, many of the variations cannot be explained away, mostly for lack of data.

First we looked at averaged data for all buildings on the system. This review suggested that buildings on the supply lines averaged about 70 gal/ft²/yr, while buildings taking water from the collection side used an average of about 45 gal/ft²/yr. These results are totally useless for purposes of estimating future demand, and are probably the result of the mix of building types, sizes, ages, conditions and other factors. This analysis was disregarded.

To try to arrive at typical usage rates, we next examined, in particular, data for FY2001, principally because the number of HDDs for that year (5809) was almost exactly equal to the HDD based on 63 years of record for the Boise Airport (5811) (Western Regional Climate Center, 2003). What we found was a continued wide variation in values for the number of gallons per square foot used per year. They varied from a low of 7 to a maximum of 287, excluding the YMCA that also uses it for heating swimming pool water. Even buildings apparently similar in size and construction, adjacent to each other, varied one full order of magnitude during FY2001: 16 to 164 gal/ft²/yr. Other interesting examples are:

- Old Ada County Bldg (650 Main St), 30 gal/ft²/yr, vs. City Hall (150 N Capitol), 45 gal/ft²/yr.
- Other relatively well-maintained buildings, e.g., the Convention Center, 68 (with large open areas and high ceilings); Idaho Power, 56 (year-round use for air "tempering", so slightly high); Federal Bldg, 45 (not counting domestic hot water, which is metered separately).
- Medical facilities seem to have high heating demand: the new Elks Hospital, 200; and the Idaho Veterans Home, 287.
- As might be expected, older, smaller buildings seem to require much more geothermal water, e.g., Basque Museum, 152, and Perrault-Fritchman, 122.
- Older, larger buildings that have been recently renovated seem to be relatively efficient: the Idaho Bldg (55), Fidelity Bldg. (46), and Union Bldg. (61). The significant thing here is that all these buildings are heated with relatively cool water from the collection side of the system. This data should be used with care though, because the Idaho and Union Bldgs. are known to have groundwater-based backup heating systems and the extent to which they were used during this period is not known.

Remaining Capacity

Based on these data, it would not be unreasonable to estimate that a modern, well-maintained building of a reasonable size could be heated with about 45 gal/ft²/yr of supply side water. This estimate, in itself, is not particularly useful since the supply side of the system seems to be fully allocated unless the pumping limit under the moratorium is increased. However, it can be used to estimate a flow rate for new buildings on the collection system. The way the City system works, users are assumed to remove 50°F from water from the supply side and 20°F from the collection side. If this is achieved, it should take 2.5 times as much water to provide the same amount of heat from the collection side as from the supply side. From this, one could estimate that 112.5 gal/ft²/yr would be required to heat a new building. In order not to suggest more precision than is real, and perhaps to introduce a small element of conservatism, we will use 120 gal/ft²/yr for the projections that follow. From previous discussion, we have noted that there is likely about 200 MG of unallocated collection system water, if the discharge to the river were terminated after converting the buildings along River Street from supply water to collection water. At the rate derived immediately above, one could estimate that about 1.67 million square feet of new construction could be added to the existing base of about 2.58 million square feet, for a total of 4.25 million square feet. To this should be added the buildings regarding which discussions regarding service have previously been held with the City.

There may also be several potential opportunities to increase the capacity of the City system. These are discussed below, in Section III.

System Extension Costs

As part of this study, we were asked to estimate the cost of extending service to new users. The question was asked on the premise that there was remaining capacity in the supply side of the system. The brief answer to that question is that recently, service was extended to the Water Center at the corner of Front Street and Broadway Avenue. Based on construction cost alone, that service, including both supply and collection lines, both 8-inch diameter, cost approximately \$150 per linear foot (l.f.) of combined service line (Toothman, 2003). However, there was a special requirement for the backfill because it was installed beneath a state highway, which would not likely be incurred elsewhere in downtown Boise. The premium for the special backfill is estimated to be on the order of \$20/l.f. If this premium is subtracted out and if design and construction administration costs of about 15% of the construction cost are added in, then the cost of a similar combined line installation under ordinary (non-state highway) conditions are estimated to be about \$150/l.f. The similarity of this unit price to that for the Water Center line is coincidental. This is for insulated fiberglass on the supply side and uninsulated fiberglass on the collection side. For collection pipe only, it would be conservative to deduct the cost of the insulated fiberglass pipe and assume all other costs remain the same. Therefore, a reasonable approximation to the cost for 8-inch collection line only might be on the order of \$120/l.f.

Operating Costs

The geothermal water supply service from the City system is priced according to a relatively arbitrary calculation method intended to encourage its use. As an incentive, the price of the geothermal water is

based on 70% of the equivalent cost of energy from the local gas company, as adjusted from time to time by the Idaho Public Utilities Commission. In other words, the cost floats with the price of natural gas.

To calculate user costs, first, there is a \$4.00 per month “customer charge”. Then, there is a “consumption” or “commodity” charge, for which there are two different season rates, and for each season the consumption charge rate declines with increased use. Recent rates, effective August 2003, are presented below:

For “Supply Water”:

Rate	April through November	December through March
First 49,000 gallons	\$0.3083 per 100 gallons	\$0.2890 per 100 gallons
Next 441,000 gallons	\$0.3001 per 100 gallons	\$0.2809 per 100 gallons
Over 490,000 gallons	\$0.2921 per 100 gallons	\$0.2732 per 100 gallons

These rates are predicated on the consumer extracting 50°F from the water.

For “Collection Water”:

Rate	April through November	December through March
First 49,000 gallons	\$0.1233 per 100 gallons	\$0.1156 per 100 gallons
Next 441,000 gallons	\$0.1200 per 100 gallons	\$0.1124 per 100 gallons
Over 490,000 gallons	\$0.1168 per 100 gallons	\$0.1093 per 100 gallons

These rates are predicated on the consumer extracting 20°F from the water.

