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GEO-HEAT CENTER QUARTERLY BULLETIN

HOT SPRINGS POWER & ICE

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A Quarterly Progress and Development Report on the Direct Utilization of Geothermal Resources

CONTENTS

Cover - Top: Dedication of the 200kW geothermal power plant at Chena Hot Springs, AK, 8/20/06 (Left to Right: Gov. Frank Murkowski, Bernie Karl, U.S. Senator Ted Stevens) Bottom: Peninsula Hot Springs, Victoria, Australia

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WE ARE BACK!

Hopefully, most of you have missed receiving our *Quarterly Bulletin* over the past year – as we had to suspend publication after last September's issue (Vol. 26, No.3) due to lack of funding. Last fall all of our grant funds for publishing the Bulletin came to an end, and new funding was not received until late this spring. Thus, this is the first issue under our new grant from the U.S. Department of Energy, Office of Science, titled: "Technical Support and Transfer of Geothermal Technical Knowledge and Information." We now have funding for at least four issues of the Quarterly Bulletin, and hopefully this will continue if geothermal continues to be of interest to the Department of Energy.

This first issue is devoted to spas with a special feature on what has happened at Chena Hot Springs in Alaska, August 2006 – the successful completion and running of the Ice Museum, and the dedication of the binary power plant. This event marks the application of the lowest geothermal fluid temperature used in the world for electrical power generation.

The Geo-Heat Center staff has been busy with other projects under the Task Ordering Agreements (TOA's) funded by the National Renewable Energy Laboratory at Golden, Colorado supported by USDOE funds from the GeoPowering the West (GPW) Program. We have been working on 15 separate projects, as proposed by the various state GPW Working Groups, in Oregon, Nevada, Utah, Idaho, Hawaii and California along with special projects in North Dakota and Nebraska. Seven of these projects have been completed with a final report and others are near completion. We have also completed an analysis of a potential onion dehydration plant in eastern Oregon funded by an Oregon Department of Energy Grant. The TOA's that we are working on are:

1. Nez Perce Geothermal Heat Pump Feasibility Study, Idaho (Completed)
2. Winnebago Life Cycle Cost Analysis, NE (Completed)
3. Williston Geothermal Feasibility Study of a Biofuel Facility, North Dakota
4. Herald & News Building Well Drilling/Testing and Heating/Cooling System Design, Klamath Falls, Oregon
5. Geothermal Industrial Park, Elko, NV (Completed)
6. Myrtle Tree Development Project, Canby, California (Completed)
7. Technical Assistance Expertise for GPW and State Working Group Meetings (Completed)
8. USDA Farm Bill Energy Efficiency Improvements Template for Geothermal Heat Pump Applications (Completed)
9. Heating System Replacement for Mt. Grant General Hospital, Hawthorne, Nevada (Completed)
10. Feasibility Study of Direct Use Enterprises in the County of Hawaii
11. Technical Assistance in Matching Greenhouse Expansion Plans with Geothermal Resources, Garden Valley, Idaho
12. Geothermal Heating Feasibility Study for the Utah Transit Authority, Salt Lake City, Utah
13. Ground Source Heat Pump System Design for Coeur d'Alene Tribe Cultural Center, Plummer, Idaho
14. Feasiblity Study of Geothermal Resources for GRID Rail Industrial Park , Fernley, Nevada
15. Assessment of Downhole Heat Exchanger in Existing Wells, Puna, Hawaii

Starting in July of this year, we added a new employee to the Geo-Heat Center: Debi Carr, who replaced Donna Gibson as our office manager. She transferred from the Provost Office, and thus is familiar with the campus operations. We are pleased to have her join the Geo-Heat Center.

All of the staff now have new email addresses as follows:

John W. Lund, Director:
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Toni Boyd, Civil Engineer:
toni.boyd@oit.edu

Andrew Chiasson, Mechanical Engineer:
andrew.chiasson@oit.edu

Debi Carr, Office Manager:
deborah.carr@oit.edu

Gene Culver, Mechanical Engineer, continues to work for us part-time, but does not have an email address.

Depending upon future USDOE and GPW funding, we hope to continue the TOA program, in fiscal year 2007 (FY07), starting in October.

We welcome any suggestions that you might have on improving the *Quarterly Bulletin*. Comments, criticisms, praises and submission of articles are always appreciated.

The Editor

CHENA HOT SPRINGS

John W. Lund, Geo-Heat Center

INTRODUCTION

I visited Chena Hot Springs Resort, about 60 miles (100 km) northeast of Fairbanks, Alaska, in the summer of 1981 and wrote an article on my experience for the *Bulletin* (Vol. 6, No. 3, Fall, 1981, pp. 23-25). My experience included driving the gravel road from Fairbanks, and in the process, losing a window in my brother-in-law's car from a passing truck. The site at that time was primitive with few buildings, gas was $2.00 per gallon (about double compared to Fairbanks) and a convention center was on the drawing board. We did enjoy soaking in the various pools.

This August, I again visited the resort, with many of my fellow geothermal experts. This time I drove on a paved road all the way from Fairbanks. The occasion was the 1st Annual Renewable Energy Fair and dedication of the low temperature, 200 kW, geothermal binary power plant by the owner Bernie Karl, Governor Frank Murkowski and U.S. Senator Ted Stevens. This plant, built by United Technologies Corporation (UTC) of Hartford, CT (www.utc.com), uses the lowest temperature geothermal resource in the world for power generation – at 165º F (74ºC) – and is the first in Alaska. Following the dedication of the power plant, the Alaska Geothermal Working Group held two days of meetings, which included a reception in the Aurora Ice Museum, drinking "Appletini" from individually hand-carved champagne ice glasses, bartended by Bernie Karl.

Much has been added to the Chena Hot Springs Resort since 1981, an ice museum, lodging, expansion of the greenhouse and visits by many Japanese tourists who love to see the Aurora Borealis in the winter and soak in the geothermal waters. A summary of the various projects are described below, and a more detailed article is provided in this issue on the Aurora Ice Museum.

HOT SPRINGS AND POOLS

In 1905, Robert Swan looking for a place where he could ease the pain he suffered from rheumatism, set out in a boat loaded with supplies on the Chena River looking for the hot springs that had been reported by a surveying party the year before. Traveling the North Fork of the Chena and then into Monument Creek, he found the hot springs in August of 1905. This led to the development of the hot springs, and by 1911, the property had a stable, bathhouse and twelve small cabins for visitors. Later the waters were analyzed and found to consist of silica (85 ppm), sulfate (68 ppm), chloride (29 ppm), sodium (110 ppm) and bicarbonate (115 ppm), similar to water from one of the famous springs at Carlsbad in the former Czechoslovakia (see, Lund, 2000). Today the resort consists of the main lodge with a dining area, bar and conference room, an Activity Center, the office/storage building, a large lodge building with numerous well furnished rooms, six cabins, the pool/spa building, the Ice Museum, the power plant building, airplane hangar, dog kennels and numerous other smaller buildings such as a massage and renewable energy center. The hot springs averages around 110ºF (43ºC) which are fed into an outdoor pool, and an indoor pool around 94ºF (34ºC). Several hot tubs are also available.

The outdoor pool directly fed by the hot springs.

At present there are 20 geothermal wells on the property, the deepest at around 1,010 feet (300 m) and producing up to 165ºF (74ºC). Much of the reservoir analysis and drilling supervision had been done by Dick Benoit of Sustainable Solutions, Reno, Nevada and David Blackwell of Southern Methodist University. All the buildings are heated with the geothermal waters, saving about $183,000 per year.

Dick Benoit venting the main geothermal supply line to the power plant.

