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DISTRICT SPACE HEATING FROM A SINGLE GEOTHERMAL WELL, WARREN ESTATES, RENO, NEVADA

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ABSTRACT

WILLIAM E. NORK, INC. has designed and tested a geothermal well which is capable of meeting the heating requirements for 60 homes located at Warren Estates Subdivision, Reno, Nevada. A 833 feet deep well was completed April 1982. A temperature log of the well showed a bottom-hole temperature in excess of 211°F (99.5°C). A pumping test conducted in May 1982 indicated that the well is capable of yielding 150 gpm indefinitely. In the near future more tests will be conducted involving output potential from a custom-designed downhole heat exchanger.

REGIONAL GEOLOGY AND HISTORY

The Moana (KGRA) Geothermal Resource Area is the geothermal heat source for approximately 150 residences and businesses in southwest Reno (Figure 1). The water tempertures vary from less than 100°F to greater than 200°F, depending upon location.

Subsurface geology in the Moana Area is not terribly complex. It consists of basement rock (heat source) which is made up of Tertiary Age volcanic units that are overlain by a series of diatomaceous siltstones and unconsolidated sands. The diatomaceous siltstone is commonly referred to as "blue clay" by well drillers and "hot well" owners of the Moana Area. Overlying the siltstone and sand layers is alluvium. The thickness of the different units varies depending upon location. Along Lakeside Drive and Manzanita Lane the average well depth to the heat source is between 200 and 300 feet. As one moves westward and to the northwest, well depths increase to as much as 1400 feet.

There are indications, through surface features and surface seismic analysis, that many faults exist throughout the Moana Area. The faults are parallel and trend generally north-south which would be expected of an echelon (step) type faulting, given the basin and range geology which exists in this area. These faults probably convey the hot geothermal water upward to a level where the water meets an impermeable boundary, which may be another fault or the blue clay. Once the boundary or contact has been reached, the water moves laterally and hydraulically downgradient unless tapped by a well.

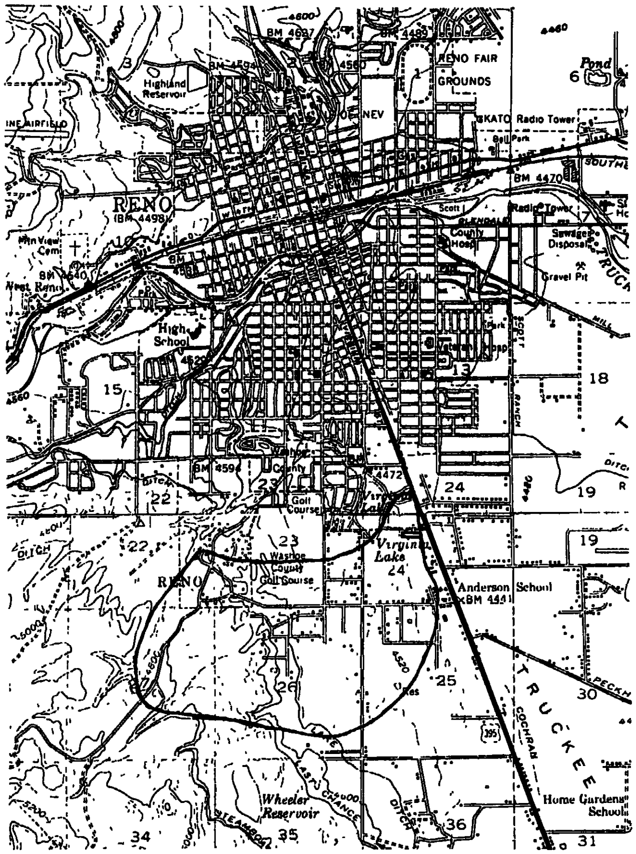

Figure 1. Approximate boundary of Moana geothermal resource.

The total extent of the geothermal resource area is unknown, however, its general limits and temperature yielding capability are somewhat known.