So, if a customer owned a 50,000 ft² building using the supply side of the system, and heated it from November to April, with 4/5 of the heating demand between December and March and equal energy demand in each month, the customer would pay \$48 per year in customer charges and \$6430 in commodity charges for a total annual heating bill of \$6478. The same customer connected to the collection side with the same heating demand distribution would pay the same \$48 per year in customer charges and \$6750 in commodity charges for a total annual heating bill of \$6798. These costs are virtually identical, some of the difference being attributable to the rounding from 112.5 to 120 gal/ft²/yr. Unfortunately, there is presently no similar building on the collection system with which to compare the assumed consumption rates and costs. As mentioned previously, of the three (“Y” customer) buildings on the collection system, two are known to have backup groundwater supplies; the last has no known alternative heating system, but apparently consumes half as much water per square foot per year as the two with backups do.

Backup Systems

As shown on the table in the Appendix, there are 47 buildings on the City system. Of these, 27 have backup systems, 19 do not (Johnson, 2003) and one is unknown. This would suggest that a preponderance have backup systems. However, on closer examination and as discussed above, it is possible that some of the older buildings such as the Idaho Building and the Union Building actually use their groundwater based “backup” systems as their primary systems and the geothermal system as the backup during particularly cold periods. Obviously, critical facilities like hospitals require backup systems. Government buildings seem to have backup systems as well. However, more recent commercial buildings, whether

new construction or renovations, e.g., the office buildings along River Street, the Sedgwick (Marsh) Building and the Empire Buildings do not have backup systems. When asked what criteria are applied to make the decision whether to install a backup system or not, a local mechanical engineer told us that the City system has proven itself to be reliable. Also, buildings have the ability to retain some heat for reasonable periods of time (thermal mass). According to our discussion, the decision whether or not to install a backup system is generally left to the owner's discretion (Musgrove, 2003). Not having a redundant system that would be used infrequently, if ever, is certainly a significant cost saving. Additionally, if the backup is a totally different type of system, such as a boiler, as opposed to merely a backup water source to be used by the heat exchanger and/or heat pump, the maintenance and staff training requirements can significantly increase operating costs.

Incentive Effectiveness

When asked whether the 30% “fuel” cost incentive is effective in inducing owners or designers to specify the use of the geothermal system, we found that the cost of purchasing and installing heating systems is relatively insensitive to the type of heating system selected, so no advantage or penalty is incurred by selecting a geothermal heating system. However, we surmise that, if energy prices were to increase substantially, this statement may no longer be valid. Also, heating a building in the Boise area is a relatively small portion of the energy demand of a modern building. In order of importance, by far the greatest energy cost for commercial buildings is the cost of electricity for lighting, followed by cooling costs; heating is next, but far behind the first two. Actually, the heat generated within a building by the lighting system and the occupants offsets a significant portion of the heating requirement and adds to the cooling demand. The energy to heat domestic hot water for most commercial buildings is insignificant. Though “desuperheaters”, which extract heat from geothermal water for water heating do exist (Geothermal Heat Pump Consortium, 2003(b)), they are not commonly used in the Boise area because the hot water demand for commercial buildings is very small. Often, a small electric resistance heater is provided on each floor (Musgrove, 2003).

The greatest challenge to making the geothermal system cost-effective is reportedly the difficulty in consistently extracting 50°F from the supply side water and 20°F from the collection side water (Musgrove, 2003). Though buildings can usually achieve the required efficiencies when the geothermal systems are first installed, after a while, they go out of adjustment and do not achieve the efficiencies necessary to justify use of the geothermal equipment on an economic basis. This is borne out by the City's data. There are significant irregular water flows that have continued undetected for significant periods of time. On the other hand, there is no restriction on the amount of heat that a customer can extract from the geothermal water, i.e., if a system can extract more than 50°F from the supply side water, it is free to do so, which would simply make the geothermal heating system more economical to operate (Johnson, 2003).

The discussion in this subsection presupposes that natural gas, the incumbent fuel of choice and the basis of pricing geothermal service, continues to be relatively inexpensive. However, present indications are that the price of natural gas has and will continue to increase for the foreseeable future. Comparing the City's published rates for 2002 and 2003, rate increases ranging from a low of 35% to a high of 42% are

noted. At some point, the City may elect to disconnect its pricing structure from the price of natural gas and increase the effective financial incentive.

B. NONTRADITIONAL USES

There are a number of interesting uses to which geothermal water is put in Idaho, some relatively common and others not so common. Heating commercial greenhouses was one of the early uses for geothermal water in the Boise area. Two wells were drilled in the Stewart Gulch area in 1921 and 1922 at the site presently known as the Flora Company near 36th Street and Hill Road (Petrich, 2003). Greenhouse operations using geothermal water can be seen today along the South Fork of the Payette River near Garden Valley and other places.

In addition to natural hot springs that are open to the public, there are also a number of swimming facilities, some of them open to the public. Bergdorf is a popular geothermal swimming location. There was another at Idaho City, recently closed to the public. According to the Central District Health Department (Reno, Mersch and Schmalz, 2003), there are few restrictions on the use of geothermal water for swimming purposes. Generally, if geothermal water flows continually through a pool, it is exempt from many of the State regulations that govern the design and operation of swimming pools (Idaho Code 16.02.14.310). However, there are other requirements. Pools belonging to a building project, i.e., those that are not open to the general public, are not regulated regardless of the water source. Any pool open to the paying public is regulated. However, a fountain such as the Boise Centre on the Grove, or a soaking pond would not be regulated. The quality of the City's geothermal water is apparently good enough to swim in. A comparison of water quality data from the City's system with the drinking water standards established by the US Environmental Protection Agency and the Idaho Department of Environmental Quality indicates that it meets all primary standards except fluoride and all secondary standards except sodium. Primary standards relate to the safety of drinking the water and secondary standards relate to the aesthetic qualities of the water. However, it is reported to have some of the typical objectionable hydrogen sulfide (H₂S) odor that is characteristic of geothermal waters (Johnson, 2003). Therefore, it is highly likely that a swimming facility, particularly one enclosed at any time of the year, would most likely use fresh water that would be heated by the geothermal water via a heat exchanger. In this case, it would be treated as an ordinary swimming pool. If the water were chlorinated, it would likely have to be disposed of in the City's sewer system rather than being discharged to the Boise River or in the City injection well. However, it may be possible to use ozone or ultraviolet light in lieu of chlorine.