GEOTHERMAL POWER PLANT

The approximately 200 kW binary power plant was installed at the resort in July 2006, and has been running ever since. The secondary fluid in the plant is R-134a, which has a lower boiling point than water and is heated by geothermal water at 500 gpm (32 L/s) through a heat exchanger at 165ºF (74ºC). Cooling water from a shallow well or infiltration gallery is around 40ºF (4ºC), providing a large temperature difference ("delta T") which improves the efficiency of the system. The resort has used diesel generators in the past, since it is isolated from the electric grid, costing around 30 cents/kWh. The new power plant will provide 7 cents/kWh electricity, a major savings for the resort. The high cost of diesel energy and the large "delta T" certainly makes this unit economical. Maintenance is estimated to be $50,000 per year. The unit uses Carrier chiller components to dramatically reduce the cost of production and allow for modular construction. The total unit cost around $1,500 per installed kW. Plans are to add another 200 kW unit, and shortly reach one MW. Bernie Karl is looking at expansion in the future, depending upon on sustainable production from the geothermal resource, however, the bar has been lowered from around 208ºF (98ºC) to 165ºF (74ºC) for geothermal electric power generation (see Geo-Heat Center Quarterly Bulletin, Vol. 26, No. 2 – September 2005 for a description of other lower temperature combined heat and power uses at http://geoheat.oit.edu/bulletin/bull26-2/bull26-2.pdf).

The insulated supply and disposal pipelines for the power plant are each about 3,000 ft. (1,000 m) long, but fortunately, the cold water supply is gravity fed from a large collection gallery, thus there is no pumping cost for the condenser side of the plant.

The Ice Museum chess set.

The 200kW United Technologies power plant.

THE AURORA ICE MUSEUM

The Aurora Ice Museum was built as a way to boost tourism at the resort, along with offering year-round employment for many of the ice artists in the area. The museum, a structure made of ice blocks cut from a local beaver pond in winter, is open all year-round – even in the summer when the temperatures reach 90ºF (32ºC)! The museum features a great hall and lounge area, chandeliers made of individually carved ice crystals, countless sculptures including a functional gigantic chess set, life sized jousting knights, and observation tower made of ice and four galleries with varying themes, one room even has an ice toilet. The architect of most of the art is 13-time World Ice Art Champion Steve Brice, and his wife, four-time champion Heather Brown. A 15-ton (53 kW) absorption chiller designed by Energy Concepts Co., powered by the geothermal resource keeps the museum frozen. The 200 gpm (13 L/s) geothermal water is then cascaded to the pool supplementing the pool heat, and may be sent to the greenhouse in the future. It has 10,000 visitors annually, and hosts numerous weddings. Details on the cooling system are provided in another article in this issue by Gwen Holdmann and Donald C. Erickson.

The Ice Museum with protective covering.

Knights jousting.

HORTICULTURE PROJECTS

Chena Hot Springs Resort is working toward becoming a self-sustaining community, which includes independence in food production. A small test greenhouse was installed in 2004, heated by the geothermal resource. They were able to maintain the greenhouse temperature of 85ºF (29ºC) while the outside temperature dropped to -45ºF (-43ºC), typical for interior Alaskan winters. The resort recently added a two-bay 4320 ft^2 (400 m^2) greenhouse where tomatoes, lettuce, green beans, peppers, cucumbers and numerous greens and herbs are grown. During my visit I tasted fresh raspberries and had lettuce and tomatoes in my salads at dinner. It is managed by a trained horticulturist, Rusty Foreaker.

The new greenhouses.

Interior of greenhouse.

Additional information on Chena Hot Springs Resort can be found on their webpage: www.chenahotsprings.com or by calling (907) 451-8104. Chena also has a geothermal projects website at www.yourownpower.com, which gives more detail on all of their renewable energy and sustainable development projects.

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ABSORPTION CHILLER FOR THE CHENA HOT SPRINGS AURORA ICE MUSEUM

Gwen Holdmann, Chena Hot Springs
Donald C. Erickson, Energy Concepts Company

INTRODUCTION

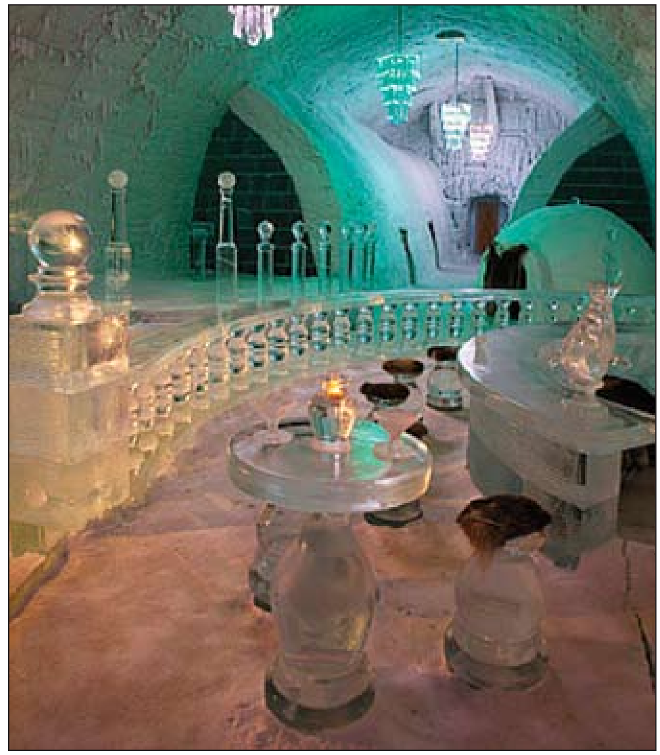
Absorption chilling uses a refrigeration cycle that requires little or no electric input, because it does not employ a mechanical compressor. Instead, the refrigeration effect is produced through heating and cooling a circulating absorbent liquid. When a moderate temperature heat source is available and/or local electric costs are high, absorption refrigeration can be quite economical. The type of absorption chiller most familiar to the general public is the 'propane refrigerator', which is found in RV's or at remote homesteads. In fact, absorption chilling is not a new concept. The first simple ammonia/water absorption chiller was built by Ferdinand Carre in 1846 and marketed as an ice-making machine.

Moderate temperature geothermal resources have long been recognized as promising heat sources to drive an absorption cycle, but the 230ºF minimum temperature classically considered necessary to make an air-cooled system cost effective encroached on temperature ranges which could similarly be used for power generation. For this reason, and because of increased maintenance issues when working with unique systems, no absorption chillers were in operation on geothermal sites between 1989 and 2004. Prior to 1989, the Oregon Institute of Technology used a lithium bromide/water absorption chiller for air conditioning buildings on campus.

THE AURORA ICE MUSEUM

In 2003, Chena Hot Springs Resort built the first Ice Museum in the United States. Chena is located 60 miles (100km) northeast of Fairbanks, Alaska, which is the traditional world capital of ice art. The Aurora Ice Museum was from its inception intended to be a year-round structure, something which had never before been attempted. Unfortunately, due to a number of reasons, the initial version of the Museum did not survive an unseasonably warm spring in 2004.

One of the primary problems was immediately identified as the cost of refrigeration for the structure. A standard 200-ton (700kW) Trane air-conditioning unit reprogrammed to circulate 300 gpm (19 l/s) of glycol was originally planned, but the cost of operating the unit was quickly deemed too high. Chena Hot Springs is located 30 miles (50km) from the nearest utility grid. Prior to the installation of a geothermal power plant in 2006, the cost of power generated onsite from a 200kW diesel generator was calculated to be 30¢ per kWh. The onsite generator was not large enough to power the 200-ton (700kW) Trane unit, and so a separate 500kW generator needed to be installed to start and operate it. The fuel cost alone for operating the Trane unit was over $500 per day.



Interior view of the Aurora Ice Museum.

