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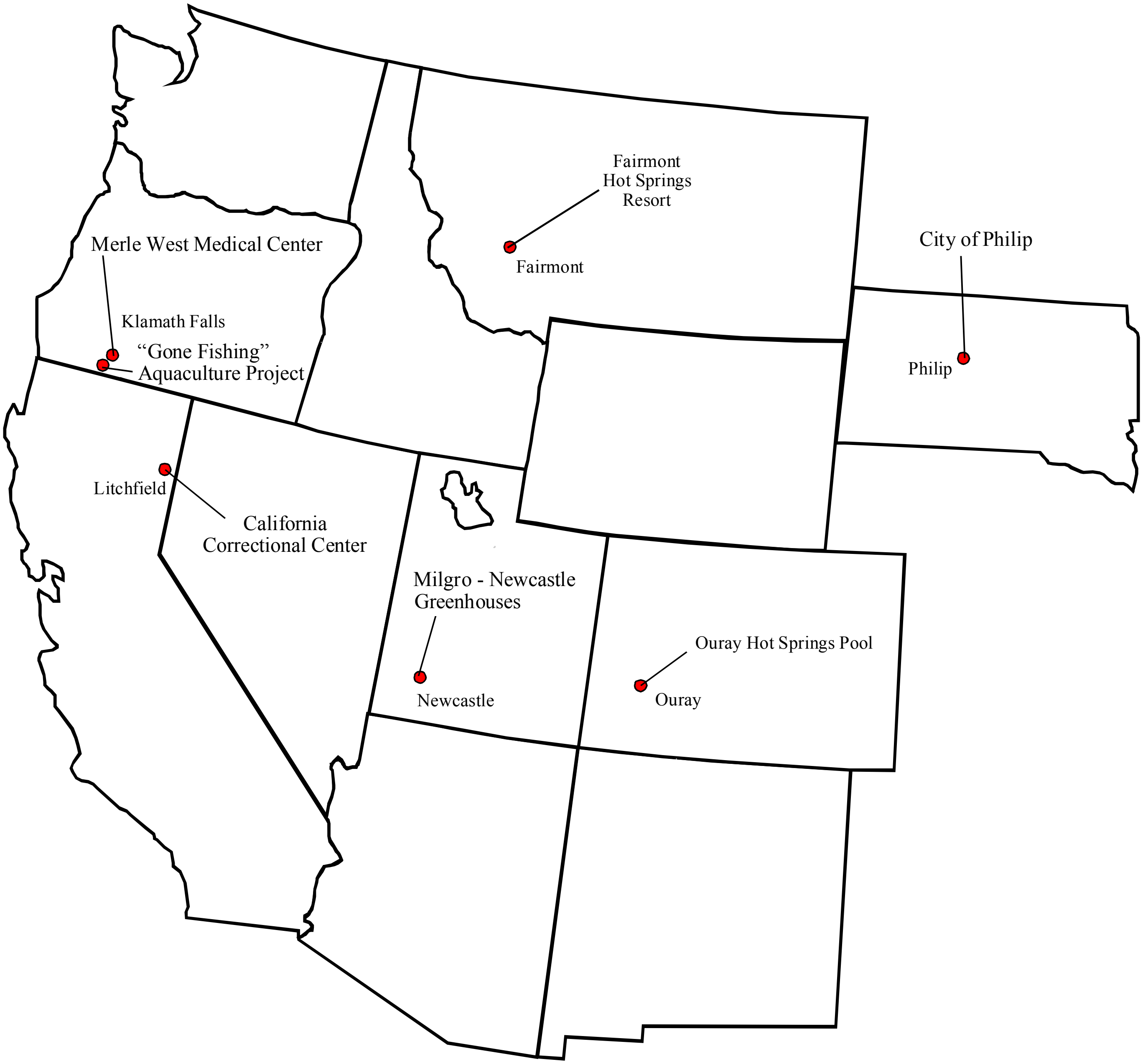

GEOTHERMAL DIRECT-USE CASE STUDIES

Vol. 24, No. 2 **June 2003**

GEO-HEAT CENTER QUARTERLY BULLETIN

ISSN 0276-1084

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

CONTENTS

COVER: The following case studies were developed at the request of the USDOE National Renewable Energy Laboratory (NREL) to provide a thumb-nail description of a cross-section of geothermal direct-use projects in the U.S. They were compiled and written by the Geo-Heat Center Staff this past year, and an additional set will be prepared for the current year.

BACK COVER:
Dr. Roy Mink Named New Director of USDOE Geothermal Program
Geothermal Resources Council, 2003 Annual Meeting, Morelia, Mexico, October 12-15, 2003.

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CALIFORNIA CORRECTIONAL CENTER
SUSANVILLE, CALIFORNIA

CCC in foreground, Honey Lake Valley and Diamond Mountains to the south.

LOCATION

The California Correctional Center is located in Honey Lake Valley of northeastern California, about seven miles east of Susanville in Lassen County. The facility, operated by the state of California, was converted to geothermal heating in 1983. The facility houses around 5,800 minimum custody inmates, and some 1,100 custodial and support staff are employed at the 1,112-acre site.

RESOURCE

Two wells, approximately 1,400 feet deep, were installed on a tract of land some two miles east of the site by the Carson Energy Group, Inc. of Sacramento (1981 and 1983). The wells are located just south of the Modoc Plateau volcanic region in lacustrine gravels and near-shore deposits of pluvial Lake Lahontan, which is cut by a small west-northwest striking lateral fault. The wells are owned and operated by the city of Susanville, the surface land owner, but a royalty is paid to the subsurface landowner. One well produces 169EF water and the other delivers 162 to 165EF water. In 2001, the casing on the hotter well collapsed and was deemed too costly to repair, and the cooler well has been used since then. Four binary power plants and a small district heating system in the city of Susanville also use geothermal heat in the area (170 to 230EF). The water has about 600 ppm with mainly sulfate, sodium, chloride, and bicarbonate species, and with trace amounts of hydrogen sulfide, boron and arsenic that exceed drinking water standards.

UTILIZATION

Geothermal heat is used for 50 to 80% of the prison's space and domestic water heating, as well as for a medium-sized greenhouse. It is supplemented by the existing diesel-powered system. The geothermal heating is used for inmate dormitories, but generally not for the staff areas. Heat is supplied by a centralized force-air duct system to individual rooms. The estimated peak heating load is 158 therms/hr and the annual load is 434,000 therms for a utilization factor of 0.255 and a peak capacity of 4.65 MWt.

A 75-hp oil-lubricated pump produces about 300 gpm into an underground supply line (asbestos cement and iron piping) to the prison boiler room. After passing through a sand filter, the supply water is routed to one of two plate heat exchangers for space heating and a small heat exchanger for domestic hot water. Incoming water on the closed loop system is about 70EF, and the outgoing water on the domestic loop is heated to about 124EF using a stainless-steel plate heat exchanger. Water going out to the space heating loop is usually heated to 140 to 150EF when needed in the winter time. Three 30-hp pumps produce flows in the space heating loop as needed. After being passed through the heat exchangers, the 140 to 150EF geothermal water is sent to a medium-sized greenhouse about 500 yards to the east. Here a portion of the hot water is diverted and passed through a manifold heating system underneath two lengths of plant trays. This heating is used during cool periods to maintain a fairly constant temperature of 72 to 79EF in the greenhouse.

After the geothermal water passes through the greenhouse, it is returned to the city and distributed to a dispersion area consisting of a 20-acre application area and a 200-acre evaporation pond. The water is sprinkled over the application area to either evaporate or drain into an overflow pond. Some of the water flows directly into a privately-owned pond that supports bass, waterfowl, deer and antelope. Cottonwood trees and other riparian species have established themselves around the perennial pond. The estimate temperature of the water coming into the pond is around 122EF.

OPERATING COST

The initial capital cost of the system installed in 1980 is unknown, and has probably been amortized over the past 22 years. The well are estimated to have cost around $180,000. At present, the state of California pays the city of Susanville $17,062 per month on a "take-or-pay" basis, which allows them to use up to 525,000 therms/year. This cost includes the well pump, electricity cost, maintenance and overhead for the city. In addition, the prison Chief Engineer of Plant Operation estimates that slightly less than $1,000 per year is expended for repairing pipe leaks (about one repair per year in the 10"-pipe) and for other routine maintenance work. This then works out to about $0.39/therm. If the measured usage exceeds the 525,000 therms/year, then a charge of $0.39/therm is accessed for the additional amount.

The city of Susanville, which supplies the geothermal water, budgets $150,000 per year for this operation. This includes: $22,500 for personnel, $20,500 royalty to the property owner (amounting to $0.04/therm), $70,500 for services and supplies (which includes $20,000 for utilities), and $36,500 for overhead (accounting, billing, etc.). This amounts to about $0.29/therm. The actual pumping energy use for the year 2001/2002 was 323,200 kWh at a cost of $27,205.

The competing fuel is natural gas, for which the city charges $1.22/therm, diesel at slightly under $1.00gal = $0.70/therm, and electricity at 6.9cents/kWh = $2.02/therm. Thus, the savings to the prison would be slightly over $36,000 per month as compared to natural gas supplied by the city and a saving of about $13,500/month compared to diesel. However, a recently installed state-owned natural gas pipeline in the area may replace many of the area's current geothermal operations, including that of the prison, the price yet to be determined. This may occur when the current contract runs out in 2007.

ENVIRONMENTAL IMPACT

While the system does not have an injection well, the disposal of the geothermal water on the application area and associated ponds appear to have minimal environmental impact. There does not appear to be any corrosion or scaling problems in the system, especially since plate heat exchangers are used to isolate most of the secondary system.

REGULATORY ISSUES

No major problems were encountered with the permitting process. The project required an environmental assessment for Lassen County, a discharge permit from the California Water Quality Control Board, and a well drilling and completion permit from the California Division of Oil, Gas and Geothermal Resources. If built today, the project would also require a wet lands permit.

PROBLEMS AND SOLUTIONS

The only major problems are the replacing of the well pump bearings, bowls or shafts about every three years at a cost $10,000, and breaks in the supply line (about one per year) at a cost of $800/year. These, however, appear to be normal operating costs. They recently upgraded the variable-speed drive on the well pump from fluid coupling to variable frequency, due to the cost of replacement parts for the older system. One well did collapse after 20 years of use and is no longer used.