Two relatively new buildings along River Street and the new Elks Hospital use water from the City's system to melt snow on sidewalks. Until recently, the American Linen Company, a commercial laundry and linen service, used water from the City water system for hot wash water as well as for boosting wash water temperature. The wash water was discharged to the sanitary sewer so it was lost to the geothermal collection system.

Aquaculture is another relatively common use of geothermal water, principally in the vicinity of Bliss, where trout have been raised for many years. Catfish have been raised this way in Idaho for more than 30 years. However, the most unusual use of geothermal water in Idaho that we could find is near Buhl, where a company raises alligators for their hides and meat. And since it is part of a diversified

aquaculture operation that also raises and processes fish, the alligators are a natural disposal system for the waste resulting from the fish processing operation (Geothermal Resources Council, 2001).

SECTION III - INCREASING THE BOISE SYSTEM UTILIZATION

A. TRADITIONAL USES

Additional Resources

As has been discussed above, it appears that the capacity of the supply side of the City's geothermal system is presently either fully utilized or fully committed. However, according to the study by IWRRI and LANL, which was commissioned by the City of Boise and the National Renewable Energy Laboratory (NREL), it is possible that the pumping limit could be increased significantly. This could be accomplished by a new stipulated agreement among the IDWR and the geothermal water producers, perhaps by incrementally increasing the pumping rates and observing the resulting effect on the adjacent wells. One scenario analyzed in their study represents a 50% increase in the pumping limit. Compared to the present pumping limit of 230 MG/yr, that would make another 115 MG/yr available. At an estimated rate of 45 gal/ft²/yr, for the supply side customers, that would permit the development of about 2½ million additional square feet of buildings. On the collection side, about 960,000 additional square feet could be developed, assuming one-time use of the collection water. The City's well field consists of three wells, only one of which is presently needed to meet most present demand, so no additional well costs would be incurred. Properly located, little or no additional distribution piping may be necessary to serve the additional customers. In addition to the potential increase in the annual geothermal water pumping limit, there may be other opportunities to increase the resources available to the City. As mentioned previously, it may be possible to supplement the City's collection system with collection water from the BSWD collection system, if it is constructed. Another interesting possibility would involve the Capitol Mall system. The production and injection wells of this system are relatively close together. From system startup around 1983 until 1990, production temperatures declined about 10° F, after which they stabilized at the new, lower temperature (Petrich, 2003). One possible explanation is that the cooler injection water has, in effect, diluted the warmer production water and the system has come to thermal equilibrium. If so, disposing of the Capitol Mall water further from the production well might result in production temperatures recovering to their original values. Disposal into the City's collection system could be an attractive option. Similar data do not seem to exist for the VA system, so the merits of discharging the used VA water into the City system are unknown at this time.

All the previous discussion has been based on the geothermal resource as the sole source of heat. However, the energy picture in the Pacific Northwest is changing and new technologies are on the horizon. Distributed electricity generation, i.e., relatively small generators located close to the point of use, is increasingly common. As relatively large consumers of heat and electricity re-evaluate their long term needs for less expensive or backup power supplies, sources of waste heat may be located near downtown Boise, whether natural gas fired combustion turbines, microturbines or fuel cells. Conceivably, the City's collection water might be used as cooling water for such equipment, thereby being reheated and returned to the supply side of the system. The electricity from such generating equipment might be consumed by the City itself or by the large medical institutions located near downtown Boise, either for supplemental or back-up power.

System Improvements

The improvements to the City's distribution system would depend on what transpires with the pumping limit. If no additional water can be pumped from the City system wells, there is no point in extending the supply system, except as necessary to serve future customers to whom commitments have already been made, e.g., Capital Station Convention Center and the Hosac project near the intersection of 13th and Myrtle Streets. However, it may be desirable to complete the system along River Street. An uninsulated "collection line" was originally constructed as the system's outfall to the Boise River. When this line was enlisted to serve the new office buildings along River Street from 9th Street to 13th Street; no supply line was installed. This line presently continues to discharge to the Boise River. However, because the five customers are essentially "in series", supply side water is presently provided to them through the collection line; these are the system's "Z" customers. At a minimum, extending a supply pipeline along River Street from 9th Street to approximately 11th Street may be advisable. In principle, only a collection line would be necessary to complete a loop to convert the "Z" customers to "Y" customers, and free up supply line capacity for new "X" customers. A return collection line paralleling the existing River Street line could return collection line flows to the vicinity of 9th Street, so it could be reinjected, if desired. However, such an uninsulated line would not help extend the system to potential new "X" customers if additional supply water becomes available in the future. Extending a supply line may be one potential alternative route to serve the proposed projects requesting geothermal service in the vicinity of 13th and Myrtle Streets, including the Capitol Station Convention Centre. This alternative would require that the River Street parallel line be an insulated supply line, and that its extension include both supply and collection lines. This line could run along the Pioneer Pathway to 11th and Myrtle streets, then connect with the existing system, perhaps at 11th and Main Streets. The likely effect is that flow would actually occur from Main Street toward River Street, depending on supply side demand in this area. The loop down River Street and up along the Pioneer Pathway could make service available to the relatively undeveloped area west of 8th Street Marketplace, and between River and Myrtle Streets. This represents approximately 3000 l.f. of pipeline extension. At approximately \$150/l.f., that represents an investment on the order of \$450,000.