Since the early 1900's the Moana Geothermal Waters have been used for space heating in homes through the use of springs and wells. The majority of the presently used wells are for single family residences and are equipped with downhole heat exchanger loops installed in wells. In addition to the heat exchanger, a small pump is usually installed in each well which is operated periodically to remove the cooler water which may accumulate in the upper portion of the well. In the last few years, single family residences, quasi-municipal (more than one home), and businesses have developed a keen interest in the geothermal potential of this area. The number of wells tapping the geothermal resource is likely to increase in the future as more homes and other users take advantage of this inexpensive heat source.

SITE SELECTION

On February 19, 1980, drilling began on an exploration hole located in the south-central portion of the Warren Estates property (Figure 2).

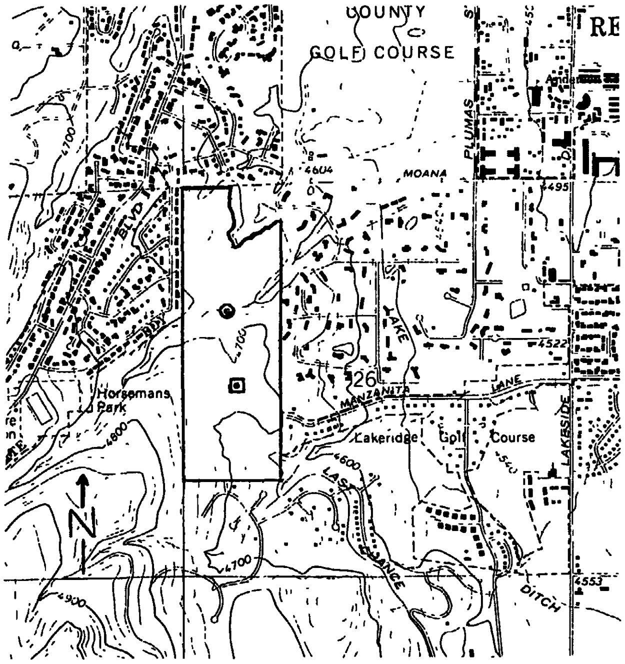

Figure 2. Warren Estates Project boundary with well locations.

⊙ Production well site
▣ Exploration well site

Site selection was based on surface geology, interpretation of geophysical data, and accessibility by drilling equipment. On April 1, 1980 a 696 feet deep exploration hole was ready for testing. Temperature log of the borehole showed temperatures of up to 204°F. During the pumping test the initial discharge temperature was 204°F, dropping to 176°F midway in the test and rose to 183°F at conclusion of testing. The upper cold water zones were not cemented off, which probably resulted in cold water leakage around the casing after the initial start up. At the conclusion of 17 hours of step-drawdown testing, the total drawdown was 17.39 feet with a final pumpage rate of 91 gpm. Specific capacity was determined to be 5.25 gpm/ft. The pumping test indicated that a properly constructed production well at this site could yield as much as 500 gpm of geothermal water at a temperature of about 200°F, or more.

As the housing market slumped and interest rates rose, a decision was made to develope the subdivision in phases. The initial phase would consist of 60 units located within the northern portion of the property. A production well site was then chosen within the area of the first phase (Figure 2). As in the siting of the exploration hole surface geology and geophysical data were used. In addition a newly developed water temperature contour map (by the author) contributed to the production well site location.

DRILLING AND COMPLETION

The drilling of Warren Estates Production Well No. 1 was commenced on February 19, 1982 by Paul Williams and Sons, Sparks, Nevada. A 12-inch diameter pilot hole was drilled to a depth of 810 feet using the mud-rotary method. A temperature and electric log profile was run to evaluate the capability of the well site to produce the expected and desired geothermal resource. Logging data indicated a geothermal resource potential which would meet the required subdivision needs. The pilot hole was reamed to 20 inches diameter to a depth of 733 feet. 16-inch O.D. blank casing was installed and cemented into place from 733 feet to the ground surface. Through use of the cement, the cold water zones were effectively sealed off from the hot water resource located below 733 feet depth. After the cement had set-up properly, a nominal 15-inch borehole was drilled from 733 feet to 833 feet depth using the air-rotary method. Hot water was encountered at a depth of 791 feet with a flow of approximately 200 gpm. Upon completion of the drilling, a combination 12-inch diameter blank casing and 0.250 slot bird cage mild steel screen was installed in the bottom 100 feet of the hole.