CONCLUSIONS

The system appears to be operating without major problems and is cheaper than current alternative fuel costs. Cheaper gas from a state-owned natural gas pipeline may replace the geothermal heat in 2007; however, the price has not been established at this point.

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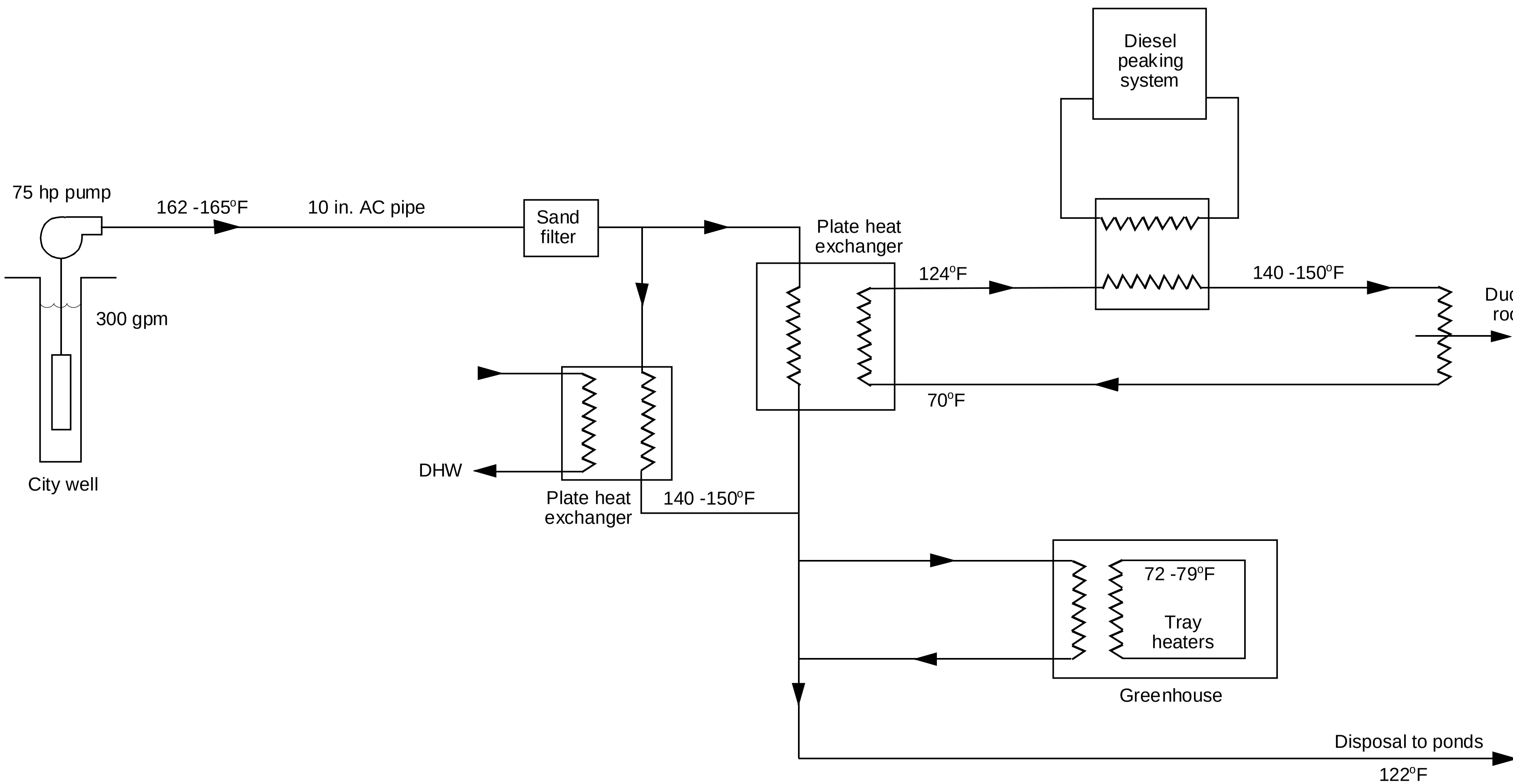
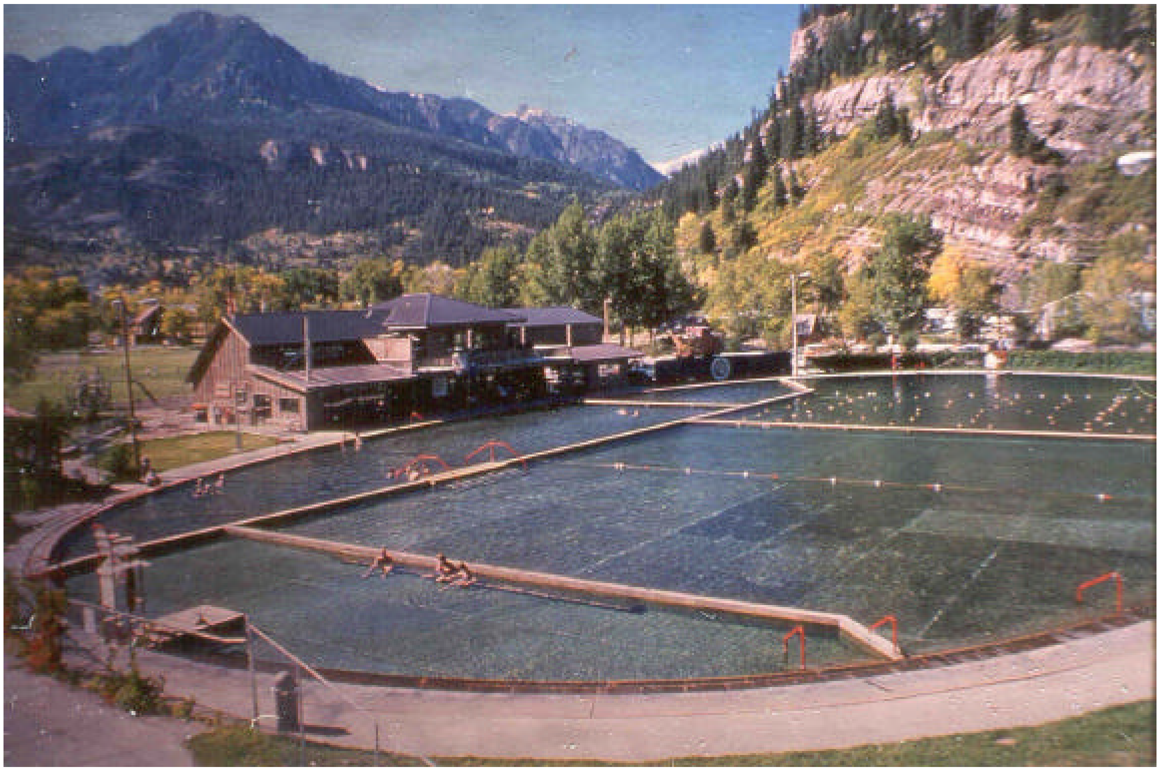


California Correctional Center Geothermal Schematic

OURAY HOT SPRINGS POOL
OURAY, COLORADO



LOCATION

The Ouray Hot Springs Pool is located on U.S. Highway 505 at the north end of the town of Ouray (about midway between Durango and Grand Junction). At an elevation of approximately 8,000 ft, the town is located in a valley surrounded by the 12,000 to 13,000 ft peaks of the San Juan Mountains making for an impressive setting. The original construction of the 125 x 150-ft ellipse shaped pool was completed in 1927 by the Ouray Recreation Association After two years of operation, the pool was taken over by the city and has been operated as a public facility ever since.

RESOURCE

Numerous hot springs issue from locations both in and around the town of Ouray. These springs typically produce fluids in the 80 to 150ºF range depending on location and are used for heating the pool and some local privately owned spas and motels. The original plan was to use water from a resource on the pool site. Unfortunately, this proved insufficient so a trench was constructed to bring water from the Box Canyon Spring, approximately one mile to the south, to the pool. This resource proved to be sufficient to allow operation of the pool during the warmer months of the year and eventually the trench was converted to a pipeline. In the 1980s, the town decided to explore the development of a district heating system. Six test wells were drilled, two of which were near the pool. Though the district heating system was not developed, one of the wells is used to supply water to the pool and this additional source is sufficient to permit year round operation. At present, the pool receives approximately 120 gpm of 145ºF water through a pipeline from the Box Canyon Spring and approximately 134 gpm at 124ºF from well OX-2. The water chemistry for the springs varies somewhat, but is very hard (500 to 1,000 pm as $CaCO_3$), TDS of approximately 1,000 to 2,000; pH of 7 (field) and 8 (lab) and 500 to 1,000 ppm sulfate. Scaling is a problem in most cases.

UTILIZATION

Water from the two sources described above is supplied to the pool and in the winter months to a heating system for the pool buildings (totaling approximately 5700 sq ft). For the pool itself, the combined flow from the spring and the well is delivered to a concrete tank on the west side of the facility. Here chlorine is added and the water is pumped to the filter room. The geothermal water is passed through two sand pre-filters to remove iron and manganese and then is mixed with pool water after it has passed through the main filters. Three distinct temperature zones are maintained in the pool--a smaller 104ºF section, a larger 98ºF section and the main portion of the pool is allowed to "float" using whatever geothermal water is left after satisfying the warmer sections.

Temperature is maintained by manually adjusting valves which mix the geothermal water with the filtered pool water. Overflow from the pool is delivered to the Uncompagre River located adjacent to the facility.

In addition to the pool heating, a small flow is diverted from the Box Canyon Spring line to provide heating of the pool building. Geothermal water is supplied to a plate heat exchanger at a rate of 90 gpm. The heat exchanger produces 110°F water which is circulated to the radiant floor/fan coil system in the building. This system provides approximately 288,000 Btu/hr (0.1 MWt) to the building with an annual use of 0.6 billion Btu. Assuming an average pool temperature of 75°F and an average air temperature of 50°F, the peak load is then estimated at 6.0 million Btu/hr (1.8 MWt). At 8,000 hours per year (assuming a few hours in the dead of summer where minimal heat is required), the estimated annual heating use is 48,000 billion Btu.