A review of a typical service agreement provides a description of how service extensions are paid for (Johnson, 2003). If a customer beyond the existing pipe network requests service, that prospective customer advances the City the cost of designing and constructing the extension. Once the customer begins receiving geothermal service from the City, the customer's account is credited with the funds advanced until it is fully offset by the cost of the service received from the City. Additional new customers who connect to the new service extension pay only the cost of connecting their building to the City's system. In all cases, the City provides and maintains the meter at no additional cost to the customer.

The recommendations above are for extensions of service only. There may be significant improvements that could be made to the City system with respect to existing customers. As noted above, there are significant swings in consumption, many of which are unexplained and are not correlated with outside air temperature variations. Defects seem to go undetected for significant periods of time. One of

the most cost-effective improvements that would make the system available to more users would be to change the complete pricing strategy. One possibility would be to go to real-time metering and charge not only for flow, but for heat as well. Relatively inexpensive thermocouples on the inlets and outlets of each customer service connection, and relatively simple data-logging and automated reporting devices could record the actual amount of heat withdrawn from the system by each customer. Computerized comparisons of actual versus anticipated flows as a function of temperature on a real-time basis could alert system operators to potential difficulties and inefficiencies in the system, allowing a prompt repair and conservation of water that could be better used to serve additional customers. These are standard industrial system technologies available off the shelf. Additionally, the present, regressive pricing structure, where the unit price decreases with increasing consumption might be re-examined.

B. NONTRADITIONAL USES

We have considered a number of nontraditional uses of geothermal waters in downtown Boise that would:

1. Allow the presence of the geothermal system to foster the redevelopment of downtown Boise.
2. Highlight the geothermal system as a fun, attractive feature of the downtown area.

One of the problems is that the geothermal system is transparent to most users. Few people even realize that they live and/or work in a building that takes advantage of the City's geothermal system; or walk past a geothermally heated fountain every day. For example, how many people are aware that the fountain in front of City Hall on the corner of Capitol and Idaho is kept from freezing by geothermal heat, as compared to the fountain in front of MK Plaza that turns into a giant icicle every winter? It probably never occurs to most passersby.

At first we thought of a major feature in the middle of a new complex of buildings in a "Boise Geothermal Plaza" arrangement. Such a feature might consist of a greenhouse with year-round flowers and perhaps a pond with attractive tropical fish, *koi* (golden carp) perhaps, and plants, possibly orchids. The pond could also be kept warm all year with geothermal water (whether or not the water in the pond was actually from the City's system). However, this would require an enclosure in the winter. Such an enclosure would either have to be retractable or the space would have to be air-conditioned in the summer when the outside air temperatures exceed 100° F and the "greenhouse effect" renders conditions in the garden intolerable for plants or people. Though this idea had its attractions, it was discarded as too impractical because of its limitations. However, it is presented here anyway to stimulate thought and discussion among the readers, who may think of similar but more practical alternatives.

The idea that did seem to have a lot of merit would be a smaller scale version of Boise Centre on the Grove: a small park and/or amphitheater, with a small shell to protect performers, actors, musicians, or poets perhaps, and geothermally warmed benches for the audience. It could be supplemented with a geothermally warmed fountain, similar to that at the Grove, for when there are no performances. To give more of a geothermal flavor, some "geothermal steam", H₂S and all, could be released from time to time, if not considered excessive. The steam would have to be artificially heated since the City's water is not hot enough anywhere in the system to do this naturally. The landscaped areas of the park could be warmed with geothermal water during the early spring and perhaps into the fall with warm water

circulation pipes buried in the soil. When weather conditions are too warm to require supplemental heat, it would be turned off. Obviously, at some point winter weather would become too cold, and activities would be suspended until the early spring, when they could resume. Sidewalk areas could be kept clear of snow in winter months for outdoor events.

A variation of this would be to construct a large outdoor pond, possibly with a fountain in it, that would be frozen in winter for ice skating, with geothermally heated benches and warming hut and, perhaps, snow melting with geothermal water for adjacent sidewalks.

Another idea that might be interesting is that Boise Parks and Recreation has been studying the feasibility of creating a whitewater park at the weir in the Boise River in the vicinity of Shoreline Drive and 14th Street. Coincidentally, this is the location of the 12-inch diameter outfall from the City's geothermal system to the Boise River. At present, approximately ten percent of the water pumped from the City well is discharged to the river at this location to maintain flow in the line along River Street. What better place to watch kayakers practicing or competing than from a geothermal soaking pool? Or what better place for the kayakers themselves to warm up from the cold river water in the spring? The collection line temperatures would be expected to be on the order of 100°F, which may be ideal for such a use. Such discharge could be discontinued during the remaining months if the parallel River Street line were constructed.

We are aware of interest in capturing some or all of the water presently discharged to the Boise River to create a "creek" or other water feature and, thereby, to enhance the Pioneer Pathway. However, it must be remembered that the water temperature may still be about 100° F, and plants may not be able to tolerate such high temperatures. Alternately, there may be opportunities to do something similar with water from other sources, not within the scope of the present study. Nevertheless, some of the geothermal water run through pipes buried in the banks of a creek along the Pioneer Pathway could probably be used to enhance the vegetation in spring and fall, and to keep the sidewalks clear of snow.

C. RECOMMENDATIONS

As a result of the discussions held subsequent to reviews of the draft report, some general recommendations were developed that would be consistent with CCDC's goals and objectives, i.e., to use the geothermal system to promote the redevelopment of areas in and around the downtown Boise area. Additionally, there are some recommendations worth pursuing that have been discussed in previous sections of this report.

