LIGHTNING DOCK KGRA
NEW MEXICO'S LARGEST GEOTHERMAL GREENHOUSE, LARGEST AQUACULTURE FACILITY, AND FIRST BINARY ELECTRICAL POWER PLANT

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Aerial photograph of Burgett's Greenhouses (lower) and AmeriCulture (upper)(USGS photograph).

LIGHTNING DOCK KGRA

The Lightning Dock Known Geothermal Resource Area (KGRA) is located in the Animas Valley of the "boot heel country" of southwest New Mexico about 10 miles south of Interstate 10 off of the Animas-Cotton City exit or about 20 road miles southwest of Lordsburg, New Mexico. The name Lightning Dock comes from a peak in the Pyramid Mountains just east of the geothermal area in the Animas Valley.

The Lightning Dock geothermal system is a blind system with no surface manifestations and the resource was fortuitously discovered during cable tool drilling of an irrigation well in 1948 (Summers, 1976). Since that time, geochemical sampling of fluids, electrical and gravity geophysical surveys, temperature gradient drilling, shallow production well drilling of the resource for direct-use heating for green-housing and aquaculture, and a deep geothermal exploration hole has been done at the site (Cunniff and Bowers, 1988; Dellechaie, 1977; Elston, et al., 1983; Jiracek, et al., 1977; Norman and Bernhardt, 1982; Smith, 1978). Information developed by these activities provide the basic geoscience information for the Lightning Dock geothermal system.

The Lightning Dock geothermal system is contained in a small intra graben horst block at the intersection of three major regional tectonic features. A mid-Tertiary caldera ring fracture zone, a major basement structure zone, and a young incipient normal fault tip intersect in the region of the thermal anomaly (Elston, et al., 1983). The late-Pleistocene fault tip may enhance or reopen older fractures. An intra horst fault zone or a mid-Tertiary caldera ring fracture intrusion in the younger horst block probably hosts the upflow zone. The shallow outflow plume flows through highly-silicified and fractured "bedrock" that is overlain by a thin cover of unconsolidated basin fill. A potential deep outflow plume between 1,200 and 1,800 ft depth is hosted in a "problematic unit" that may represent karst at the top of the Paleozoic carbonate section or possibly one of at least three other tectono-stratigraphic configurations common to the structural setting of the site in the region that could have solution and fracture permeability (Witcher, 2002).

The "tear drop" shape of the heat flow anomaly at Lightning Dock largely outlines the heat loss from the top of the shallow outflow plume reservoir. A north flow is indicated in the shallow outflow plume. The relatively sharp western and eastern boundaries of the anomaly are probably limited to some extent by fault zones that prevent lateral dispersion and mixing. Heat flow and temperature gradient data indicate a total natural heat loss for the system less than 10 MWt (Witcher, 2001). A base reservoir or upflow zone temperature around 310 to 320ºF is determined with quartz geothermometer and the temperature profile of the 7,000 ft depth Steam Reserve Animas 55-7 geothermal test well (Dellechaie, 1977; Elston, et al., 1983; Cunniff and Bowers, 1988).

A 48-hr pump test of a Lightning Dock well indicates reservoir transmissivity in excess of 25,000 gpd/ft and an important hydraulic boundary on the west side of the Lightning Dock heat flow anomaly (Witcher, 2001).

Chemistry of geothermal waters at Lightning Dock are very good quality sodium sulfate-carbonate waters with TDS around 1,100 mg/L. However, fluoride concentrations can exceed 10 mg/L. Most geothermal waters contain elevated arsenic concentrations; however, the Lightning Dock waters show no detectable arsenic (Dellechaie, 1977; Elston, et al., 1983; Witcher, 2002). Gas concentrations are reported by Norman and Bernhardt (1982) for the Lightning Dock thermal waters and dissolved carbon dioxide and hydrogen sulfide are very low.