ENERGY CONCEPTS COMPANY

Once the first Aurora Ice Museum melted, it was clear that in order to justify rebuilding the structure an alternative refrigeration system would be needed. The geothermal resource at Chena Hot Springs is 165ºF (74ºC), substantially lower than the minimum threshold generally considered for absorption systems. Fortunately, the owners of Chena were familiar with an absorption chiller operating in Kotzebue on the northwestern coast of Alaska, to make ice for the local fishing fleet. The Kotzebue chiller was powered by 165ºF (74ºC) jacket water from a diesel generator (coincidentally the identical temperature as the Chena geothermal resource). The system uses a three pressure ammonia/water absorption cycle, and had been in operation for 10 years. Chena contacted Energy Concepts Company, the manufacturer of the Kotzebue system, in late 2004, to order a similar unit for the Aurora Ice Museum. The order was placed in early January 2005, and installation was required by the end of March. This meant that there was no time for a shop test of the unit before shipping. It also meant that the unit had to be air shipped to meet the schedule, and hence compactness was at a premium.

CHENA ABSORPTION CHILLER

Chena Hot Springs required significantly more refrigeration capacity than Kotzebue, and so Energy Concepts designed a unique three pressure system for the Ice Museum, using an ammonia-water absorption cycle. One significant advantage Chena had over other sites was a supply of readily available cold river water to cool the absorbers and condenser. Special heat exchangers are used throughout the system to give high performance in a very compact package. The components which contact external fluids (hot spring water, river water, chilled brine) are constructed of stainless steel. Other internal cycle components are carbon steel. The chilled brine which transfers heat out of the Ice Museum is a $CaCl_2$ solution, concentrated to allow temperatures as low as -50ºF (-46ºC) (typical for winter temperatures at Chena). The brine circulates behind the Ice Museum and through an air handler, which cools an annular space in the Ice Museum between a thin inner wall and the external insulated wall. With 165ºF (74ºC) hot spring water (85 gpm (5.4 l/s)), and 40ºF (4ºC) (80 gpm (5.0 l/s)) river water, the brine is delivered at -20ºF (-29ºC) (55 gpm (3.5 l/s)) and the temperature in the ice hotel is maintained at a constant 24ºF (-4ºC).

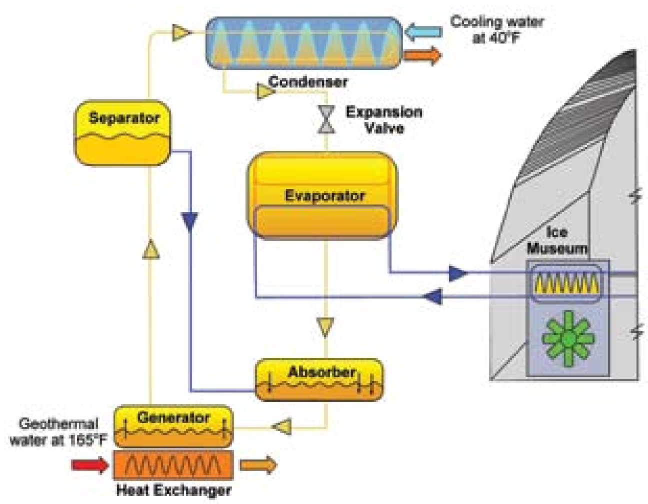
An additional system component is a 2000 gallon (7.56m^3) brine storage tank, which acts as a giant 'fly wheel' in the system. If the brine in the tank is kept below freezing, it can continue to provide cooling to the Ice Museum for one hour during shutdown of the absorption chiller for any reason. Additionally, defrost of the air handlers has not been perfected and is accomplished using hot water sprayed onto the coils. This heat can unbalance the absorption chiller, and therefore the tank allows the brine to circulate freely while allowing the air handlers to be cut out of the loop.

SYSTEM ECONOMICS

While the absorption chiller uses only two 1/2hp (0.37kW) pumps to circulate the ammonia-water mixture, an additional 20hp (15kW) are required to operate the cold and geothermal supply pumps, 3hp (2kW) are required for the CaCl2 brine circulating pump, and 20hp (15kW) are required for the air handler. In total, the absorption system requires 44hp (33kW), while the backup vapor compression system requires 148hp (110kW) to operate. This results in fuel cost savings alone of $400 per day, or more than $12,000 per month at current diesel fuel prices ($2.47 per gallon ($0.65/liter) for bulk diesel).

The Chena absorption chiller plant ("Thermochiller") has now operated through two warm seasons, keeping the Aurora Ice Museum frozen year-round. It demonstrates that absorption refrigeration is possible with very low driving temperatures, and in very compact packages. The Chena Thermochiller displaces both the conventional mechanical compressor chiller plant, and also 100 hp (75 kW) of otherwise required power plant capacity. The capital cost of the Thermochiller is substantially less than the capital cost of those two displaced components. Therefore, even with the installation of the 2 x 200kW geothermal power plant at Chena, the absorption chiller will remain in operation as the most economical cooling option for the Ice Museum because the upfront installation costs have already been covered.

Absorption Chiller prior to installation.



Chena Hot Springs Absorption Refrigeration System.

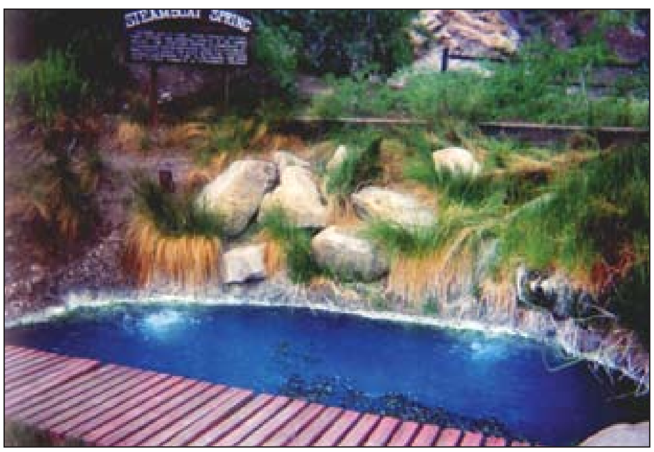
[1]*The geothermal supply pump is operated regardless of absorption chiller operation as it is used for onsite district heating system.*

STEAMBOAT SPRINGS, COLORADO

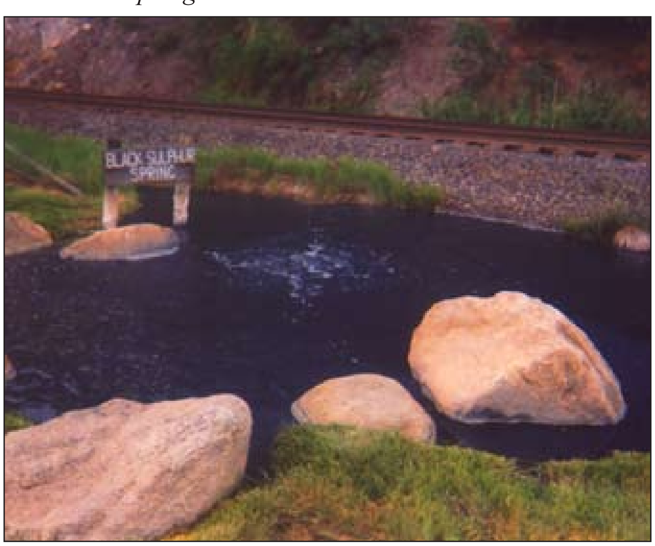
John W. Lund, Geo-Heat Center

INTRODUCTION

Steamboat Springs, a small community in northern Colorado, is known for its winter sports and to a lesser degree for its numerous warm springs along the Yampa River. The town got its name in the early 1800's from French trappers who heard a hollow, resonant "chugging" sound that they thought was a steamboat on the river. Instead it was a small underground chamber that expelled hot water at regular intervals. The town's founder, James Crawford, staked his land claim next to the spring in 1874. Even though the geysering, that once reached heights of 5 to 14-ft (1.5 to 4.3 m), was destroyed by blasting for the railroad in 1908, the town still retains the name. The original spring can still be found on the banks of the Yampa River along with the adjacent Black Sulphur and Narcissus/Terrace Springs. The spring is only at 78ºF (26ºC) and bubbles slightly from carbon dioxide gas. Black Sulphur Spring's color is due to the hydrogen sulfide, and the muds from Narcissus/Terrace Springs are thought by some to help skin disorders.