1. System Extensions

Our recommendations for system extension are presented in Figure 1, Boise City Geothermal System. This figure is a modification of the City of Boise Department of Public Works Customer map, which actually depicts all the geothermal systems in the downtown Boise area, their wells, and customer locations. We have modified this drawing to show the following features:

- a) An interconnection from the new line serving the Water Center along Broad Street to Capitol Boulevard, to serve the redevelopment along Myrtle Street east of Capitol Boulevard, with possible future extensions further east along Myrtle Street. This would be a combined supply and collection line;

- b) A supply-line-only connection from the end of the combined supply and collection line at 9th Street near the Boise Public Library along River Street to the Pioneer Pathway; and
- c) A combined supply and collection line north along the Pioneer Pathway to the entrance to the proposed Capitol Station Convention Center near 11th and Myrtle Streets, then up 11th Street to Main Street. This item, with item “b”, above, would bring geothermal water service to the area north of River Street and west of the 8th Street Marketplace of CCDC’s River/Myrtle District;

2. 14th Street Plaza

A geothermal-themed, 14th Street Plaza is shown in Figure 1 in the vicinity of 14th and Grove to represent a public open space that could be constructed to foster redevelopment of this neighborhood, and is understood to be consistent with present CCDC goals. This feature could include several of the recommendations introduced previously, including open space, geothermally warmed planters, heated seating, a fountain/ice-skating rink, and sidewalk snow melting.

3. Boise River Soaking Pool

Constructed collaboratively with the Boise Department of Parks and Recreation as part of the proposed whitewater park in the vicinity of the existing geothermal outfall near 14th Street and Shoreline Drive, a soaking pool could bring interest and visibility to Boise’s geothermal resources. As a “once-through” system, public health concerns would be minimal, and exempt from regulation.

4. Instrumentation Program

We strongly recommend that at least a pilot flow and temperature instrumentation program be undertaken for part of the Boise geothermal system. The intent would be to develop standard instrumentation installation details that, after a comprehensive deployment, would provide data suitable for the correlation of system utilization to outside air temperatures. By fine tuning customers’ systems and demand, the City geothermal system would be more efficient and would allow more customers to be connected. As mentioned previously, this would also permit real-time monitoring and detect problems with customers’ systems so that repairs can be effected promptly. The instrumentation system should also be extended to observe and record (datalog) water level, flow and temperature data at the geothermal wells. This latter data set would be very useful to better describe the interactions among the wells of the various geothermal systems as a function of flow to support requests for increases in the City’s maximum annual pumping limit. At present, little simultaneous well data has been collected to permit a comprehensive analysis of well interaction (Petrich, 2003, p. 51).

5. Inter-System Collaboration

The City should explore the options of collaborating with the other geothermal systems in Boise. One alternative could include collaboration with the Warm Springs District to assist with and, perhaps, benefit from the construction of a discharge water collection system. The City might be able to obtain more desirable financing for the BSWD than they could otherwise obtain, among other benefits, in return for some of the water collected and/or hot water not used by BSWD. Another is the possibility of accepting the discharge from the Capitol Mall system to enhance the flow in the City’s collection system. Similar

discussions could be held with the operators of the VA system. There is also interest in the local water community in performing tracer studies to determine flow patterns from injection wells to the production wells to better understand the potential well interactions and interferences. This information could be useful to the City to support requests for increases in pumping limits, so the City might benefit from assisting with such a study, possibly financed with system revenues or grants from other public agencies.

6. Pricing

Lastly, we recommend that the City examine current projections of natural gas prices and consider breaking the connection between the geothermal customer charge rates from the price of natural gas. An increased economic incentive could motivate developers and building owners to become City system customers. The incentive could be stable pricing, not related to the price of fossil fuels, rather than a fixed discount to a highly variable rate. The price of the geothermal service should be related to the cost of service plus reserves for system operation and maintenance, plus desired system upgrades, including research and instrumentation.

SECTION IV - CCDC'S ROLE IN GEOTHERMAL RESOURCE UTILIZATION

The role to be played by the CCDC in encouraging the use of Boise's geothermal resources can be many faceted. Some have been alluded to above, in various forms. Boise's geothermal resources are virtually invisible or transparent to the average resident. Some of the suggestions collected and developed could be executed by CCDC itself and others could be executed in collaboration with other organizations. These organizations could include the Smart City Committee, IWRRI, the Idaho Department of Water Resources (e.g., the Energy Division), Visitors Bureau, Department of Commerce and technical organizations such as the American Institute of Architects, and others, particularly those interested in the "LEED" (Leadership in Energy and Environmental Design) and the "Green Building" programs.

A number of ideas were generated by CCDC staff, GeoEngineers, and other reviewers. These ideas are presented and discussed briefly below.

1. Encourage the City to install and operate the flow and temperature instrumentation discussed above, i.e., improved metering. CCDC personnel could be instrumental in educating the City's customers and other citizens, as well as facilitating discussions and raising awareness of the geothermal system to increase acceptance of the change in pricing basis.
2. Monitor status of City's pumping limitations under the moratorium and stipulated agreements, and provide support for incremental increases in the annual pumping limits.
3. Create a geothermal awareness program, akin to the "Golden Medallion" program of the electric industry in years past. Buildings using the geothermal resource could be provided readily identified signage that recognizes the environmental sensitivity and awareness of the building owners and occupants.
4. Investigate further the feasibility of a "heat recovery" concept wherein facilities that generate surplus heat could use the City geothermal system as "cooling water" and receive credits for the heat added to the system. Though not cost effective at present for air conditioning commercial