OPERATING COSTS

No pumping of the geothermal fluids for this facility is required. The spring is located uphill from the pool and flows by gravity through the pipeline. Well OX-2 is artesian and no additional pumping is required. The only pump located on the geothermal side of the system is the one that transfers the water from the concrete tank to the pool filter room. The 15-hp pump operates continuously resulting in an annual cost of approximately $7,800. Aside from this, regular maintenance consists of replacing the sand in the geothermal pre-filters every six months. Once a year, the plate heat exchanger must be cleaned and descaled and this incurs a cost of $200. The original asbestos cement pipeline from the spring was replaced recently with 10" PVC material at a cost of approximately $20,000. Periodic descaling of the pipeline is performed annually at a cost of about $500. The total budget to operate the pool amounts to approximately $540,000 per year and revenues from its operation are $660,000 per year.

REGULATORY/ENVIRONMENTAL ISSUES

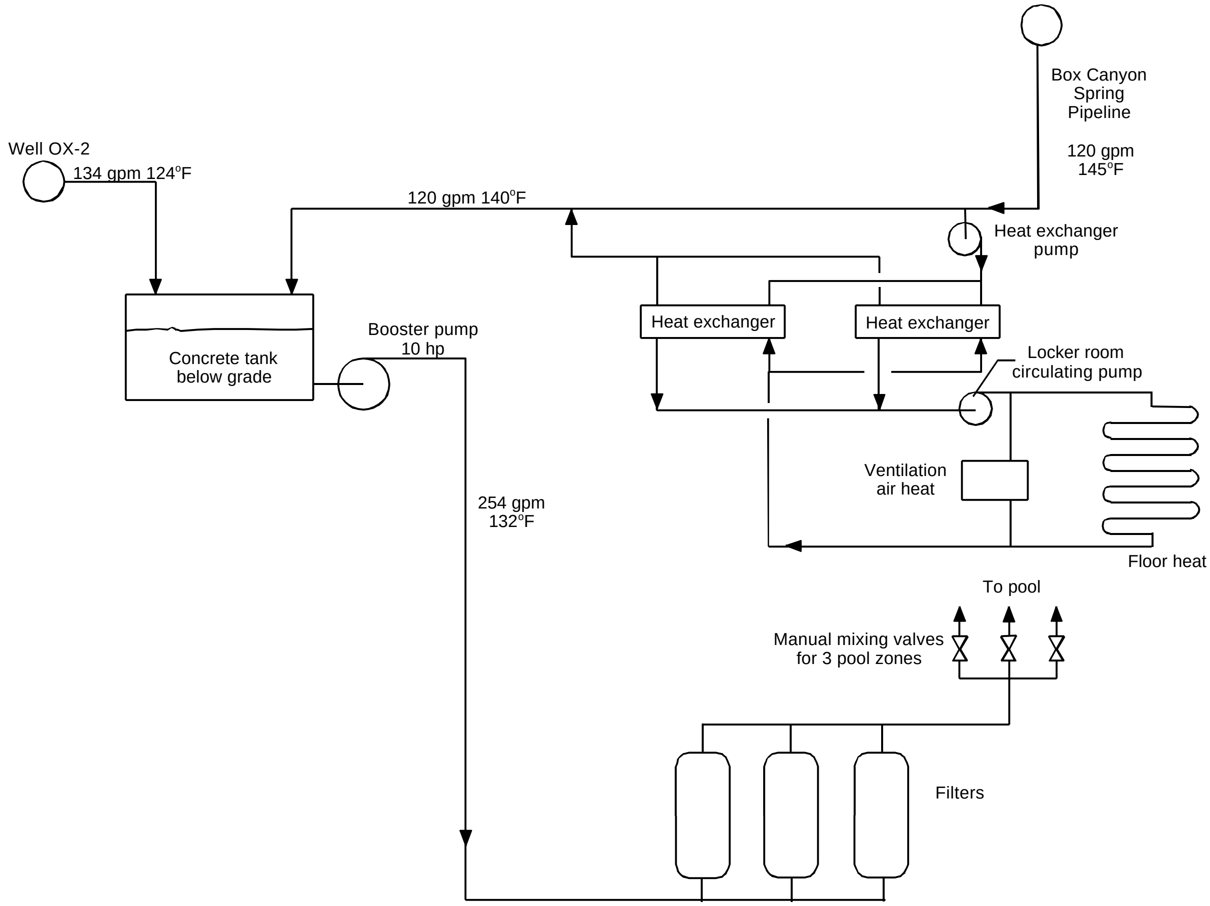
Since the pool was established in 1927, it existed long before most regulatory agencies and rules were developed. The pool operates as a "flow through" design and disposes directly to the Uncompagre River. This river does not support a fish population due to its natural water chemistry. In recent years, a chlorination system has been added to the pool and a residual chlorine level of 1.0 ppm is maintained in the pool water. This is well below the level required in conventional pools. Disposal of the water to the river is governed by a state surface disposal permit which specifies flow, TDS, temperature, chlorine and ammonia limitations.

PROBLEMS AND SOLUTIONS

The very simple nature of the system results in a low incidence of operating problems at the facility. Other than the replacement of the pipeline mentioned in the above section, no major mechanical issues have surfaced with the system.

The drilling done by the town in the 1980s, though not directly connected with the pool, did cause some problem with one local spa. The spa claimed damage to their spring flow from the test drilling and a legal agreement was developed with the town to supply a small flow (30 gpm) to the spa owner as compensation. At this writing, a pipeline is being designed to deliver the flow from the existing Box Canyon line supplying the pool.

Conclusions and Recommendations: The pool is a very successful operation and one which generates substantial tourist activity for the town--the primary industry in Ouray. Given the age of the pool, the low level of maintenance is impressive.



Ouray Hot Springs Pool Schematic

”GONE FISHING” AQUACULTURE PROJECT KLAMATH FALLS, OREGON

Overview of the 72 15-ft x 100-ft fish ponds near Klamath Falls, OR.

LOCATION

The “Gone Fishing” aquaculture project is located about 10 miles south of Klamath Falls, Oregon, near Merrill in the Lower Klamath Valley adjacent to the Klamath Hills. The original ponds were construct in 1984 and had limited use. The present facility, operated by Ron Barnes, started in 1990 using the effluent from a geothermal greenhouse operation on the Liskey Ranch on Lower Klamath Lake Road. In 1998, he purchased 80 acres of land just north of the greenhouses on the opposite side of the road. Today, the operation consists of 37 ponds located on the Liskey Ranch and 35 at the new location. The aquaculture ponds are used to raise 85 varieties of tropical fish (cichlids) that originated from Lake Malawi in East Africa’s Great Rift Valley and from Central America. He sells 250,000 of the fish (3" to 4" long) annually to tropical fish wholesalers from Portland, OR to San Francisco, CA; shipped weekly by truck to Sacramento, and then by air to the various outlets.

RESOURCE

The geology of the area consists of large normal fault blocks, typical of the Basin and Range province. The Klamath Hills are typical of these fault blocks, allowing geothermal waters that circulate at depth, and move to the surface in shallow aquifers. At the original location, a greenhouse complex consisting of four 6,000 square-foot buildings are heated using a peak of 400 gpm from six geothermal wells ranging in temperature from 80E to 200EF and all are around 100 feet deep. The newer set of ponds are provided geothermal water from a 460-foot deep well that pumps up to 300 gpm of 210EF water. The water surface in the newer well is at 120 feet and the lineshaft pump bowls are set at 190 feet. The water from the wells is alkaline with a pH of 8.8 out of the wells, but the chemical composition of the pond liners (diatomaceous earth) and soil surrounding the ponds reduce the pH to about 7.5 as the water flows through the system. The water is primarily a sodium-sulfate type of about 600 ppm that can be used directly in the ponds without harm to the fish. This is about the same chemical composition as the water of Lake Malawi.

UTILIZATION

At the greenhouse location, a 14,000-gallon steel railroad car tank is buried in the ground that receives water from one of the wells, and then supplies 180E to 185EF water to the greenhouses. Depending upon the outside temperature, the water leaves the greenhouses at 165E to 180EF; where, it is then piped to Barnes' original ponds that are kept at nearly a constant temperature of 80EF ±3EF; even though, the fish can easily tolerate ±10EF. The wastewater from the ponds is then fed to a holding pond where it is cooled and then used for stock watering and irrigation. The water from the newer well is stored in a similar railroad car tank of 14,000 gallons and then gravity fed through a 4-inch diameter aluminum pipe adjacent to the ponds. Each pond is then supplied 197EF water through 1-inch CPVC pipe. It quickly mixes with the pond water, causing no harm to the fish, and levels out the pond water at around 80EF. The pond water is kept within 3EF of the desired temperature. The wastewater, that is not lost through evaporation and leakage, is disposed of into the same stock pond. The flow to the ponds varies from 50 to 300 gpm depending on the outside temperature and wind, with an annual average of about 100 gpm. A few of the ponds, which are in a more porous soil, have to be lined with black plastic to prevent severe water leakage.

The temperature and flow rate into the various ponds is controlled manually by feel. Gate valves at each pond are then set to achieve the proper temperature. This "hand feel" method is felt superior to electronic control valves, as these often stick open and thus, "fry" the fish. It is felt that pond temperature is kept with ±3ºF, sufficient for optimum growth.

It is estimated that the installed capacity of the newer facility, based on a peak of 300 gpm and a 10ºF-temperature drop in the water, is 1.5 million Btu/hr or 0.44 MWt. Using an annual average of 100 gpm, the total energy use is then 4.38 billion Btu/yr.

OPERATING COST

No cost figures are available for the original ponds constructed adjacent to the greenhouses. The new ponds and well construction in 1998 were funded by two Oregon Economic Development loans for a total of $100,000. The well cost $15,000 and the excavation for the ponds cost $15,000. The remainder of the funds were used for controls, pumps, piping and storage tank. Operating cost at the original site is at a fixed rate of $350 per month, since the resource is owned by Liskey Farms, Inc. There are no pumping power costs, since the ponds are filled with wastewater from the greenhouses. At the new location, the pumping power cost varies from $280 to $400 per month with an annual average of $350 per month. The cost of electricity is 5.7 cents/kWh; thus, an average of 6,140 kW are used monthly. Approximately $500 per month is used for repairs and maintenance. Thus, the total annual operating cost is approximately $9,000. Barnes estimates that by using the geothermal heat energy, that he avoids the use of about 24 million kWh in electricity annually, for a savings of $1,350,000.