Steamboat Spring.



Black Sulphur Spring.

The other famous spring in the town is Heart Spring, used by the Yampatika Ute Indians for centuries. The Utes and the Arapahos are reported to have had many battles for domination over this sacred ground, as it was believed to be source of physical and spiritual healing. James Crawford, was the first European settler to use the springs, and in 1884 he built a log bathhouse over the springs. H. W. Gossard, who owned the property between 1931 and 1935, named the spring for its shape. He added a second story to the bathhouse and introduced the winter carnival, a tradition that continues today, and it featured a local man diving into the pool from atop a 100-ft (30-m) ladder. I have even seen a photograph of the spring showing a moose diving into the water, which I assume was not part of the carnival. The springs and pools were sold to the Health and Recreation Association in 1935 and are open to the public. The heart shaped pool is fed by gravity and then flows to the therapy pool, the large hot pool and then to the lap pool before flowing into the Yampa River. The 102ºF (39ºC) spring water consists of natural bicarbonates and lithium, along with the unique effervescence and other minerals provide bathers with a stimulating therapeutic experience. The water is mainly sodium, chlorides and sulfates with a pH of 8.0.

Heart Spring and hot pool.

HOT SPRINGS WALKING TOUR

A guide for a two-mile, seven-springs walking tour is available from the Historical Museum or the Chamber of Commerce in Steamboat Springs, and is illustrated at the end of this article. This tour takes you along both sides of the Yampa River and next to the famous Howelsen Hill ski jump that is even used in the summer using a roller system for the run. Iron Spring, the former Soda Spring, Sulphur Springs and Sweetwater/Lake Spring are located on the north side of the river, and Steamboat, Black Sulphur, Heart Spring lap pool, Narcissus/Terrace, Lithia Spring and Sulphur Cave Spring are located on the south side of the river. They are all in the 50° to 80ºF (10° to 27ºC) temperature

Heart Spring lap pool.

Travertine deposits along the Yampa River.

range. In addition, there are more than 150 hot springs near Steamboat, some on private land and are closed to the public, some as tiny seeps in hay fields.

Soda Spring was a place, where in the early 1900's, locals would bring sliced lemons on a hot summer day and make lemonade with the 55ºF (13ºC) carbonated water. Unfortunately, highway construction stopped the spring from flowing, but the spot is marked with a small gazebo. Lemonade was also made from Iron Springs, as the water was considered a tonic for "ailments of body and will." Sulphur Springs attracts animals such as deer, elk, black bears and horses, as they have a particular craving for the odiferous water. Lithia Springs, as its name would imply, contains a high content of lithium and is said to have many beneficial medicinal qualities – especially for treating manic depression; however, the lithium concentration is probably not high enough to provide any benefit. Legend of Sulphur Spring Cave tells that early Indians used this cave and its springs during rituals. It may have been used as an oracle, similar to those in Greece and elsewhere. An ancient mycelial fungus is found in the cave.

GEOLOGY

In the Steamboat Springs region, there is an absence of recent volcanic activity, thus the thermal water are probably heated meteoric waters that have circulated to depths of 12,000 to 15,000 ft (4,000 to 5,000 m). At this depth the waters are heated by conduction through the surrounding rocks, radiogenic activity, exothermic mineral reaction and the earth's geothermal gradient (about 2ºF per 100 ft or 3ºC per 100 m). The conduit for the thermal waters that rise due to lower density is believed to be through a sub-parallel and orthogonal network of faults and fractures that cross the region. One major fault system runs east-west parallel with the valley and just behind Howelsen Hill where there is an extensive travertine (calcium carbonate) deposit. Other northwest trending faults are found at Fish Creek and west towards the north side of town.

SNOW MELTING PROJECT

The City of Steamboat Springs through their Planning Department is investigating the use of geothermal water for a snow melt system at the Mt. Werner ski area just east of town. The pedestrian walk-way will consist of 200,000 square feet (18,600 square meters) of surface area. Unfortunately, there are no surface indications of a geothermal resource in the ski area, thus, it is proposed to drill a series of temperature gradient holes based on a geologic field investigation by Gerry Huttrer of Geothermal Management Company, Frisco, Colorado. Initial estimates are for a peak load of 125 Btu/hr/ft^2 (37 W/m^2) or 25 million Btu/hr (7,325 kW). Possible alternatives include using the geothermal waters directly, using a downhole heat exchanger, and using a geothermal heat pump, depending upon the temperature and flow rate encountered. Hopefully, by next season, more will be known about the potential geothermal resource and its best use.

On September 19th, the Steamboat Springs City Council approved the exploration for local sources of geothermal energy which could be used to heat the snowmelt systems. Funding for the project's estimated $2 million to $2.5 million cost would come from the city's urban renewable authority, or URA, which uses increases in property tax revenues from the base area to fund improvements to the area. The Council gave approval for the use of URA revenues to fund geothermal exploration, at an estimated cost of about $107,000. This funding will be used to drill four temperature gradient holes near the ski base to depths of 500 feet (150m) recommended by Gerry Huttrer. The City will be accepting bids from contractor to start drilling before winter.

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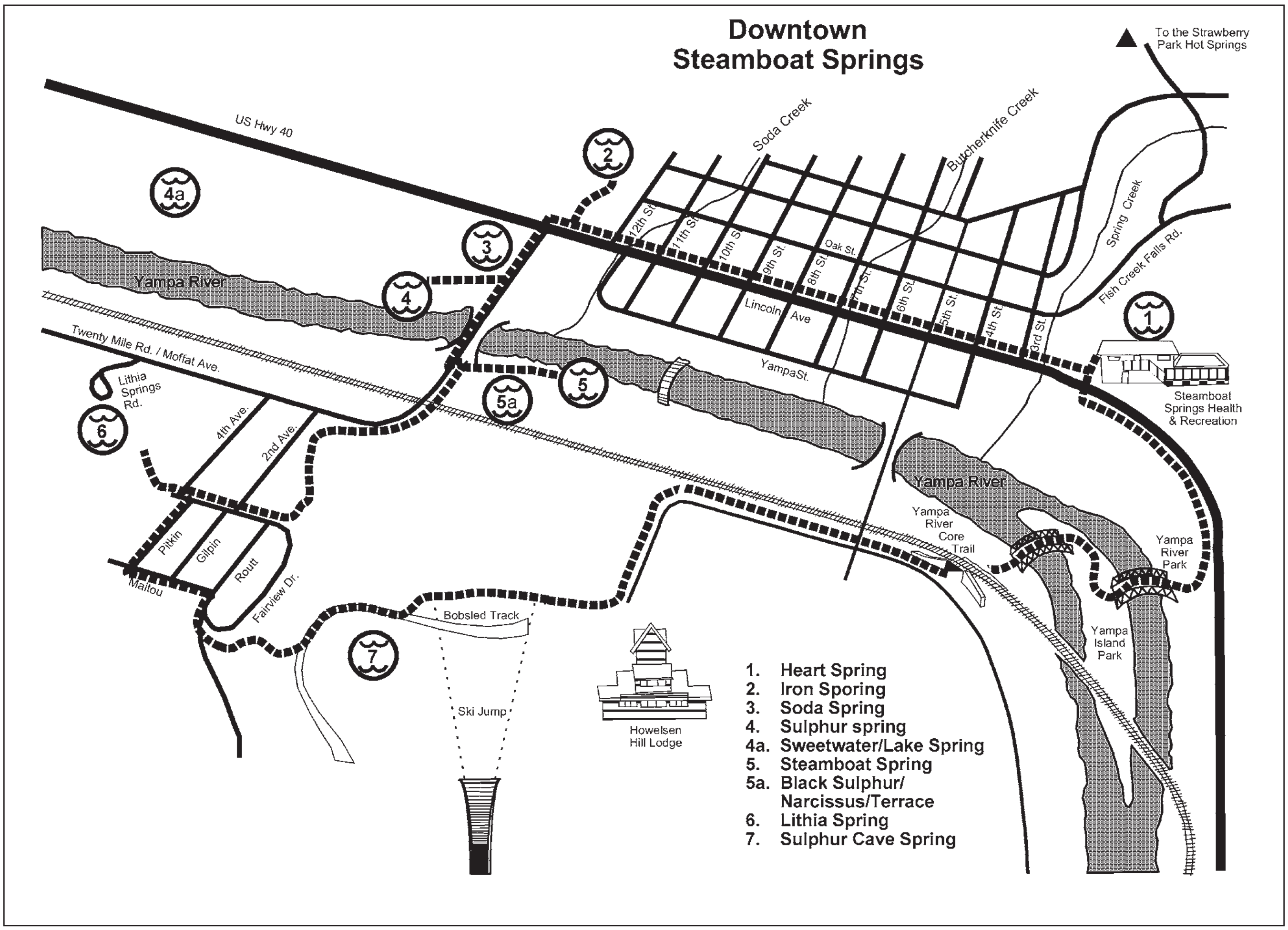
A Walking Tour of the Springs of Steamboat, pamphlet from the City Museum, (undated)