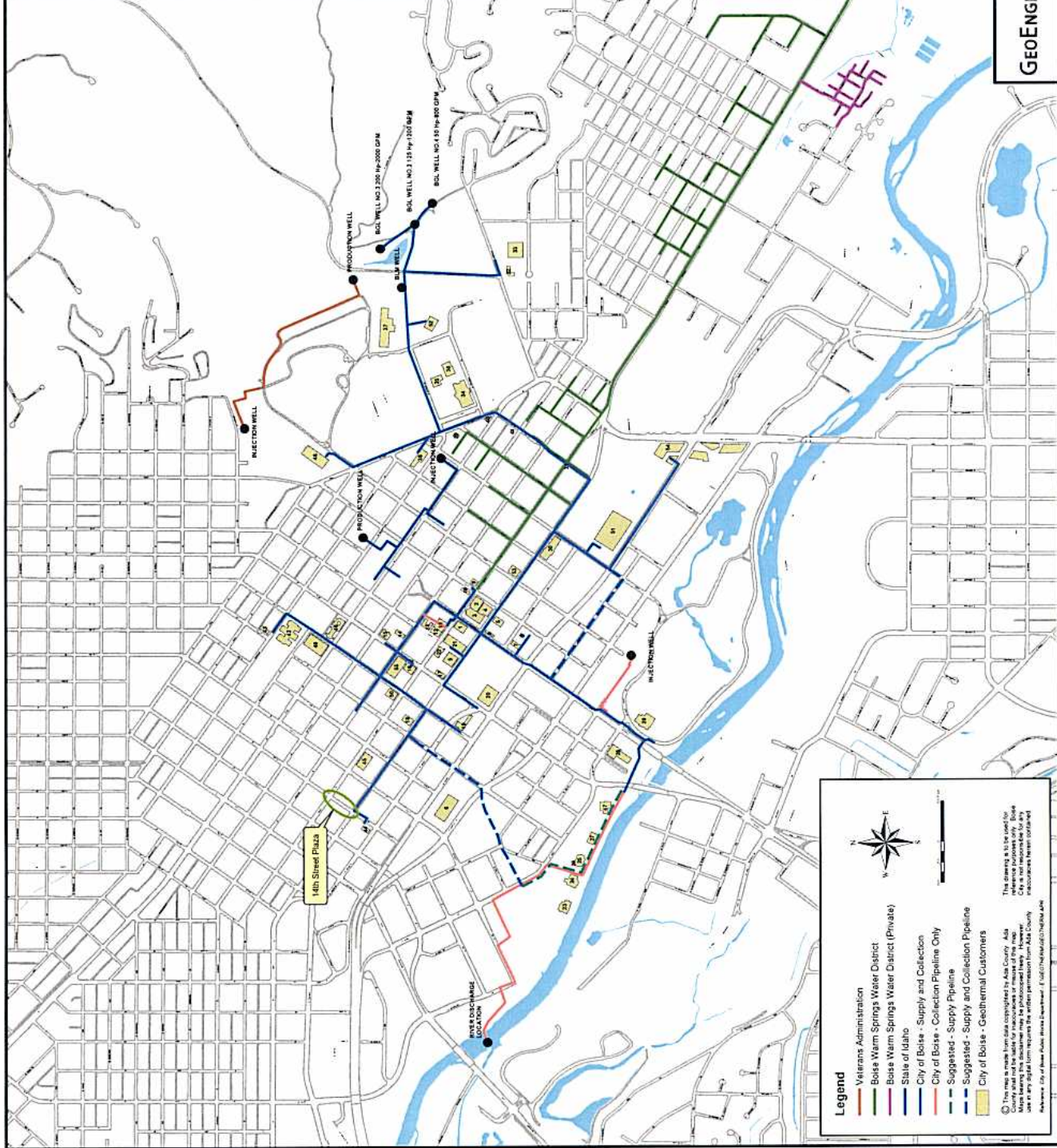
buildings, it could be feasible for large industrial or commercial refrigeration units and distributed generation (electricity generating facilities).

5. Investigate the energy consumption of the heat pumps in heating systems on the collection side of the City system to evaluate the actual savings achieved in comparison to the 30% energy rate discount. Combine this effort with the suggestion to disconnect charge rates from natural gas prices.
6. Encourage the BSWWD to pursue the recovery and re-use of water discharged after its first, direct use, whether to construct a “collection system” of its own or to provide it to the City to augment the City’s collection system flows. CCDC could facilitate meetings between BSWWD and the City to foster a more collaborative environment.
7. Promote awareness of the City’s collection system resource to increase its utilization. Post the present report on the CCDC website.
8. Encourage the City to formulate a more formal policy regarding flows presently allocated to stalled development projects or buildings disconnected from the system to allow the City to re-allocate those flows to newly proposed projects.
9. Develop a policy and provide funds to developers proposing to redevelop areas of interest to CCDC by advancing the funds for extension of the geothermal lines. Once the buildings are constructed and occupied, CCDC would be reimbursed until the cost is recovered, i.e., CCDC would create and operate a revolving fund to minimize developers’ up-front costs, perhaps collaboratively with the City. Similar incentives could be provided in the form of grants for developers of particularly desirable projects, i.e., mixed use and/or housing projects that help CCDC achieve its goals.
10. Promote legislation at the state and federal levels to promote the use of geothermal and other renewable energy resources.
11. Sponsor seminars and workshops for engineers, architects, builders and developers to introduce them to the City geothermal system and the opportunities and benefits it and CCDC provide. Post the relevant information on the CCDC website.
12. Create a display available to the public, but especially to design professionals, where they could observe real-time performance data and records of performance of current geothermal installations. This display could be located at City Hall, the Water Center or any other building utilizing the City’s system that would be willing to host the display.
13. Sponsor a “brainstorming” session to gather ideas for geothermal features along the Pioneer Pathway, Boise Parks and Recreation white water park, 14th Street Village, and other applications.
14. Redevelop the Pioneer Pathway as a utility corridor to foster the redevelopment of the River/Myrtle District with up-to-date telecommunications, electric power, telephone, geothermal water service and other utilities.
15. Collaborate with City staff to locate and size line extensions to support future development anticipated and supported by CCDC.

16. Promote the geothermal resource as a part of Boise identity or “branding” in marketing the City, education and tourism promotions.