REGULATORY/ENVIRONMENTAL ISSUES

The main concern originates from the Oregon Department of Fish and Game. They do not want any of the fish to escape into waterways in the area. As a result, a 200EF barrier is provided in the original pond area that would "cook" any escaping fish. In the newer pond area, very little if any water overflows out of the ponds, and the little that does, mainly during the winter months, goes into a holding pond. Barnes is considering raising Tilapia and in this case, Fish and Game will require him to have a greenhouse type structure over the raising ponds and tanks to prevent any fish from escaping or being picked up and dropped by birds. The harvested fish cannot be shipped to market live, and thus must be killed and frozen on site before shipping. Also the Oregon Department of Environmental Quality would regulate the waste discharge from the Tilapia ponds; thus, a filter system would have to be installed, and a closed circuit system used. Water disposal from the tropic fish ponds is not a problem, as 500 lbs of fish per pond provide little waste. Discharge from over 20,000 lbs/year would be regulated by DEQ.

PROBLEMS AND SOLUTIONS

Four main problems exist at the facility: 1) lack of cold water for cooling the ponds; 2) corrosion in the aluminum pipes; 3) taking of fish by birds; and 4) limited capacity of the resource. Since, this is a geothermal area, cold water is a problem for both the greenhouse and aquaculture facilities. Cold water is then provided by cooling geothermal water in holding ponds. Internal corrosion in the aluminum pipe is a problem in the new facility due to the 195EF temperature of the water. In the facility adjacent to the greenhouses, the pipes have been in for over 20 years and have experienced no corrosion, as the water temperature is only 180EF. Black iron pipe placed under roads have experienced external corrosion from the soil. Birds are a problem at the older facility, since the ponds are adjacent to irrigation canals where Egrets and other birds live. This is not a major problem in the newer facility - so all that is really done at this point is to scare them away when they are working around the ponds. The maximum amount that can be pumped from the newer well is 300 gpm, and this is often reached during the winter months, especially when there is wind. This would then limited the size of the proposed Tilapia facility. Based on consultations with engineers at the Geo-Heat Center, they will experiment with two methods to reduce the evaporation. Since evaporation from the ponds can contribution to as much as 50 to 60% of the total heat loss, a wind barrier, and bubble mat pond cover are being considered. The bubble mat, similar to ones used for swimming pools and hot tubs, would cover a portion of the pond, since some of the pond area must be exposed to the air to provide oxygen to the fish. Various combination of 25, 50 and 75% pond coverage will be tried.

CONCLUSIONS

The "Gone Fishing" aquaculture operation appears to be successful, and plans are to expand from tropic fish to Tilapia. The success of the operation is due to two factors: 1) a readily source of geothermal energy, available at shallow depth with adequate temperature and flow; and 2) a operator/manager, Ron Barnes, who has the background and knowledge of aquaculture methods. He started small, and has increased in reasonable increments as he gained experience with using the geothermal resources. There are minor problems with corrosion of metal pipes, and efficient use of the resource, but these are being solved, and do not present a major expense and management problems.

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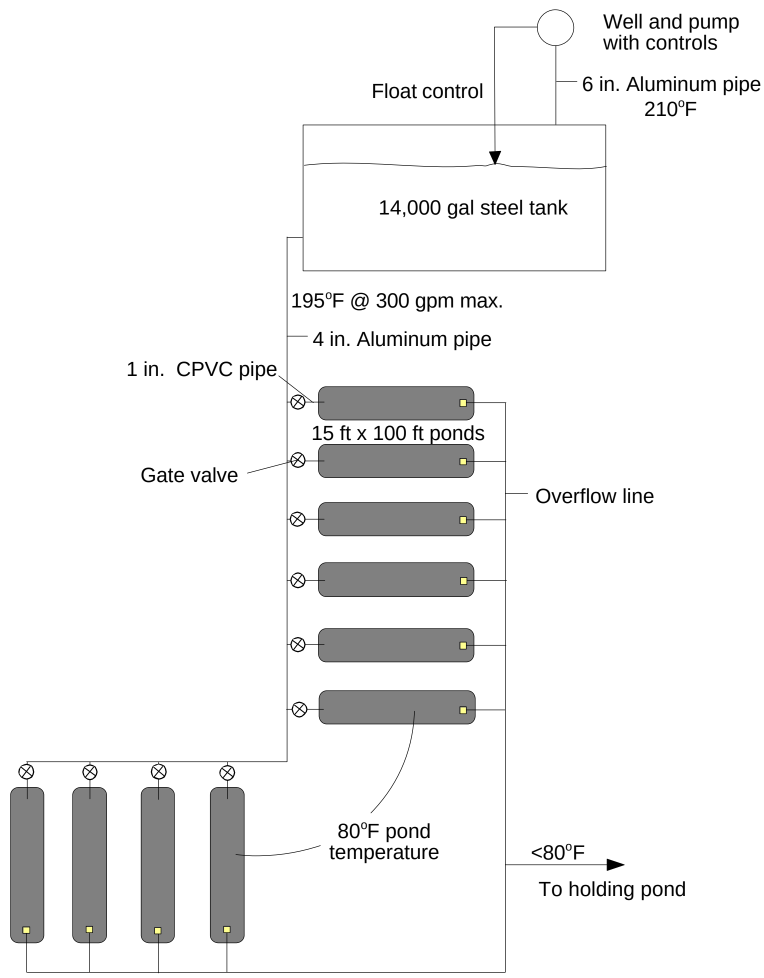


"Gone Fishing" - Schematic of the Newer Installation

MERLE WEST MEDICAL CENTER
KLAMATH FALLS, OREGON

LOCATION

The Merle West Medical Center (MWMC)(formerly Presbyterian Intercommunity Hospital) is located in Klamath Falls which is in south-central Oregon. Elevation at Klamath Falls is approximately 4,100 ft and the local climate is characterized by an annual total of 6,500 heating degree days. The medical center complex is adjacent to the Oregon Institute of Technology (OIT) campus at the north end of the city of Klamath Falls. The hospital was originally constructed in 1964 and the geothermal system was added as a retrofit in 1976. Numerous building additions have been completed since--virtually all geothermally-heated.

RESOURCE

The MWMC produces from the same aquifer serving the OIT campus and most of the other 550 geothermal wells in Klamath Falls. The water issues from a northwest trending fault bordering the east side of town. Water flows in a generally southwest direction from the fault mixing with cooler surface water as it proceeds. Temperature of the water tends to reach a maximum of approximately 220°F nearest the fault. Water chemistry is relatively benign with a pH of approximately 8 and TDS of 800 to 1,000 ppm. Despite this, isolation is typically employed, since the fluid does contain a small amount (approx. 0.5 ppm) of hydrogen sulphide. MWMC is served by a single production well 1,583 ft in depth with a static level of 332 ft. The well was originally tested at a flow of 500 gpm of 195°F water with a drawdown of 15 ft.

UTILIZATION

The original geothermal system for MWMC was designed to provide space heat and domestic hot water to the 96,000-sq ft main building; a new 56,000-sq-ft addition; the adjacent 56,000-sq ft nursing home and snow melting for the main entrance area. Since that time, the approximate areas heated have grown to include 300,000-sq-ft main building; 45,000-sq-ft medical office building; 56,000-sq-ft nursing home and a 80,000-sq-ft residential care facility. The system as indicated in the attached schematic includes a production well producing a peak flow of 600 gpm of 195°F water and equipped with a 125-hp motor. The well pump is controlled to maintain a constant pressure at the upper end of the system. The water is delivered to a complex of six heat exchangers in the main building, one in the residential care facility and two in the medical office building. In all cases, loads are arranged in series such that a maximum delta T can be achieved. In general, flow control at each heat exchanger is provided by a 3-way valve which serves to either divert geothermal water through the heat exchanger or past it to subsequent loads.

After passing through the plate heat exchangers, the fluid is delivered either to a final snow-melt system or diverted to the injection well collection tank. Two 15-hp injection booster pumps provide the pressure necessary to deliver the water to the injection well. The injection well is 1912 ft deep and was added to the system in 1990 (see regulatory section).

The estimated peak heating load for the buildings is 21 million Btu/hr (6.1 MWt) and the annual use is 22 billion Btu.

OPERATING COSTS

Operating costs specific to the geothermal system are not maintained by MWMC. For purposes of accounting, however, costs are apportioned to different individual sub-facilities comprising the MWMC. For example, the 80,000-sq-ft residential care facility is billed approximately $0.024 per sq ft monthly to cover maintenance and capital improvements to the geothermal system. In addition, they are billed for the heat consumed as measured by an energy meter. Similar arrangements are in place for the other two major stand alone buildings.

The actual electrical energy input for the system in terms of operation is quite small relative to the quantity of energy produced. Based on an approximate design capacity of 21,000,000 Btu/hr, a total pumping requirement of only 165 hp is needed. The geothermal pumping is not separately metered but calculations indicate that approximately 430,000 kWh would be required on an annual basis to operate the systems production, snow melt and injection pumps.

The MWMC engineering department performs all regular maintenance of the system and its director estimates that the equivalent of one full-time employee is required to handle the maintenance of the geothermal system.