Seven-spring walking tour.

STRAWBERRY HOT SPRINGS

John W. Lund, Geo-Heat Center

Overview of Strawberry Hot Springs.

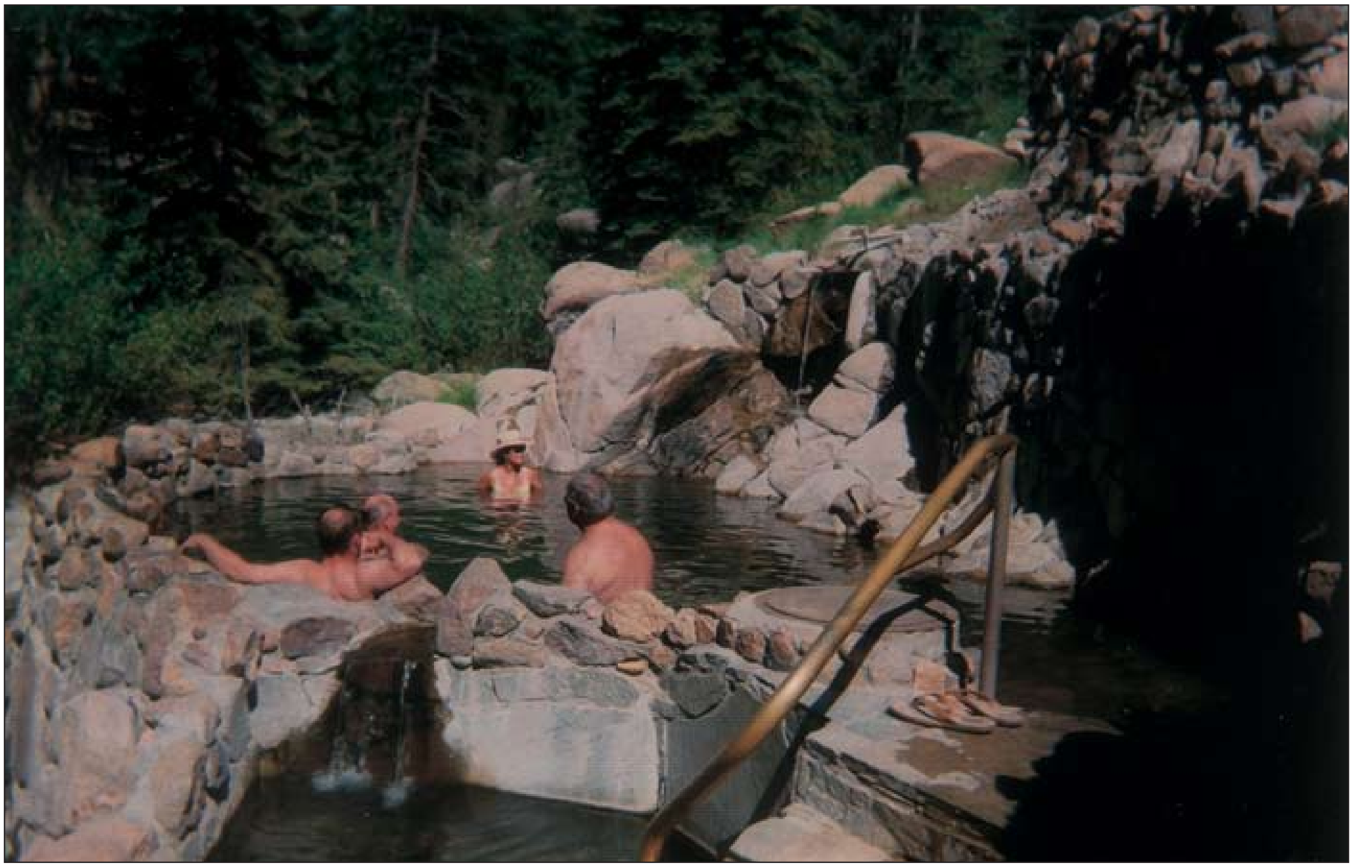
This remote hot springs is located on private land within the Routh National Forest at an elevation of 7,500 feet (2,250m), about 10 miles (16km) north of the town of Steamboat Springs, Colorado.

Originally the hot springs were used by the local Ute Indians to heal their body and soul after battle with other tribes. They believed that the vapors contained their creator's essence and soaking in the pools rejuvenated the soul.

European settlers claimed the land in the 1870's and drove the Utes out. What followed was boisterous and destructive use of the springs resulting in trash and poor sanitation that disgusted the Utes. The ownership passed from private partners to The Steamboat Springs Health and Recreation Association, however they provided little supervision of the site, and parties had to often be broken up by the local sheriff. Finally, in 1982 the current owner, Dan Johnson, bought the property and transformed it into a peaceful site to soak. Cabins and rock-lined pools have been built, along with a bathhouse, a changing tepee and massage therapy are available. There is no electricity and only one telephone to help stranded motorists in the winter.

The hot springs issues from rocks on the hillside at 147ºF (64ºC) and fills several pools arranged on the hillside and creek bottom. These pools are kept at 102ºF to 104ºF (38°C to 40ºC), but bathers can cool off in the ice mountain streams that are slightly warmed by the hot spring water.

The source of the spring.



One of the small pools.

Getting there can be an adventure, especially during winter months. The last eight miles from Steamboat Springs is a gravel road with steep ups and downs, requiring 4-wheel drive or chains in the winter. The county imposes a $500 fine for drivers who are unfortunate enough to get stuck in the winter. There is a shuttle bus from Steamboat Springs, or as some do, you can cross-country ski the last eight miles.

Obnoxious behavior has been eliminated, mainly due to an entrance fee. After dark, bathing suits are optional and with an adults only requirement. During the day children are welcome. Bus loads of school age children often visit the site. The entire facility can be rented for private functions, as well.

Fish Creek Falls waterfall.