Geologic and hydrogeologic information suggests that the system is the discharge of deeply-penetrating regional groundwater flow in bedrock. The heat source is most likely regional background heat flow and not basaltic magma as has been suggested by Elston, et al. (1983). Basaltic magma in the shallow continental crust is generally not sufficiently voluminous in subsurface bodies with the proper geometries favorable for sustained heating of groundwater.

This system is not unlike other higher temperature systems in southeast Arizona and southwest New Mexico (Witcher, 1988). With a location at relative low elevation, it is in a favorable location for "forced" or advective discharge of fluid and heat from a regional bedrock groundwater flow system and a combination of Cretaceous and Tertiary uplift has facilitated non-deposition or erosional stripping of regional aquitards to create a local "geohydrologic discharge window" (Witcher, 1988). Recharge for this system is no doubt from higher terrain, both mountains and valleys, to the south. Oxygen isotopes on the geothermal waters indicate that recharge probably occurred during wet periods during the latest Pleistocene to Recent (Elston, et al., 1983).

All currently producing geothermal wells at Lightning Dock are between 350 and 600 ft depth, and produce from the shallow outflow plume reservoir. Well production ranges from a few hundred gpm to 1,200 gpm, typically at 210 to 235ºF.

BURGETT GEOTHERMAL GREENHOUSES

Burgett Geothermal Greenhouses, Inc., established by Mr. Dale Burgett in 1977 in the Animas Valley south of Lordsburg in southwest New Mexico, is the largest geothermally-heated greenhouse complex in the U.S. The initial structure of wood and fiberglass covered 72,000 square feet (1.65 acres) and was used to grow potted mums and geraniums ("for a quick return on investment"). However, his long range plans were to grow cut roses for the southwest markets. At that time, there were two wells on the property, drilled in 1948. By 1980, a second greenhouse had been erected, increasing the facility to three acres and by this time, the operation was producing only roses. In 1982, Mr. Burgett attempted to generate electric power using a 40-kW and 100-kW binary unit, designed by Wally Minto of Florida (Sun Power Systems - SPS). Unfortunately, neither produced any energy and were abandoned.

In 1984, Mr. Burgett designed and built his own greenhouse and in 1986, he moved two 80-ft by 400-ft Lord and Burnham greenhouses that were originally located in the western mountains at Cloudcroft which were designed with steep roofs to allow snow to slide off easily (Photo 1). This increased the operation to eight acres. Up to this time most of the roses were grown in the ground, but now some were grown hydroponically in a "bucket system."

Photo 1. ***80-ft by 400-ft Lord and Burham greenhouses.***

By 1990, the operation had grown to 22 acres which included the largest greenhouse at 300,000 square feet (6.9 acres)--on the theory that bigger is better. However, he learned that sometimes it was hard to control the environment from one end to the other. As a result, in 1993 when the last greenhouses were built, Mr. Burgett went back to the 150,000 square foot sized structures. The operation now has nine greenhouses covering 1,400,000 square feet (32 acres) and is still producing cut roses (Photo 2). Some are grown hydroponically and others directly in the ground.

In 1995, three binary power generators were moved in from Lakeview, Oregon – a 350 kW unit and two 400-kW units of ORMAT/SPS design (Photo 3). They were run for two session of approximately eight months each, but cooling water and the design of the heat exchangers/evaporators became a problem, thus the generators have been shut down. Mr. Burgett is attempting to acquire a cooling tower, as the spray operated cooling ponds are not adequate.

Photo 2. ***Interior of one of the greenhouses with Mr. Burgett.***

Photo 3. ***ORMAT/SPS binary power units.***

The operation produces approximately 25 million roses a years, which are shipped to markets from Las Vegas, NV to Houston, TX and as far north as Albuquerque. He presently has 90 employees, including day laborers from Mexico. The geothermal resource consists of one well on state land producing 1200 gpm (Photo 4), and three wells on federal land. State royalties are based upon the square footage of heated greenhouse, while Federal royalties are determined by actual energy use and required the installation of meters that cost nearly as much or more than well construction costs to install, maintain, and monitor. The Federal energy use is monitored by the U S Bureau of Land Management (BLM) from the energy meters (Photo 5). The maximum usage is 2,000 gallons per minute to keep the greenhouses at 60°F at night. The 220 to 235°F geothermal water is circulated directly through finned tube heat exchangers in each greenhouse. The installed capacity is 19 MWt and uses about 184 billion Btus of geothermal energy annually. This amounts to an energy savings of about $736,000 annually, as compared to using propane.