TESTING AND RESULTS

A two-step drawdown test was conducted May 12, 1982, 11:00 a.m. to 2:00 p.m. on Production Well No. 1. The prepumping depth to water was 91.55 feet from the top of the well casing. The initial water temperature as the pump was activated was 150°F. The pumping rate of the first step was 100 gpm; this rate was maintained for one hour. At the end of the first step the drawdown was 22.18 feet, water temperature had risen to 190°F and the specific capacity was 4.51 gpm/ft drawdown. The depth to water was rising slightly during the last 30 minutes of the step. This rise was probably due to thermal expansion of the water as its temperature rose from 150°F to 190°F. At the completion of the first step, the pumping rate was increased to 150 gpm. The second step was two hours in duration, the drawdown at the end of the step was 51.67 feet, water temperature had risen to 205°F, and the specific capacity was 2.90 gpm/ft drawdown. Transmissivity, the ability of the aquifer to transmit water, was determined to be 47,000 gpd/ft.

The exploration hole, located 1,100 feet south of the production well was monitored during the pumping and recovery sequence. A drawdown of approximately one-half foot was observed at the end of the three hours of pumping. Transmissivity of the aquifer at this location was calculated to be 48,000 gpd/ft. A Storage Coefficient of 2.9×10^{-4} was calculated from the data gathered.

A third step was originally planned, in addition to longer pumping duration in each step interval. However, as the pumping water temperature approached 206°F or 207°F, a decision was made to terminate the test once sufficient data had been collected. If a third step of 200 gpm had been attempted, flashing within the well undoubtedly would have occurred.

When the decision was made to stop the test, recovery readings were taken at both the pumping well and exploration hole. At the pumping well, within ten minutes, the water level was five feet higher than the prepumping level. This water rise is attributed in large part to thermal expansion.

Based on the information gathered to-date, including extrapolation of test data, an estimate can be made that Production Well No. 1 could produce 150 gpm for an indefinite period of time with no adverse effect on the existing geothermal resource.

PROJECT POTENTIAL

The present design for the production well is to install a downhole heat exchanger. This heat exchanger will circulate city water initially fed into the closed loop system, throughout the entire subdivision piping system. A review of this design may be necessary after testing of the installed heat exchanger.

Other options which are available include a pumping/injection system. This system would involve either pumping the geothermal water from the production well and putting the same water through the subdivision loop, or installing a surface heat exchanger using geothermal water as the heat source with a separate water supply going through the subdivision loop. In both systems the spent geothermal water will be injected via a separate well. If the former mentioned system were to be used, it is estimated that the entire 60 homes within the first phase of development could be heated. The water chemistry of the production well waters is such that special consideration for possible silica and calcite precipitation must be addressed. The potential silica precipitation could be avoided by maintaining a minimum temperature within the loop system. The potential calcite precipitation may be handled by lowering the pH of the geothermal water in the loop. It is estimated that the use of a surface heat exchanger with a separate subdivision loop could meet the heating requirements of about 30 homes.

A complete well potential may be known once the remaining tests are completed. These tests will be conducted in the coming months and will permit determination of final design for meeting the subdivision heating requirement.

In addition to meeting the winter heating requirement, another possible application of the geothermal heat source would be in conjunction with a Lithium Bromide air conditioning unit. In the summer months when daytime temperature in Reno is around 100°F, the geothermal water could be used to cool the homes in a most efficient manner. Further study is required on the air conditioning aspect before possible adaption into the subdivision system.