BOISE CITY GEOTHERMAL CUSTOMERS

- 1 BASE CITY TALL TANK
- 2 BASE CITY TALL TANK
- 3 BOISE CITY HALL #1
- 4 BOISE CITY HALL #2
- 5 510 TELEPHONE BLDG
- 6 BOISE CITY HALL #3
- 7 DESIGN ASSOCIATION
- 8 BRADNER MUSEUM
- 9 BOISE CITY HALL #4
- 10 SAGELE CENTER
- 11 SAGELE CENTER
- 12 FACILITY BUILDING
- 13 GARD BUILDING
- 14 GARD BUILDING
- 15 JEFFERSON PLAZA
- 16 JEFFERSON PLAZA
- 17 ALLIANCE BUILDING
- 18 ALLIANCE BUILDING
- 19 STATE HOUSE
- 20 STATE HOUSE
- 21 CONVENTION CENTER
- 22 CONVENTION CENTER
- 23 CONVENTION CENTER
- 24 AND CLUB VENUE
- 25 FOREST RIVER VIL SCENALK
- 26 FOREST RIVER VIL
- 27 FOREST RIVER VIL
- 28 BOISE ART MUSEUM
- 29 BOISE ART MUSEUM
- 30 BOISE ART MUSEUM
- 31 BOISE ART MUSEUM
- 32 REMOVED LABORATORY
- 33 ELMS KISHAN HOSPITAL
- 34 ELMS KISHAN HOSPITAL
- 35 ELMS KISHAN HOSPITAL
- 36 FORT BOISE COMMUNITY CENTER
- 37 IDAHO VETERANS HOME
- 38 COLUMBIA MORTUARY
- 39 COLUMBIA MORTUARY
- 40 COLUMBIA MORTUARY
- 41 ST LUISES PERSONNEL
- 42 BOISE HIGH SCHOOL
- 43 BOISE HIGH SCHOOL
- 44 AMERICAN LUTHER (VACANT)
- 45 AMERICAN LUTHER (VACANT)
- 46 FIRST PRESS CHURCH
- 47 FEDERAL BUILDING
- 48 FEDERAL BUILDING
- 49 YMCA BUILDING
- 50 ADA COUNTY COURT HOUSE
- 51 ADA COUNTY COURT HOUSE
- 52 ADA COUNTY COURT HOUSE
- 53 ADA COUNTY COURT HOUSE
- 54 IDAHO WATER CENTER
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- 100 IDAHO WATER CENTER



Legend

- Veterans Administration
- Boise Warm Springs Water District
- Boise Warm Springs Water District (Private)
- State of Idaho
- City of Boise - Supply and Collection
- City of Boise - Collection Pipeline Only
- City of Boise - Supply Pipeline
- Suggested - Supply and Collection Pipeline
- City of Boise - Geothermal Customers

The drawing is to be used for reference purposes only. Boise County and the state of Idaho are not responsible for the accuracy of the information shown on this drawing. Use of this drawing requires the written permission from Ada County. Reference: City of Boise Public Street Department - 1/10/2017/140616217/140616217



APPENDIX A

BOISE CITY GEOTHERMAL SYSTEM DATA SUMMARY



APPENDIX A
BOISE CITY GEOTHERMAL SYSTEM DATA SUMMARY

Bldg Name	Address	Map Code	Supply or Collection	Node Code	Backup?	Total Bldg Area	Avg Gall/F ² /Yr	Est Dsn Yr Total	
								MG	MG
								Supply	Collection
Existing/Past Customers									
Ada County, New	200 W. Front Street	51	Supply	GXU51A	Yes	356,334	26.3	10.05	
Alexander Bldg	100 N. 9th Street	17	Supply	GXU17C	No	15,000	16.7	0.26	
Alaska Center	1020 W. Main Street	18	Supply	GXU18B	Yes	NOT USED			
Arid Club	1137 W. River Street	24	Supply	GZU24D	Yes	14,300	130.3	1.98	
Basque Museum	611 Grove Street	8	Supply	GXU08D	Yes	3,100	145.8	0.48	
Boise Art Museum	670 Julia Davis Drive	29	Supply	GXU29D	Yes	20,000	68.3	1.45	
Boise City Bank Bldg	805 W. Idaho Street	22	Supply	GXU22C/ GXS22C	No	38,000	16.3	0.66	
Boise City Bldg 2 (old Ada County)	650 Main Street	4	Supply	GXU04A	Yes	61,000	14.2	0.90	
Boise High School	1010 W. Washington St.	42	Supply	GXU42B	No	136,400	75.1	10.87	
Boise Senior Center	690 Robbins Road	35	Supply	GXU35A	Yes	14,000	12.2	0.18	
Bush Mansion	1020 W. Franklin St.	43	Supply	GXU43B	No	5,000	118.2	0.63	
Capitol Terrace Bldg	100 N. 8th Street	21	Supply	GXU21C	No	47,000	27.4	1.35	
Central Station	200 N. 6th Street	9	Supply	GXU09B	No	10,000	8.2	0.09	
City Hall	150 N. Capitol Blvd.	3	Supply	GXU03B	Yes	86,000	54.0	4.96	
City Hall Annex	150 N. Capitol Blvd.	2	Collection	GYU02B	Yes	19,000	29.7		0.62
Columbia Mortgage (Id Land & Appr)	207 W. Washington St.	39	Supply	GXU39A	Yes	3,200	97.7	0.11	
Convention Center (Existing)	850 W. Front Street	20	Supply	GXU20C	Yes	84,000	99.1	8.95	
Cornerstone Building	913 River Street	47	Supply	GZU47D	No	53,300	22.7	1.27	
Cornerstone Bldg Sidewalk	913 River Street	47	Supply	GZU47D	No	N/A	31.0	1.74	
Design Associates Bldg	619 Grove Street	7	Supply	GXU07D	No	4,500	77.1	0.37	
Eagles Center	602 W. Idaho Street	10	Supply	GXU10B	No	25,700	7.5	0.20	
Elks Hospital Annex	100 W. State Street	40	Supply	GXU40A	Yes	DISCONNECTED			
Elks Hospital, Old (demolished)		34	N/A	N/A	N/A	66,600	129.3	9.64	
Demolished						-66,000		-9.64	
Elks Hospital, New	204 Fort Place	34	Supply	GXU34A	Yes	149,210	122.7	19.11	
Empire Building	205 N. 10th Street	50	Supply	GXU50B	No	60,000	18.3	1.13	
Federal Building	550 W. Fort Street	48	Supply	GXU48A	Yes	284,000	46.5	14.08	
Federal Building Hot Water	550 W. Fort Street	48	Supply	GXU48A	?	N/A	5.4	1.64	
Fidelity Building	222-248 N. 8th Street	12	Collection	GYU11B	No	18,400	28.2		0.54
Fire Station No. 1	707 Reserve Street	32	N/A	GXU32A	Yes	7,000	198.9	1.48	
Disconnected						-7,000		-1.48	