REGULATORY/ENVIRONMENTAL ISSUES

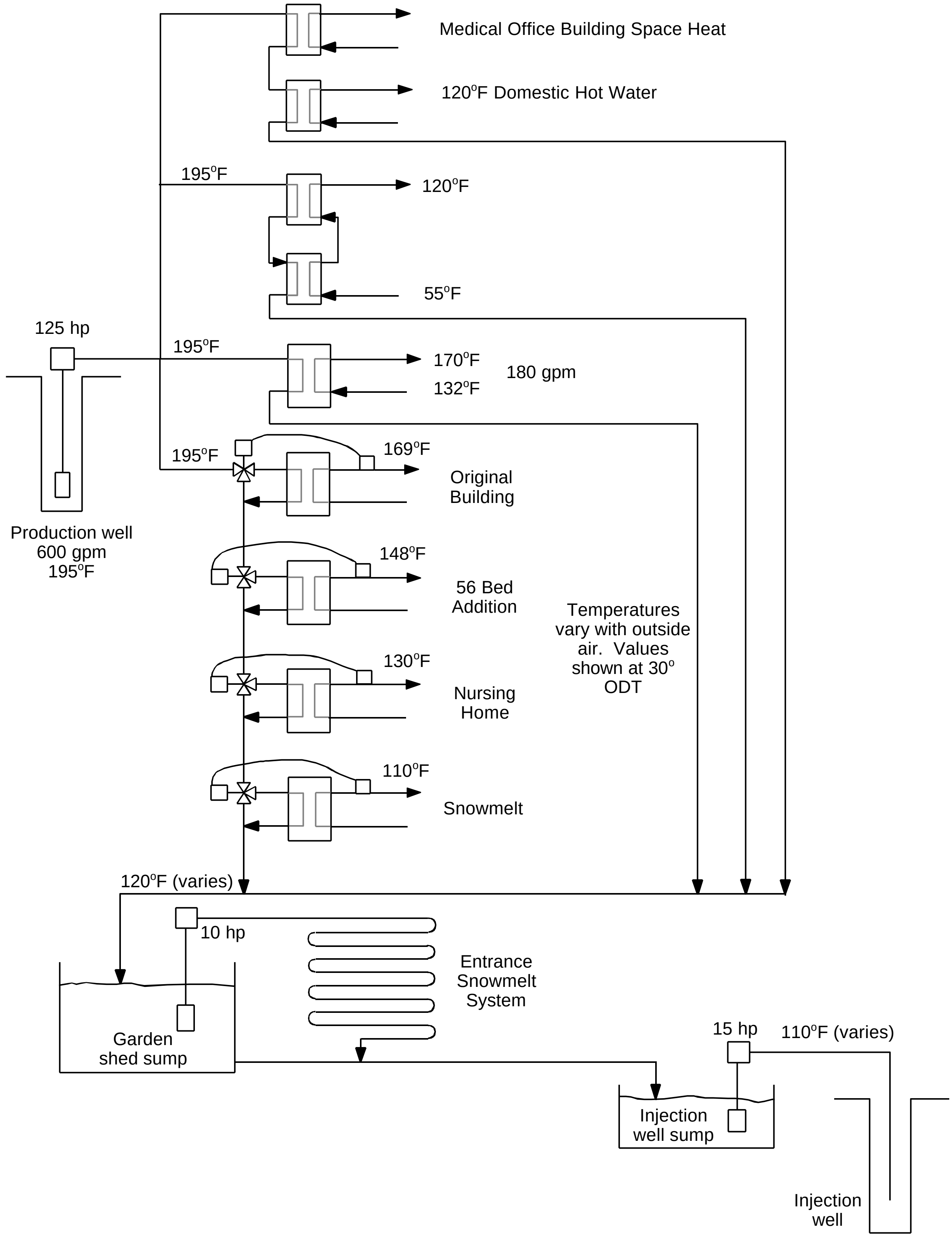
Few regulatory issues are associated with the operation of a system like this in the state of Oregon. Well drilling and construction is permitted in the same way as normal water wells with a start card and well completion report required to be submitted to the Department of Water Resources. Since the system is located within the city limits of Klamath Falls, injection is the required method of disposal. The ordinance requiring injection was passed in 1985 and stipulated that all existing systems would have to commence injection by 1990. As a result, MWMC completed a well for injection in 1990 to comply with the ordinance. Prior to that time, effluent was disposed of on the surface with drainage to Klamath Lake. Due to the age of the system, no permits were required. Injection requires only the submission of a one page summary form to the Department of Environmental Quality.

PROBLEMS AND SOLUTIONS

The MWMC system has been in operation for nearly 25 years. In that period of time, numerous modifications have been made to the system some as the result of problems and some as the result of newly available equipment. The original design included a well pump controlled by a fluid coupling type of speed control. The well pump produced into a 4,000-gallon tank that was vented to atmosphere and from that point to the individual heat exchangers Relatively frequent well pump failures were experienced for a time and this was thought to be the result of a control sequence that maintained the pump in operation but at a speed that was insufficient to produce flow at the well head.. The control was reset to eliminate this mode of operation and pump life was then extended to an average of six years between overhauls where it remains today. In 1995, the pump was equipped with a variable-frequency drive for speed control and the tank was removed from the system entirely. The original design employed all shell and tube heat exchangers. This equipment was much larger than the current plate heat exchangers, more difficult to clean and less effective at heat transfer. In the mid-1980s, all of the original heat exchangers were replaced with plate and frame units. There has been some problems encountered with gaskets in the plate heat exchangers. Swelling has been encountered in some cases and this is thought to possibly be related to the small amount of oil in the geothermal fluid from the well pump (oil lubricated enclosed shaft type). Some problems have also been encountered with butterfly valve lining material. Fluroelastomer lined valves have been used but the cost is excessive and this problem is yet to be fully resolved. The injection system involves the use of a concrete sump in which "can" type vertical pumps are located. Originally, these pumps were standard, steel column, cast iron bronze fitted pumps. Due to the fact that the geothermal fluid is saturated with oxygen at this point in the system, the original pumps were plagued with failures. All stainless steel pumps were installed and these problems have largely been eliminated. A similar situation and remedy was experienced with the snow melt pumps located just upstream of the injection pumps. The original controls for the system were the standard pneumatic design of the day. These were replaced with a DDC system in 1990 and the operation and monitoring of the system was vastly improved according to the MWMC engineering department.

CONCLUSION

The MWMC system is one of the oldest large geothermal systems in the U.S. It has proven to be a reliable energy source for a critical facility for the past 25 years and has in the process accommodated substantial increases in capacity. The system currently displaces approximately 275,000 therms per year in natural gas purchases. In 1977, the total investment in the geothermal retrofit of $320,000 was expected to generate annual savings of approximately $104,000 per year when all additions envisioned then (total building area 275,000 sq ft) were completed. At this writing, the system is serving approximately 470,000 sq ft and as a result the savings have re-payed the original cost many times over.



Merle West Medical Center Geothermal Schematic

FAIRMONT HOT SPRINGS RESORT
FAIRMONT, MONTANA

Fairmont Hot Spring Resort as seen from the air.

LOCATION

Fairmont Hot Springs Resort, formerly Gregson Hot Springs, is located in western Montana along I-90 between Butte and Anaconda. The resort sits in a valley at the base of Pintler Wilderness area and is near the Continental Divide. The resort consists of two Olympic-sized swimming pools and two mineral soaking pools, one of each located indoors and outdoors; two three-story guest room buildings with 158 rooms; a 130-seat main dining room; 60-seat coffee shop; 90-seat cocktail lounge along with several shops; and a 7,000-square foot conference center. All of the approximately 106,000 square foot area and pools are geothermally heated. There are plans to expand the conventional center. The resort and geothermal use dates back to 1869, with the current resort rebuilt in 1972 after collapse of walls and closure in 1971.

RESOURCE

Several springs discharge about 760 gpm at 143EF from Tertiary volcanics associated with the Boulder batholith into ponds near the resort. Total dissolved solids are 559 ppm and the pH of the water is 8.41. A well, drilled in 1985 by the Montana Bureau of Mines to a depth of 600 feet provides a flow rate of 180 gpm of 170EF water. At times, the water temperature will vary from 165 to 175EF. During the summer months, the flow is reduced to 120 gpm.

UTILIZATION

The geothermal water is pumped from the well with a 50-hp lineshaft pump that has 22 bowls set at 420 feet. The flow rate is controlled by restricting the flow into the pipeline with a valve. The water flow through a 2,500-foot long fiberglass pipeline into two 1500-gallon collection pits. From the pits, the water is piped to a central boiler room; where, a forced air system supplies heat to individual rooms. Plate heat exchangers are used to transfer the heat with the secondary closed-loop water going out at 160E and returning at 150EF. In addition, copper pipes in the ponds are used to preheat the domestic hot water. Normally, this is adequate to keep the domestic hot water at around 120 EF; however, during colder periods the water is peaked with a fuel oil-fired boiler.

The geothermal water is also used directly to heat the two Olympic-sized swimming pools, each 85 by 212 feet in size, and two mineral soaking pools. Two 100 by 100 pyramid buildings and two three-stories lodging buildings are also heated. In the winter the space heating water is circulated by one 10-hp and two 7.5-hp pumps, and the pools used four 7.5-hp, three 5-hp and two 2.5-hp circulating pumps. The water enters the pools at about 110EF and exits about 98EF.

The water is then discharged to a drainage channel adjacent to the resort. The water goes into a collection pond and then is used by the Peterson Ranch for irrigation of crops (hay and alfalfa). Any chlorine in the water has dissipated by this time. Excess water, not used by the resort is bypassed directly into the local sewer line serving a nearby residential area, and ends up in a sewage lagoon adjacent to the property.

The estimated energy use is 6.48 million Btu/hr (1.90 MWt) and the annual energy use is 43.8 billion Btu. The estimated gross savings is around $500,000 per year (assuming fuel oil at $1.30 per gallon and 80% efficiency).

OPERATING COSTS

Annual operating cost consist of two items: 1) electricity costs to run the various pumps, and 2) maintenance costs. The annual electricity cost for the pumps consist of $21,100 for the well pump, $2,700 for the 10 hp pump, $3,500 for the two 5-hp pumps, $12,000 for the pool pumps, $24,000 for the pool building heating system pumps, and $14,400 for the lobby and rooms three-speed motor blower fans, giving a total of $77,700. However, the only cost directly attributed to the geothermal system is the well pump and the 10-hp and two 5-hp pumps for a total of $27,300. The annual maintenance cost is for preventative maintenance amounting to about $3,500. Thus, the total annual operating cost due to the geothermal system is around $30,800. All other operating costs would be the same, regardless of the type of fuel used for heating.

REGULATORY/ENVIRONMENTAL ISSUES

The only potential problem would be the disposal of the used water onto private land for crop irrigation and stock watering. Excess hot water that is not used goes directly into the local sewer line and is disposed into a sewage lagoon adjacent to the property. However, since the dissolved solids are under 600 ppm and the chlorine used to treat the pools water has dissipated by the time it reaches the ranchers property, there are no environmental impacts. The temperature of the disposed water has not been considered a problem. No permits are needed for the disposal of the water; since, both the source and disposal site are on private land. The local sewer district needs an EPA permit when it pumps down the sewage lagoon for disposal of the sludge. There was a well drilling permit required for the original drilling of the well.