The ticket booth.

The site is in a valley surrounded by Aspen trees, with deer, fox, and birds all around. Nighttime soaking provides an unobstructed view of the stars. The nearby Fish Creek Falls (283 feet high, 86 meters) waterfall is one of the local attractions that is a "must see."

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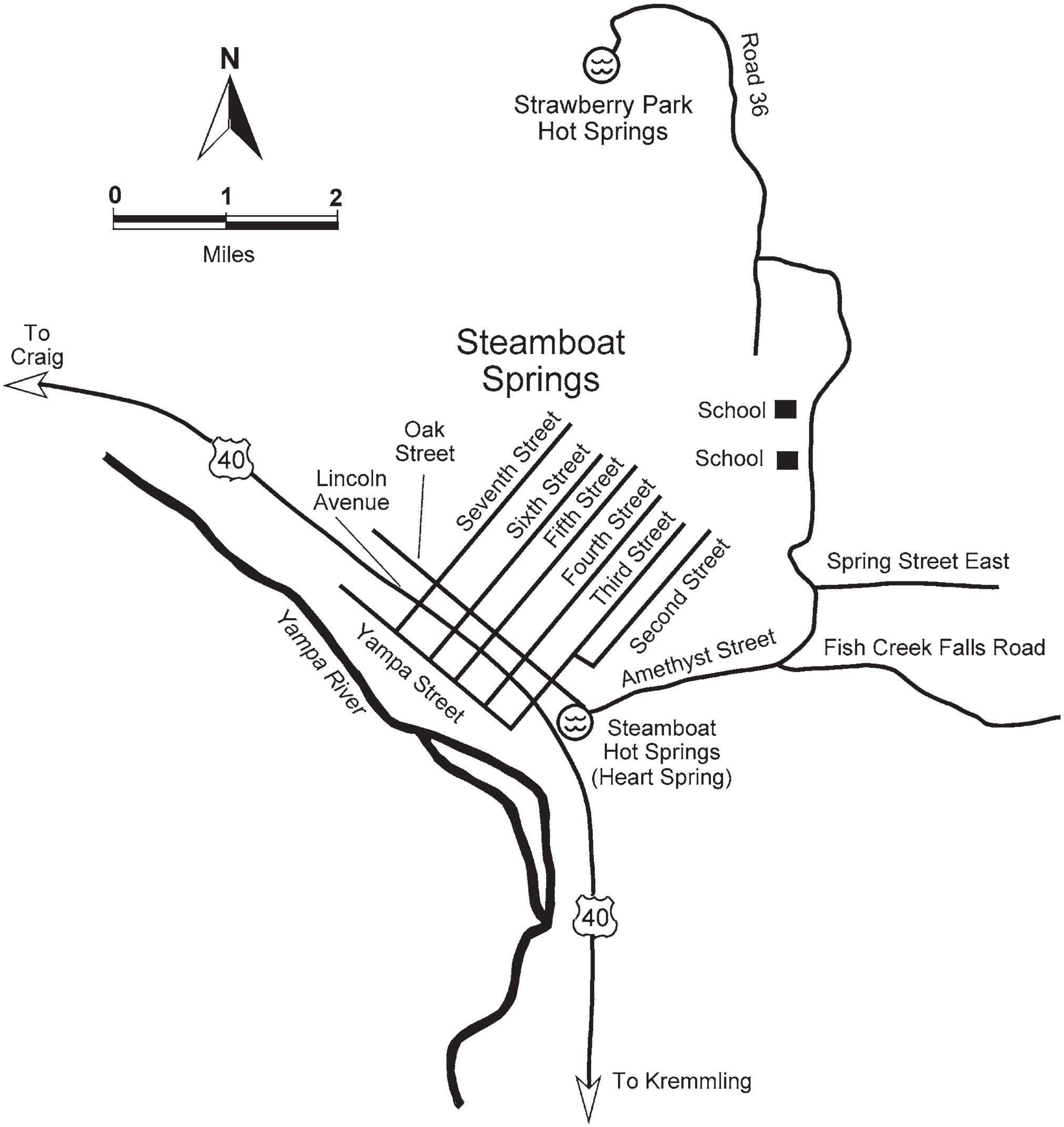
N
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Miles
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Hot Springs
Road 36
To
Craig
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40
Oak
Street
Lincoln
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Seventh Street
Sixth Street
Fifth Street
Fourth Street
Third Street
Second Street
Spring Street East
Fish Creek Falls Road
Amethyst Street
Yampa River
Yampa Street
Steamboat
Hot Springs
(Heart Spring)
40
To Kremmling

HOT SULPHUR SPRINGS, COLORADO

John W. Lund, Geo-Heat Center

Hot Sulphur Springs, located adjacent to the Colorado River, is between Kremmling and Granby, Colorado, on US Highway 40. It is located at 7,600 feet (2,300m) near the Continental Divide, and is fed by Springs at 125°F (52°C), flowing over 200,000 gallons per day (757m^3). The resort has 24 pools and private baths with no chemicals added to the spring water which is used at 98° to 112°F (37°to 44 °C).

The main resort building and swimming pool.

The springs were originally used by the Ute Indians, who were pushed back by the early European settlers. The Utes tried to discourage these early settlers and soldiers by resorting to a scorched earth policy, but to no avail.

In 1863, William Byers, publishers of the *Rocky Mountain News*, bought the springs from a Sioux woman in what was a questionable transaction. That was contested in the courts as the Utes were considered the rightful owners. Byers prevailed and built a four-story hotel (which burned in 1903), a racetrack, a covered pool and his personal summer house on the site. Early visitors had to come by coach or on horseback, and had to ford the Colorado River to reach the resort. The Moffat Tunnel, through the Front Rouge, allowed the Denver and Rio Grande Railroad to reach the site in 1928. Unfortunately the resort never grew into the high-profile destination that Byers had envisioned.

Notables who have visited the site are Zane Grey, who rented a cabin nearby, and John Wesley Powell who practiced on the rapids on the river in preparation for his historical Grand Canyon expedition.

For many years it was only a summer resort as it was difficult to reach this isolated site during winter months. Now it is both a summer and winter destination resort.

The present owners have revitalized the resort's swimming pool and have added soaking tubs, massage treatments, a conference room and private baths for individual use. There is also a vapor cave and a grotto pool with a massage waterfall (Ute Cave pool), seventeen room hotel with no television or telephones in the rooms, available for overnight guests. There is also a refurbished 1840's cabin overlooking the resort that is also available for overnight guests.

Two of the small soaking tubs.

When the resort reopened in 1997, two eagles flew over while the Ute Holy Man was blessing the spring's water – a very auspicious sign.

The Ute Cave Pool with massage waterfall.

The spring water is mainly of a sodium (435 ppm), sulfate (145 ppm), and chloride (145 ppm) composition with some silica (33 ppm), potassium (24 ppm), calcium (15 ppm), fluoride (11 ppm), magnesium (3.2 ppm), lithium (1.3 ppm), and traces of iron, manganese, zinc and arsenic.

During my visit there last summer, I was impressed with the many levels holding soaking tubs with views of the surrounding area, including Longs Peak (elevation 14,255ft – 4336m). It was a very clean, peaceful and friendly resort, worth a day or longer visit, as there is much to do in the area. The small town of Hot Sulphur Springs is not much to look at, but has a gas station, grocery store, hotel and other services available. The spa's motto is "Soaking and relaxing at its best."

A view of the resort from one of the upper soaking tubs.