APPENDIX A
BOISE CITY GEOTHERMAL SYSTEM DATA SUMMARY

Bldg Name	Address	Map Code	Supply or Collection	Node Code	Backup?	Total Bldg Area	Avg Gall/Ft ² /Yr	Est Dsn Yr Total	
								MG	MG
								Supply	Collection
First Presbyterian Church	950 W. State Street	46	Supply	GXU46B	Yes	41,500	66.7	2.95	
Forest River No. 6	1087 W. River Street	27	Supply	GZU27D	No	33,000	111.0	3.86	
Forest River No. 8	1101 W. River Street	25	Supply	GZU25D	No	43,000	13.3	0.60	
Forest River 8 Sidewalk	1101 W. River Street	26	Supply	GZU26D	No	N/A	4.5	0.20	
Forest River No. 9	1161 W. River Street	23	Supply	GZU23D	No	46,500	37.1	1.83	
Fort Boise Community Center	700 Robbins Road	36	Supply	GXU36A	Yes	19,400	107.8	2.22	
Garro Building - No Data	816 W. Bannock Street	14	Supply	GXU14B	Yes	NO DATA			
USGS - BOR - No Data		N/A	Supply	N/A	?	TBD (see below)			
Idaho Building	280 N. 8th Street	13	Collection	GYU12B	Yes	64,400	50.1		3.42
Idaho Power	1221 W. Idaho Street	45	Supply	GXU45B	Yes	220,000	65.7	15.56	
Idaho Veterans Home	320 Collins Road	37	Supply	GXU37A	Yes	70,000	215.2	15.93	
Industrial Administration Bldg	317 W. Main Street	30	Supply	GXU30A	Yes	75,000	174.7	13.95	
Jefferson Place	350 N. 9th Street	15	Supply	GXU15B	Yes	66,800	26.3	1.87	
Old Telephone Building	609 Main Street	5	Supply	GXU05A	Yes	7,000	102.8	0.77	
Perrault-Fritchman	625 Main Street	6	Supply	GXU06D	Yes	6,700	142.6	1.00	
Public Library	715 S. Capitol Blvd.	28	Supply	GXU28D	Yes	80,600	21.5	1.84	
St. Lukes Annex	316 W. Washington St.	38		GXU38A	No	DISCONNECTED			
St. Lukes Personnel Bldg	102 W. Jefferson St.	41	Supply	GXU41A	No	1,600	241.9	0.41	
Sedgwick (Marsh) Building	225 N. 9th Street	16	Supply	GXU16B	No	90,260	9.3	0.89	
Statehouse Inn	981 Grove Street	19	Supply	GXU19B	Yes	40,000	39.7	1.71	
Steiner Corporation (American Linen)	1402 Grove Street	44	Supply	GXU44B	No	70,000	116.5	9.13	
Disconnected						-70,000		-9.13	
Union Block Building	720 W. Idaho Street	11	Collection	GYU13B	Yes	15,000	62.0		0.64
Washington Mutual Plaza	199 N. Capitol Blvd.	1	Supply	GXU01B	No	123,075	6.9	0.88	
YMCA	1050 W. State Street	49	Supply	GXU49B	No	25,000	766.1	19.92	
Crossover Basque Museum			Supply					0.59	
Crossover Boise High			Supply					2.31	
Crossover FS No. 1			Supply					0.00	
Crossover Grand Oaks			Supply					0.00	
Crossover Library			Supply					0.00	
Subtotal, Existing/Past Customers:						2,576,879	68.7	171.76	5.23
Average, Supply "X" + "Z" Customers Only						2,460,079	69.8	171.76	
Average, Supply "X" Customers Only						2,269,979	70.6	160.28	
Average, Collection "Y" Customers Only						116,800	44.7		

APPENDIX A
BOISE CITY GEOTHERMAL SYSTEM DATA SUMMARY

Bldg Name	Address	Map Code	Supply or Collection	Node Code	Backup?	Total Bldg Area	Avg Gall/Ft ² /Yr	Est Dsn Yr Total, MG	Est Dsn Yr Total, MG
								Supply	Collection
Proposed Customers:									
<i>(Or present customers w/insufficient historical data)</i>								Req'd	Est'd
USGS/BOR		N/A	Supply			21,000		1.30	1.30
Water Center		N/A	Supply					17.00	9.50
Veltex		N/A	Collection					N/A	N/A
BODO		N/A	Supply					12.00	9.00
Boise Tower		N/A	Supply					20.00	10.00
Armory	801 Reserve Street	33	Supply					3.00	3.00
Capital Station Convention Center		N/A	Supply					13.00	13.00
Block Project Hotel(6th & Front St)		N/A	Supply					3.80	3.80
Hosac 13th & Myrtle		N/A	Supply					2.00	2.00
Subtotal, Proposed Customers								72.10	51.60
Estimated Total Demand								243.86	223.36
Existing Customer Base Summary:									
Note: Numbers differs from actual, current customer base because this tabulation is only of customers with useful historical data.									
Total X Customers = 2, 269,979 ft ² /36 customers = 63,055 ft ² average (1600 to 356,000 ft ² range); 160.88 MG/Yr									
Total Y Customers = 116,800 ft ² /4 customers = 29,200 ft ² average (15,000 to 64,400 ft ² range); 5.23 MG/Yr									
Total Z Customers = 190,100 ft ² /5 customers = 38,020 ft ² average (14,300 to 53,300 ft ² range); 11.48 MG/Yr									

APPENDIX B
BIBLIOGRAPHY



APPENDIX B

BIBLIOGRAPHY

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