PROBLEMS AND SOLUTIONS

There has been some problems with scaling and corrosion; thus; they have used an acid type cleaner to try to control the deposits.

CONCLUSIONS

The system appears to be operating with minimal problems, both in utilization and in disposal of the fluids. The system cannot meet peak load in certain cases; thus, diesel fuel heat is needed to backup the system. Annual savings are large, and maintenance cost small. Using the geothermal water directly in the pools is a popular attraction for tourists. There are plans to expand the convention center.

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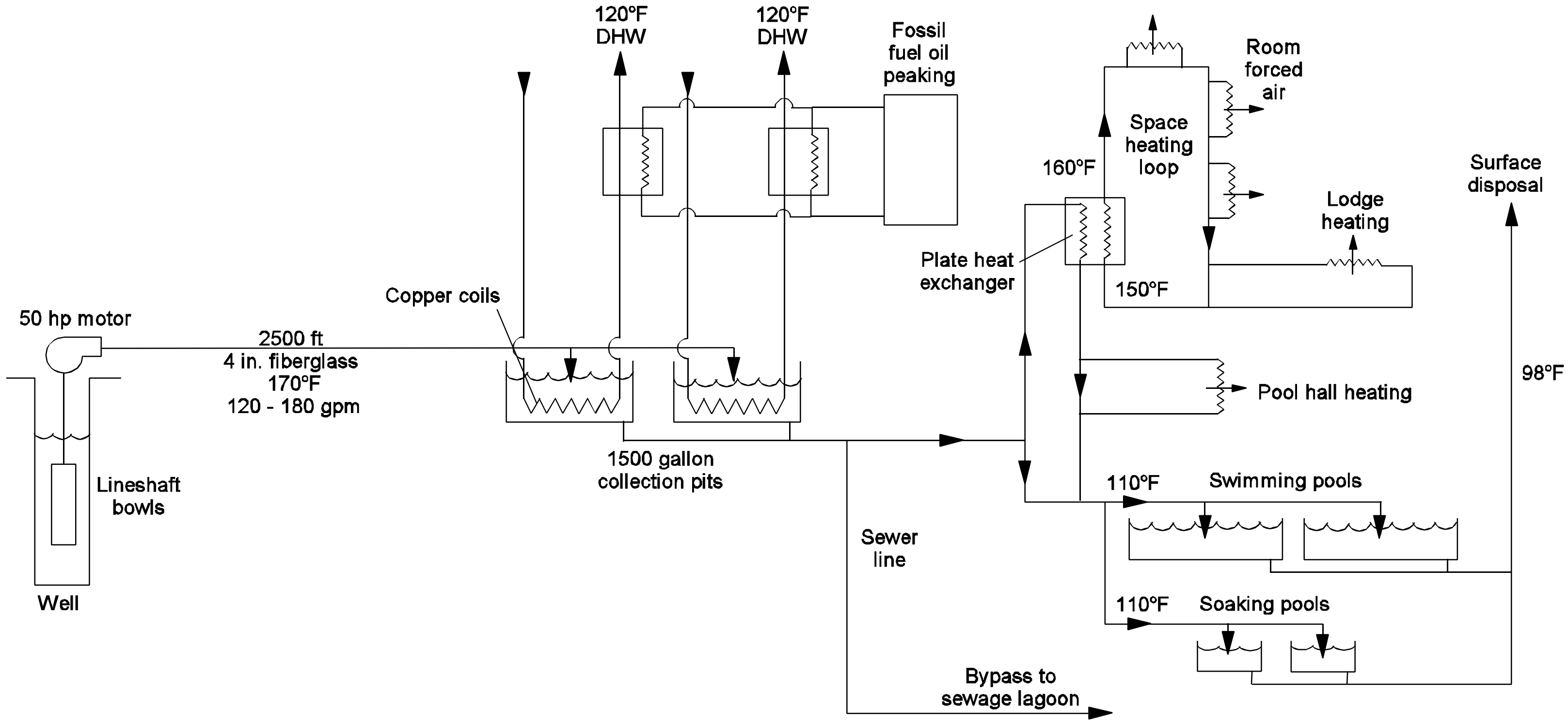
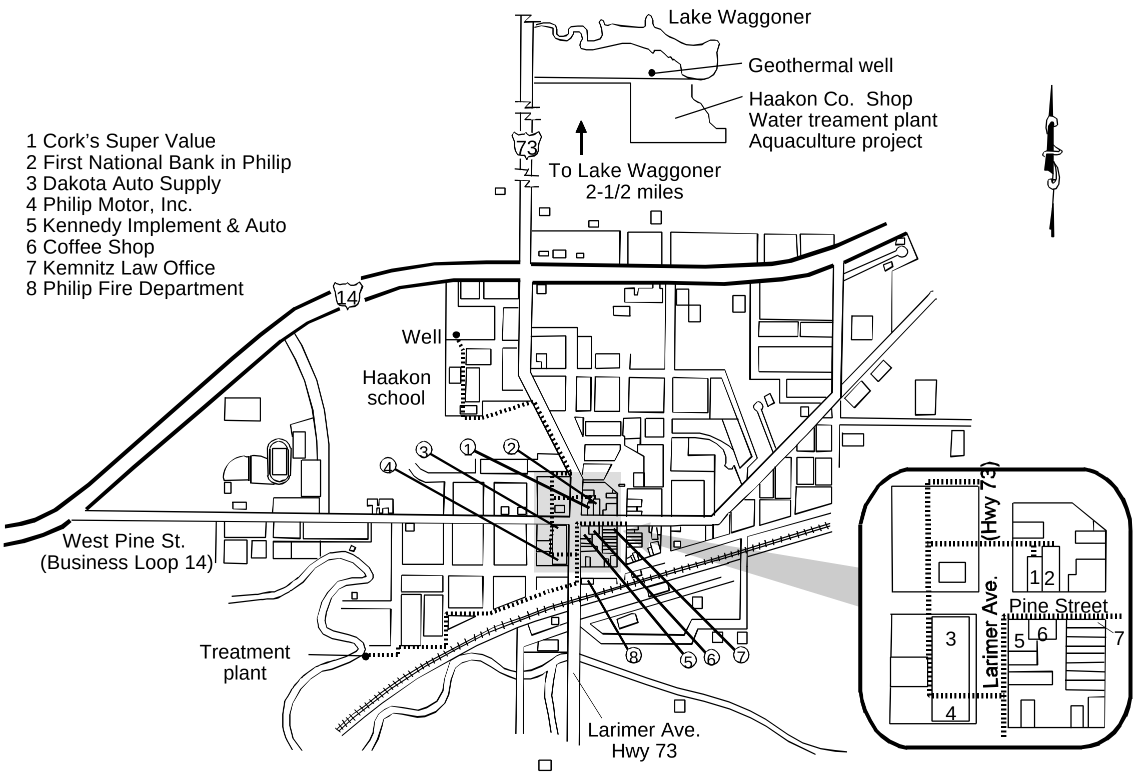


Fairmont Hot Springs Resort Geothermal Schematic

GEOTHERMAL DISTRICT HEATING SYSTEM
PHILIP, SOUTH DAKOTA



Philip district heating system schematic.

LOCATION

Philip, South Dakota in located in the southwestern part of the state, on U.S. Highway 14, about 87 miles west of Pierre. It has a population of about 1,100. The district heating project was one of 23 cost shared by USDOE starting in 1978. The city project was added on to the original USDOE cost shared project for the Haakon School, located on a hill above town. Waste water from the school has been used to heat eight buildings in the downtown area since the 1981-1982 heating season. The Philip Geothermal Corporation (for profit) was formed to maintain and operate the downtown system, and pays the school district for the use of the water.

RESOURCES

The town overlies the Madison Formation which is a large-area aquifer. The aquifer has a demonstrated capability to produce geothermal water. A single 4,266-foot deep well was drilled in 1980 which provides a maximum artesian flow of 340 gpm at 157EF. The dissolved solids content of the water is 1,112 ppm and a pH of 7.4. Radium-226 at 100 pCi/L as radium sulfate, must be removed from the spent water with a barium chloride mixture before discharging to the Bad River. The treatment plant has two 90 ft x 158 ft x 10 ft deep storage ponds that will each hold 374,000 gallons of the sludge. The geothermal fluid is first used by the grade school and high school before being sent to the city at around 140EF, and then is disposed of between 119 and 140EF, depending upon peak or no energy demand from the system. In warm weather, only 12 to 15 gpm is required.

UTILIZATION

The geothermal discharge from the schools is transported in a single pipe through the downtown area. A disposal line begins at the upstream end of the business district and parallels the supply line from the schools to the last user on the system, the fire station. From there, a single line continues to the radium removal plants and disposal to the Bad River. The eight buildings connected to the system used either Modine heaters, unit heaters, or by piping in the floor. The bank building uses plate heat exchangers to isolate the geothermal fluid. The control points for the system are at the high school and the fire station. Equipment in the fire station controls system pressure and regulates flow through the business district loop. A motor operated flow control valve on the return line is set to be full open at 20EF and full closed at 65EF outside air temperature. A second valve maintains back pressure in the distribution piping to minimize calcite precipitation. When the outside temperature is below -10EF and hydronic fluid temperature is below 90EF, a backup boiler is turned on and automatically valved into the system.

Water leaving the business district flows to the water treatment plant where Radium-226 is removed. Barium chloride is added to the water at 2.6 ppm $BaCl_2$ at maximum flow. The solution is added at a baffled trough which empties into a pond. Sludge collects on the pond bottom at a rate of about 85 ft^3 per year. Sufficient liquid volume will be maintained throughout the pond's 30-year life. Radioactivity accumulates at 0.06 curies/year. At the end of the pond life, the sludge can be removed to a disposal site or mixed with cement to form the bottom for a new pond built directly over the old one.