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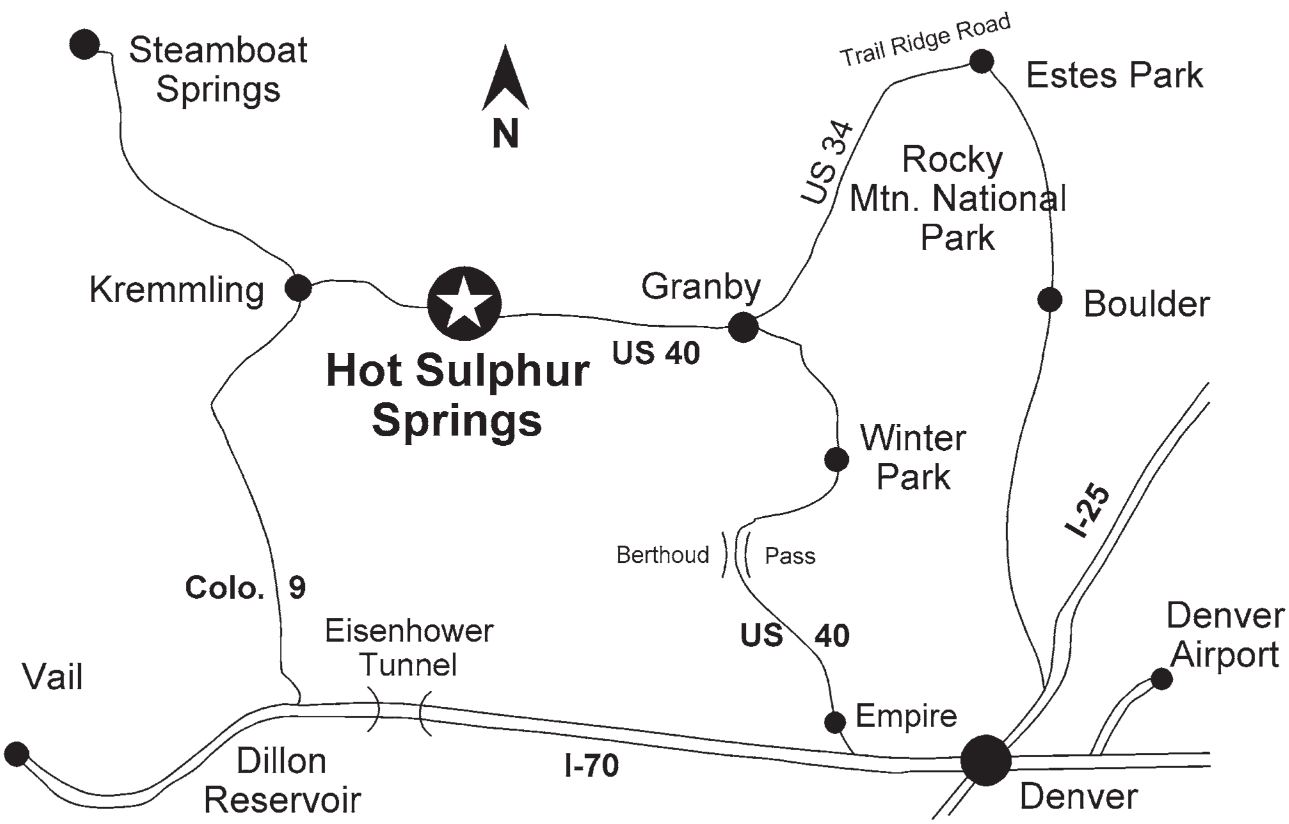
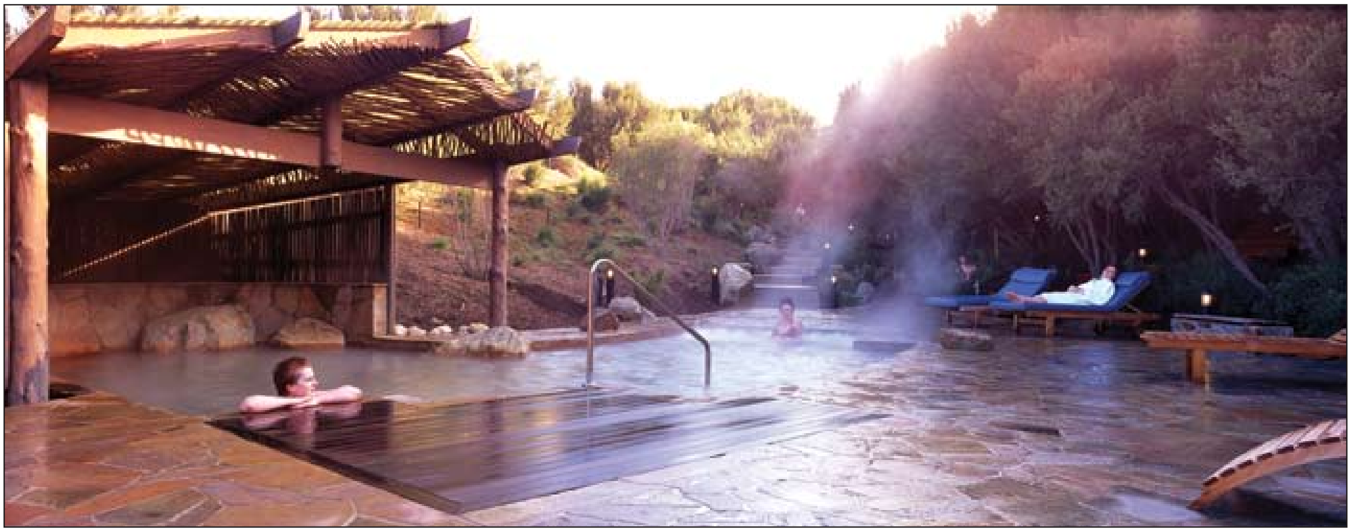


PENINSULA HOT SPRINGS – A DEVELOPERS STORY

Charles Davidson, Peninsula Hot Springs, Victoria, Australia



Main Pool.

INTRODUCTION

In the gold rush state of Victoria, there's a new rare find: liquid gold. It's pretty much a given that you'll find hot mineral springs in relatively young lands of vaulting, geological upheaval like New Zealand, Alaska, and Japan. But in the ancient, stable rock strata of the Great Southern Land, it is thought a rare find, truly liquid gold.

The Australian state of Victoria was the destination for waves of gold miners in the 1850's Californians, British, Irish and Chinese among them seeking their fortunes with pick and shovel. In February 2002, Victoria's ground again yielded excitement, when Melbourne television news stations captured the moment that hot mineral water gushed from a 2,090 feet (637m) bore at Rye on the Mornington Peninsula, about one hour's drive south of Melbourne.

The sight of the 122°F (50°C) geyser was a hugely satisfying waypoint on a fascinating journey for Charles Davidson and his brother Richard. The brothers still meet with incredulous hydrologists and geologists from younger lands amazed that they have tapped a natural hot water spring in a country where 'mountains' are more akin to the old weathered molars of some ancient, tired beast.

In fact, Japanese hydrology experts went so far as to say 'no way' to Charles when he first began to investigate spa culture and bathing, with dreams of returning from his job in Japan to build a natural hot spring center at home.

Opening on 28 June, 2006 with brothers Norm and Bruce Cleland joining the Davidson brothers, Peninsula Hot Springs is a facility employing 75 people by tapping 122°F (50°C) geothermal waters from an aquifer 2,090 feet (637m) below the 42 acre (17 hectare) Mornington Peninsula property. It is the first hot spring bathing facility in Victoria, and the only one in Australia to integrate therapeutic spa, bathing, accommodation, food and beverages. The facility includes public and private hot spring baths, a massage spa center, relaxation rooms, café and juice bar, gift shop and a booking office for activities and accommodation.

Richard and Charlie Davidson.

THE LEARNING EXPERIENCE

The inspiration for the project began when Charles visited several hot springs while in Japan in 1992, working for Mitsubishi Corporation. This sparked off several years of touring and studying hot springs around the world.