Photo 4. ***State well used by Burgett's (Jim Witcher).***

Photo 5. ***Energy meters at Burgett's Greenhouses.***

The Burgett Greenhouses, as well as other rose growing operations in the U.S. are under pressure from lower cost imports from countries such as Ecuador. Thus, according to Mr. Burgett, the greenhouse business in not for amateurs, you have to know what you are doing to succeed. Geothermal energy helps to cut costs in this competitive market.

AMERICULTURE GEOTHERMAL AQUACULTURE

AmeriCulture is among largest domestic supplier of tilapia fingerlings and is able to produce between four and seven million fingerlings annually (Photo 6). AmeriCulture raises a genetically improved Nile Tilapia or *Tilapia nilotica* in tanks under greenhouse roof to protect from weather, natural predators such as birds, and from the introduction of pathogens (Photo 7). Great care is taken to optimize rearing conditions for disease free tilapia using strict protocols, standards, and regular inspections by an aquatic disease diagnostic laboratory. The rural location and use of geothermal heating certainly assists isolating the tilapia from pathogens. AmeriCulture ships male tilapia fingerlings by UPS throughout the country. The fingerlings are graded for size and quality and counted and placed in plastic bags with oxygenated water and boxed just prior to shipping.

Photo 6. Tilapia fingerlings raised by AmeriCulture.

Photo 7. Large Tilapia rearing tanks (Thomas Lund).

In 1995, AmeriCulture began geothermal aquaculture operations at the site of greenhouses that first formerly housed the 0.5 acre Beall geothermal greenhouse operation and then later on the McCants geothermal greenhouse at Lightning Dock prior to acquisition by AmeriCulture (Photo 8). Both Beall and McCants grew roses. AmeriCulture added about 0.2 acre of additional greenhouse space and drilled a new geothermal well on a state lease adjacent to the aquaculture operations and installed a downhole heat exchanger. The new well, AmeriCulture State 1, is 399 ft deep and cased to 282 ft depth. The interval from 282 to 399 ft is open-hole across competent, but fractured reservoir. Temperatures in the open portion of the hole average around 230°F. With the downhole heat exchanger, 100 gpm of "cold" water is circulated through the closed or isolated heat exchange loop in the well (Photo 9). On average the water is heated 50°F by the time it is

Photo 8. Overview of AmeriCulture's facility.

Photo 9. Downhole heat exchanger system with Manager/Owner Damon Seawright.

returned to the surface. The heated water is then fed to a 10,000-gallon insulated storage tank at the aquaculture facility by an insulated surface pipeline that is laid out on wooden pallets to allow movement for thermal expansion. The black iron pipeline is insulated with a wrap consisting of fiberglass insulation that is covered by tar paper that is held in place by chicken wire. This insulation lasts about three years and costs less than a $0.40/lineal foot. Temperature loss between the well downhole heat exchanger and the storage tank is generally about 3°F, except during rain on older tar paper where temporary heat loss can be as high as 20ºF. Hot water in the storage tank is then used for geothermal heating of the facility that consists of six breeding tanks and about 200 smaller rearing tanks for the fingerlings. The installed geothermal heating capacity of the facility is 2.5 x 10^6 Btu/hr (0.7 MWt) and annual energy use of 11 x 10^9 Btu. The AmeriCulture website is: www.americulture.com.

CONCLUSION

Geothermal use by Burgett Geothermal Greenhouse and the AmeriCulture aquaculture facility represents one of the largest sectors, if not the largest, of the economy in Hidalgo County, New Mexico. Small-scale electrical power generation at the site and further expansion of both operations will only add to the importance of geothermal in rural economic development in New Mexico.

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