The geothermal supplies 75 to 90% of the heating requirements of the eight buildings covering 56,500 ft^2. In addition, the floor slab of the chemical treatment plant building is heated with geothermal energy. A new bank building of 12,500 ft^2 will come online soon. The peak design delivery of the system (schools and business) is 5.5 million Btu/h (1.6 MWt), with an annual energy delivery of 9.5 billion Btu. The schools removes about 16EF and the business district about 11EF from the peak flow of 340 gpm, which is only about 83% of the system capacity. As a result, the city uses about 41% of the output of the system or 2.25 million Btu/h peak (0.65 MWt) and 3.9 billion Btu/yr. The heating season is normally from October 1^{st} to May 1^{st}.

OPERATING COST

The capital costs of the entire system are estimated at $1,218,884 of which 77% was DOE funds. Annual operating and maintenance cost for the entire system is nearly $8,000 (updated from 1983 data). The initial retrofit costs to the city businesses was for cast iron heat exchangers at $30,000. However, due to corrosion, these were replaced with stainless steel heat exchangers. The Philip Geothermal Corporation now pays the school district $5,000, carries a $1,000 liability policy, pays taxes, and spends about $500 for repairs, for a total annual cost of about $6,500. Each user pays a share of the cost based on the percentage of water used. The total savings of all eight buildings is $120,000 annually, whereas the school district saves $200,000. Thus, the consumer pays about 20% of the corresponding cost of propane or fuel oil, the alternate fuel in the area.

REGULATORY ISSUES

A discharge permit is required by the South Dakota Department of Environment and Natural Resources. This is renewed every two years. Samples of the discharge water (after the barium chloride treatment) are send to Pierre. EPA in Denver requires flow and temperature readings every two to three weeks. The Radium-226 must be reduced to 5 ppm (from 80 ppm) with a maximum daily reading of 15 ppm.

PROBLEMS AND SOLUTIONS

The cast iron heat exchangers had to be replaced with stainless plate heat exchangers due to corrosion. Since then, there has been no problems with scaling and corrosion in the city system. However, the iron pipes in the school well have to be replaced every four to five years due to corrosion. Plugging of pipes at the water treatment plan has been a significant operating problem. Sulfate deposits initially partially plugged the mixer and pipe downstream, thus requiring frequent cleaning. Installation of the current trough system for the barium chloride additional and mixing has solved this problem. The pipe from the second cell to the creek has to be augered every two years at a cost of $250 to $300. The control system operation has been very satisfactory as far as the users are concerned; however, it has been unsatisfactory in terms of utilizing the resource efficiently. The system only supples 75 to 90% of the energy demands for the city buildings. A backup boiler is provided from the school system installation to peak the system during the colder periods (-10EF outside and 90EF fluid temperature).

CONCLUSIONS

Except for some inefficiency in the energy utilization, and the requirement for treating the Radium-226, the system appears to be operating well. Building owners are only paying about 20% of the corresponding cost for alternate fuels. However, it should be pointed out that the initial capital cost of the system was subsidized (77%) by a USDOE grant. The system probably would not have been feasible otherwise.

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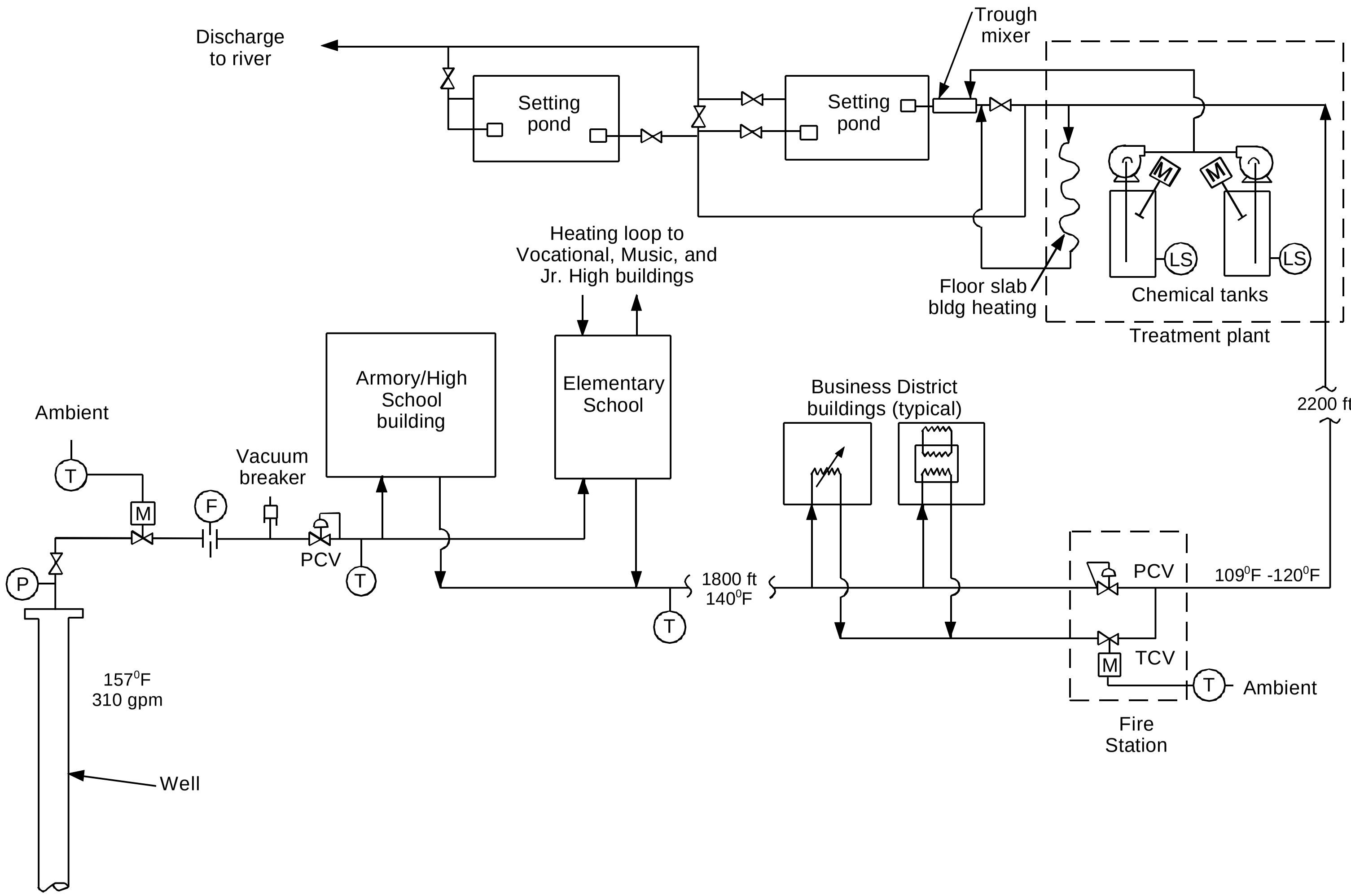

Philip, SD District Heating System Schematic

MILGRO-NEWCASTLE GREENHOUSES
NEWCASTLE, UTAH

LOCATION

The Milgro facility is located just west of the town of Newcastle, UT, approximately 37 miles west of Cedar City in southern Utah. The elevation of approximately 5,000 ft results in substantial heating requirements and below zero temperatures are commonly encountered in the winter. Milgro is the largest potted plant grower in the U.S. and in addition to its 1,000,000-sq ft geothermally-heated facility in Newcastle, it also maintains substantial conventionally-heated operations near Los Angeles.

RESOURCE

The Newcastle area has long been recognized as rich in geothermal resources. Prior to the initial development of the Milgro facility, there were three other geothermally-heated greenhouses in the immediate area (all except one now owned by Milgro). There are currently numerous wells in the area producing water in the 190º F to 205ºF range. The wells all penetrate sediments of the Escalante Valley consisting of alternating sequences of clay, silt, sand and gravel. The source of the fluids is thought to be from a buried point source associated with a range front fault approximately 3/4 mile southeast of the main production area (Blackett, 2001). The geothermal fluids flow laterally toward the northwest through the permeable portions of the sediments. Wells individually produce flows up to 1500 gpm.

Recently, production at the Milgro facility has fallen off in the #2 well. In addition, a new injection well, despite intersecting substantial intervals of apparently permeable materials, does not accept the expected flow.

UTILIZATION

Two production wells equipped with vertical, oil-lubricated lineshaft pumps produce the flow for the system. The wells are both approximately 600 ft deep. Water from the two wells (1700 gpm at peak) is delivered to the greenhouse facility; where, the pressure is raised by individual 30-hp booster pumps for each of three 224,000 sq-ft-ranges. From the booster pump, the water is delivered to individual sub- zones in each range where a 4-way valve diverts the water either to the heating tubes under the benches or to disposal. Prior to the development of the two most recent ranges (#4 and #5), the water was all disposed of in a single injection well or to the surface (when flows exceeded the capacity of the injection well). With the development of the two newest ranges, water previously disposed of directly is now routed through the new ranges.

In the original three ranges, heating is provided by half-inch diameter EPDM tubes installed under the benches. This places the heat at the plant root level for maximum effectiveness in potted plant production. In the two newer ranges, which were developed for cut flower production, heat is supplied by two different systems--½-inch diameter tubes on the floor and 1-1/4-inch diameter overhead finned pipe. Effluent water from the other three ranges is boosted by two individual pumps for ranges 4 and 5--one 7 ½ hp for the overhead finned pipe and one 15 hp for the tubes. The head house building is heated with 18 unit heaters connected to the distribution pipe to the ranges. All distribution pipe for the ranges is steel with grooved end joining and is located overhead in the head house. Typical greenhouse inside temperature is 72°F day and 65°F night and varies with the crop.

Disposal of the water is a combination of surface and injection. The first injection well was drilled in 1993 and for several years accepted almost all of the system effluent. It was equipped with a pressure diverting valve such that water in excess of what the well could accept was diverted to surface percolation ponds for disposal. A new injection well was drilled in 2002 with the hope that it would accept all of the system effluent.

Using a figure of 23 acres, the peak geothermal heating load is approximately 51 million Btu/hr (14.9 MWt) based on an outside design temperature of 0°F. The annual use is approximately 93 billion Btu; assuming, that 75% of the sunlight hours, the sun meets the heating load.