In May 1997, Charles heard a rumor that hot geothermal water had been discovered on the Mornington Peninsula in 1979, and a search of Department of Minerals and Energy records substantiated it.

Melbourne is a wonderfully multi-cultural city, having the benefit of various waves of immigration throughout its history.

Similarly, Peninsula Hot Springs could be said to reflect a multi-cultural bathing experience with the benefit of Charles Davidson's worldwide research into hot springs and spas. In his research, Charles visited spas in Japan, China, Europe, Yemen, Egypt and Turkey. He talked with spa experts in Russia, the United States and Canada. In Japan, at a visit to Daimaru Hot Springs, he met Professor Sato, Chairman of the Organization for the Preservation of Japanese Hot Springs, who taught him the sustainable nature of the business.

For 1500 years the Sato family had been operating the Daimaru Hot Springs Inn, where they provided rest, food, shelter, and a hot bath to travelers before they set out on the trek through the high, snow covered mountain pass from Kyoto to Tokyo.

The modern day concept of needing to continually grow and expand had been surpassed by the desire to serve and to exist in harmony with the environment. A harmony with nature seemed to be their key to longevity.

Based on an introduction by John Lund after a visit to his home in Klamath Falls, Charles met with Dr. Vladimir Adilov, Principal of the Russian Mineral Authority, who in turn introduced him to several geothermal experts, including Nikolai Strozhenko, Vice Minister of Tourism in Russian and President of the Russian Spa Federation. Mr. Strozhenko had a photo on his office wall with him and Boris Yeltsin arm in arm at a health retreat at the Black Sea, confirming their belief in the healing powers of bath in Russia.

Charles also undertook a two week spa education course in Karlovy Vary (Karlsbad) in Czechoslovakia (1998) now the Czech Republic, coordinated by Dr. John Paul De Vierville, the Education Director of the International Spa Association (ISPA).

The link between the medical profession and the spa industry was almost total, as in then Czechoslovakia, all medical doctors were required to study balneology (the use of water in health and healing) as an element of their undergraduate training. Spa programs were prepared and coordinated by medical doctors. As in much of Europe, the spa is integral to national health programs and plays a vital role in the health and wellbeing of its citizens.

Charles' next stop was to Yemen, as he wanted to prove a theory that all cultures with hot springs would have bathing as an element of their living ritual, no matter their economic state. As it turned out, the Arabic way of the bath in this one of the world's poorest countries, like the culture itself, proved itself to be incredibly developed and sophisticated. In Sanah, the capital of Yemen, there were 17 public baths, one of which was 2,200 years old and still operating. While none of the city baths were fed by hot springs, he was able to visit three natural hot springs within a few hours' drive from the capital. The Arabian bathing culture saw women and men allocated separate times to bath and at all times bathing costumes were worn.

Charlie in Yemen.

Later in 1998, Charles visited "New World" baths in Canada and the United States, as the day spa boom was starting to gain momentum in these countries. Major cosmetic companies and their branded retail muds, oils, creams, and lotions were part of this growing economy.

The conclusions of his observations were that hot spring spas could be categorized into three types:

(1) the European medical spas, (2) the Asian nature-based relaxation spas, and (3) the American beauty spas.

Medical spas provide programs that follow a prescribed health routine including elements of outdoor exercise and drinking the waters for their mineral benefits. Relaxation spas draw people out into the environment where contemplation, reflection and calm are to be found. Beauty spas tickle and pamper the mind, body and spirit while driving home a branded retail product sales pitch.

THE PLANNING

After traveling to 45 countries and researching spas in 15, Charles has seen the diversity and possibilities of bath life. The simplicity of the bathing experience in thermal water and the relaxing sound of "aaaaaahhhhhh!" as you immerse yourself into the warm water was the central experience.

Back in Australia, Richard worked on the land and the planning application. Through 1998 and 1999 Richard oversaw the planting of 7,000 indigenous trees on the Mornington Peninsula property. The number has since grown to more than 20,000 plantings. Having a Masters Degree in Environmental Science, Richard shared Charlie's vision of a center that worked with its local environment enhancing, but not dominating it. The brothers felt that a bath in nature, at Peninsula Hot Springs, would have to be one in the nature of their Mornington Peninsula land and one that shares with their customers the peaceful and gentle world knowledge of the bath.

The brothers wanted time in the outdoor baths to be a 'timeless zone' where birds come to visit, and at night inquisitive possums would walk through the trees above the bath under the southern stars. They envisioned an experience that would transform people from their busy world into a place where a connection with nature can be found. "The realization that we are part of the universe and not separated from it will provide a sense of connection and self. Visitors to this place will not know the passage of time and will almost forget to leave," Charles wrote for a spa association paper before the center was completed.

Small soaking pool.

THE CONSTRUCTION

Award winning Australian architects, Gregory Burgess Architects, brought their extensive experience with the Australian environment and in particular indigenous Aboriginal connections translating to the project a living cultural experience. They worked closely with Taylor Cullity and Lethlean, Landscape Architects to design the building, pools and surrounding landscape. Hot, warm and cold baths, steam rooms and saunas along with indoor and outdoor mineral baths in both private and public configurations were made available.

This, coupled with features gleaned from overseas, provided a diversity of cultural bathing experiences with quiet spaces and tranquil places for discovery and creativity.

Small soaking pool.

In addition the buildings are heated with the geothermal waters, and a greenhouse and fish farm will also be developed to provide a living example of what is possible with geothermal waters. These will be complemented with a Center for "Geothermal and Environmental Demonstration and Education" that will share the knowledge gained with many people with an interest in what the Peninsula Hot Springs trio have learned along the way.

With the Mornington Peninsula recently receiving UNESCO accreditation as the world's first "Urban Biosphere", education on the possibilities of a sustainable future is more than a responsible activity, it is a community expectation. The thermal waters flow from Selwyn Fault and out into Bass Strait. Ten thousand years ago, when it was possible to walk from the present day Mornington Peninsula to Tasmania, one was greeted with the joy of natural hot spring pools along the way. With the rising of the waters the natural springs are now found under the ocean where they form their own micro climates of warm, fresh water zones. The only way to reach the thermal waters was to bore down. The drilling program started in late 1998, and after several failures, was completed in 2002. The final bore was drilled to a depth of 2,090 feet (637m) through a variety of sands, limestone, marls, brown and black coal, and finally to a basalt basin. The bore has a capacity of (872 gpm (55 l/s)) producing 122°F (50°C) geothermal waters. The water has a total dissolved solids (TDS) content of 3200 mg/l (ppm) and a pH of 7.09. It is classified as sodium chloride bicarbonate water and also contains 95 mg/l magnesium, 81 mg/l potassium and a wide variety of other minerals and trace elements. The water rises under its own pressure to a depth of 29 feet (9m) from the bore head, which is approximately 60 feet (18m) above sea level.

Future plans will see an expansion of the pools and spa center, construction of 180 rooms of accommodation, a wellness center spa, as well as a wellness school, and a variety of satellite spas with country themes including Maori from New Zealand, Japanese, Arabic and Indian. The facility seeks to be fully sustainable with an underpinning belief of treading lightly. It has an egalitarian philosophy offering an experience that is available to and welcomes everyone.

Well and heat exchangers.

CONCLUSIONS

John Lund and his family were guests at Peninsula Hot Springs in July 2007, and spent an evening soaking in the various pools and tubs. Relaxing under the stars and the Southern Cross, they were able to understand Charles' dream and goal to provide "bathing in nature". We were also privileged to be entertained by a local musician and sample the wonderful food prepared by Charlie's chef-in-residence. Charlie's 75 full-time and part-time employees were like one big family, all having pride in the spas' operation. "We have visited and dipped in many hot springs throughout the world, but this was one of the best", commented John.

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