OPERATING COSTS

Operating costs, specific to the geothermal portion of the greenhouse are not available from Milgro; however, some general cost data can be inferred from available information. The total maintenance budget for the facility is $16,000 per month. This figure includes maintenance on the structures, vehicles, electrical systems, plant growing equipment and the geothermal system. An interesting point is that this amounts to less maintenance per square foot for the geothermal facility than for Milgro's conventionally-heated greenhouses in the Los Angeles area --though this is related to the fact that the conventionally heated structures are much older.

The geothermal system includes a total of approximately 485 hp in connected load associated with pumping (well pumps and booster pumps) and approximately 9 hp in unit heater fans. Assuming that the well pumps are operated in rough proportion to the heating requirements (#1 well pump is equipped with a variable-frequency drive) and that the booster pumps are operated more or less continuously in the heating season along with the unit heater motors, a total electricity consumption of 1,500,000 kWh per year would result. At a cost of $0.045 per kWh, this would amount to approximately $67,500 per year.

REGULATORY/ENVIRONMENTAL ISSUES

Geothermal fluids in Utah are regulated as "a special kind of underground resource." The use of or injection of the fluid constitutes a beneficial use of the waters of the state and as such water rights are required from the State Division of Water Rights. In addition, rights to a geothermal resource or fluids are based upon the principle of "correlative rights" conveying the right of each landowner to produce his equitable share of underlying resources. Well construction and permitting is regulated by the Division of Water Resources of the Department of Natural Resources. Because all of the facilities fluids are injected no special environmental permits associated with disposal are required.

PROBLEMS AND SOLUTIONS

Despite the very large size of this system, operation has been very reliable over the nine years it has been in operation. In general, the early problems were in the area of hardware and the more recent problems have been associated with the resource. The initial design of the system was based upon the use of plate heat exchangers to isolate the heating system from the geothermal fluid. Due to slow system response time, these heat exchangers were removed from the system in 1995. Since that time, geothermal water has been used directly in the heating equipment (primarily EPDM tubing). The relatively benign nature of the water (approximately 1100 ppm TDS, pH 8) has resulted in few problems. One area that was troublesome was that of control valves. These valves are used throughout the system to provide temperature control for individual zones in the ranges. Numerous failures of standard valves were experienced due to exposure to the geothermal water until replacement valves were coated internally with teflon. Well pumps encountered less than acceptable service life early on. In an effort to reduce failures in the bowl assembly, bearing lengths were increased and the result has been a typical service between overhauls for the pumps of approximately six years.

More recently problems have centered on wells and possibly the geothermal resource itself. An injection well was installed in 1993. This well was initially able to accept most of the system effluent however it periodically was necessary to pump the well to re-establish it's ability to accept water. In addition, this well did not have a sufficient enough surface seal to prevent water from migrating up along the casing to the surface. This caused erosion of the area around the well head. Eventually this well's capacity was reduced to the point that it would not accept a significant flow. A new injection well was drilled in 2002 several hundred feet north of the existing injection well. It is not clear at this point how much water this well will be able to accept.

Production from well #2 has recently decreased by approximately 30%. It is not clear what the reason is for this since water level measurement facilities are not available in the wells. There has been some decrease in static levels (thought to be about 12 ft) but this should not be sufficient to eliminate key production zones. As a temporary measure, a pipeline is being installed to transfer water from another Milgro well located east of the wells #1 and #2. Production wells #1 and #2 have experienced drops in temperature of approximately 10°F in the recent past. It is thought that the reduced flows and temperatures may be related to the ongoing drought in the area and the lack of complete injection of system effluent. These issues are the subject of ongoing work at this writing.

CONCLUSIONS

The Milgro-Newcastle greenhouse is one of the largest and most successful direct use applications in the country. The recent issues associated with the well performance are at least in part related to the substantial and rapid growth that the operation has undergone. It is expected that through careful monitoring and design, the local resource will be capable of supporting the existing and planned facilities well into the future.

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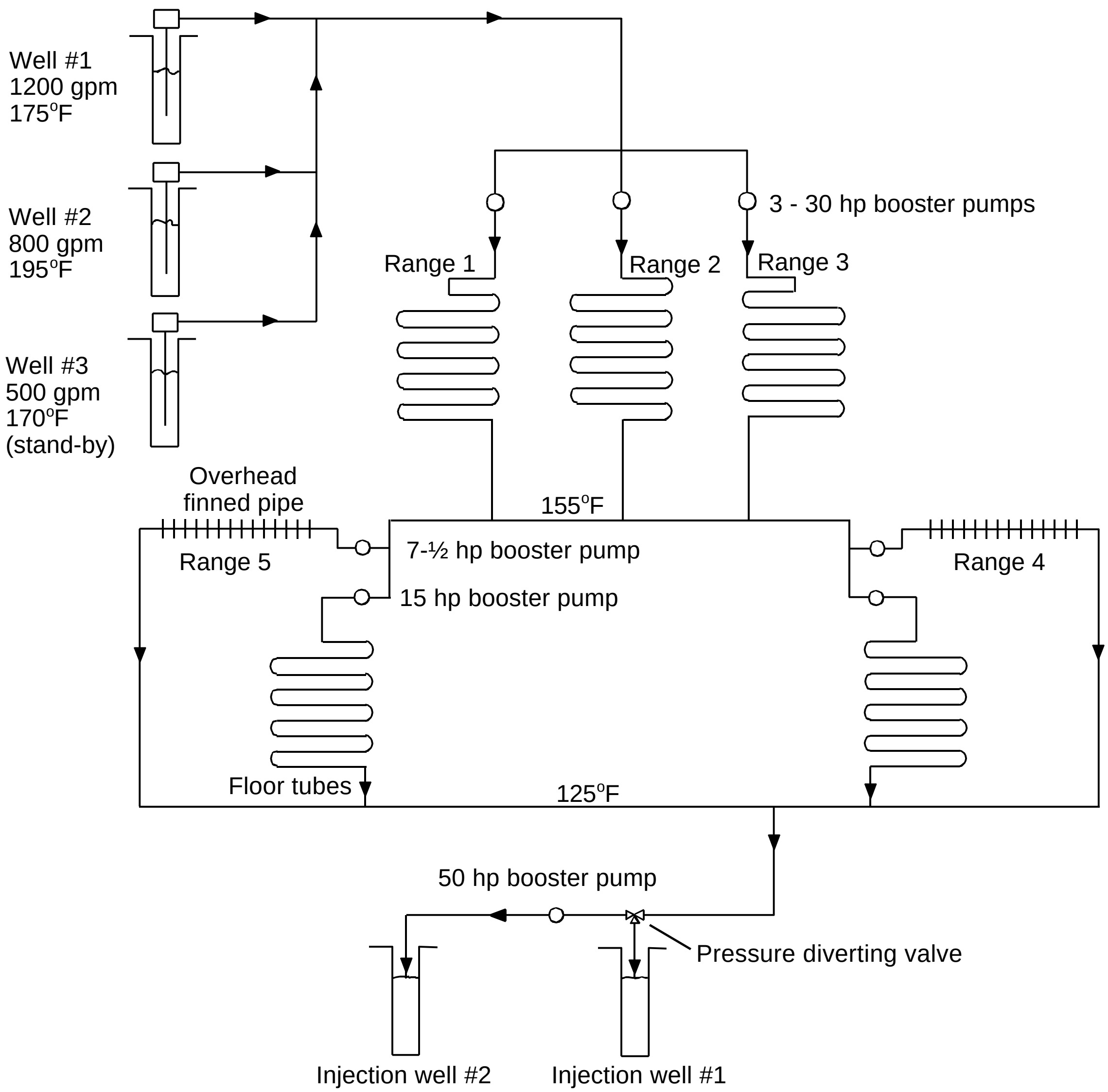

Milgro-Newcastle Greenhouse Schematic

DR. ROY MINK NAMED NEW DIRECTOR OF USDOE GEOTHERMAL PROGRAM

Leland ("Roy") Mink became the new Director of the U.S. Department of Energy's Geothermal Program in February. Dr. Mink replaced Peter Goldman, who will head the USDOE's wind and hydropower programs. Dr. Mink began his career as a hydrogeologist with the Idaho Bureau of Mines and Geology (1972-75) and was associate professor of hydrogeology at Boise State University (1975, 1982-85). He served as a research geohydrologist for the U.S. Environmental Protection Agency (1976). Dr. Mink also served as a geothermal energy project manager with USDOE in Washington, DC and Idaho Falls, ID (1977-80). His industry experience includes working as a hydrologist and project engineer for Morrison-Knudson in Boise during the 1980s. His most recent assignment was as professor of hydrogeology at the University of Idaho-Moscow, and director of the Idaho Water Resources Research Institute. He has a Ph.D. in geology from the University of Idaho. (Source: *GRC Bulletin*).

GEOTHERMAL RESOURCES COUNCIL 2003 ANNUAL MEETING MORELIA, MEXICO OCTOBER 12-15, 2003

"International Collaboration for Geothermal Energy in the Americas" is the theme of the GRC's first annual meeting outside the United States. The meeting is co-sponsored by Mexico's Comisión Federal de Electricidad (CFE) and the U.S. Department of Energy (USDOE), and will provide an ideal opportunity for developers, suppliers and support organizations to exhibit their equipment and services to the world geothermal community. Morelia is located about halfway between Mexico City and Guadalajara.

Interested persons are invited to present their latest technical work in geothermal research, exploration, development and utilization at the Centro de Convenciones y ExpoCentro in the beautiful and historic city of Morelia, Mexico. The draft paper of two hard copies and disk or CD in Microsoft Word or Rich Text Format (with submission form) must be received by the GRC by May 9, 2003.

The "Americas" emphasis of the meeting recognizes the importance of geothermal resources development in Mexico and Latin America. The 2003 Annual Meeting will feature distinguished international keynote speakers at its Opening Sessions; Technical and Poster Sessions on a broad range of timely geothermal resources and development topics; Technical Workshops; Field Trips to nearby geothermal fields and features; a unique Guest Program; the popular Annual Golf Tournament and GRC Banquet; and the U.S. Geothermal Energy Association Geothermal Energy Trade Show.

Additional information can be obtained from the GRC office in Davis, CA; phone (530) 758-2360 or email: grc@geothermal.org. Also, visit their website: www.geothermal.org for the complete Second Announcement and Pre-Registration Information.