AN ENVIRONMENTAL ASSESSMENT
FOR A
GEOTHERMAL DIRECT UTILIZATION
PROJECT IN
RENO, NEVADA

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Abstract. The proposed action involves the development of geothermal wells to provide hot water and heat for five users in Reno, Nevada. Data from nearby wells indicate the sufficient hot water is available from the Moana Known Geothermal Resource Area for this action. Construction activities have been planned to minimize or eliminate problems with noise, runoff, and disturbance of biota as well as other potential environmental effects. Disposal of the geothermal fluids via surface water or injection will be determined based on water quality of the geothermal fluids and geologic effects of injection. The affected environment is described by this document and needed mitigation procedures discussed.

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SUMMARY

The federal actions addressed by this Environmental Assessment include developing three geothermal wells, retrofitting boilers, construction of a pipeline, and disposing of the fluid. The proposed project will furnish space heat for five users in Reno, Nevada. These users include a school, bank, and three residential complexes. Swimming pools will also be heated where present. This project will lessen the use of fossil fuels.

Two alternatives to this proposed action were considered. The first alternative was no action. Its disadvantage is the continued reliance on fossil fuels. The second alternative was to use a different user and different well and pipeline locations. Environmental considerations are essentially the same as the proposed action. However, the user for this alternative is unwilling to participate in the project.

The Moana Known Geothermal Resource Area (KGRA) underlies the project site. Wells of less than 1,000 feet in depth are expected to provide ample water to heat the facilities. Water of at least 180°F is desired, and the total project design will need more than the 425 gpm at peak demand. Wells and pipelines will be located under parking lots, streets, and lawns. Disposal of the fluids may be via injection or surface disposal to the Cochran Ditch, sanitary sewers, or storm sewer system depending on fluid composition and regulatory requirements.

The proposed action involves a relatively small project in an urban area and impacts are expected to be minor. Some areas of concern exist and will be approached with caution, however.

Construction activities will be managed in such a way as to minimize problems with noise, surface-water contamination, and damage to biota. Drilling and pipe-laying will occur between 0800 to 1800 hours to minimize noise problems. Drilling mud and water will be removed from the site by tankers and disposed of in order to eliminate surface-water contamination. Wells and pipelines will be placed to avoid large trees which are possible roosting sites for black-crowned night herons.

Testing of the geothermal fluid and discussion with state, city, and county agencies will determine the method of disposal. Surface disposal of the fluid into the storm sewers and/or the Cochran Ditch requires a NPDES permit from the state Division of Environmental Protection. State water quality standards have been applied at the point of discharge or end of the pipe in the past. The state has recently instituted a mixing zone concept that allows the use of receiving stream waters as a diluting agent. Disposal in the sanitary sewer is a possibility if the City of Reno will permit this option. The particular chemical constituents and their levels present in the geothermal fluids, and a long waiting list for sewer connections will affect this option. Any method of disposal which affects surface water is important because of its use as a source of drinking and irrigation water. Also, there are two threatened and endangered fish species (the cui-ui and the Lahonton cutthroat trout) in Pyramid Lake. These factors will be considered in the permitting procedures required for surface disposal.

If injection is required rather than surface disposal, the second geothermal well will be used as an injection well. The State Engineer and the state Division of Environmental Protection would be involved with this decision, also. While there is a possibility of increased seismic activity as a result of

injection, studies will be made to evaluate this possibility prior to using this as the disposal option. Water will be injected into the same stratum or one of lower quality water.

Other environmental factors discussed in this document include: subsidence, prime farmlands, meteorology, air quality, general land use, demography, and socioeconomics.

1.0 INTRODUCTION

1.1 Purpose of, and Need for, Action

The federal actions addressed by this Environmental Assessment (EA) include constructing three geothermal wells, a retrofitting of the heating and hot water systems of three residential complexes, a school and a bank; the construction of a pipeline; and disposing of the fluid. The five users are:

- Salem Plaza Condominiums;
- Country Club Villas;
- Lakeside Plaza Apartments;
- Anderson School; and
- Nevada National Bank.

The need for this action is based on dwindling fossil fuel supplies, rapidly increasing costs for the fossil fuels, and therefore on the desire to develop alternatives to fossil fuels. The proposed project involves the small scale development of a known, proven, geothermal resource: the Moana Known Geothermal Resource Area (KGRA) in the Truckee Meadows region of Nevada.

This EA was prepared by Radian Corporation under sub-contract to Hydrothermal Energy Corporation for submission to the U.S. Department of Energy (DOE), which was consulted throughout the preparation of the EA. Hydrothermal Energy Corporation is the prime contractor for this project and acts in full for the subcontractors. The purposes of this EA are: (1) to

provide the information necessary for DOE to determine if environmental effects have been properly considered in the planning of this project in compliance with the requirements of the National Environmental Policy Act (NEPA) of 1969 and (2) to determine the environmental documentation necessary in accordance with the regulations published by the Council on Environmental Quality (1). The focus of this investigation was on critical factors that are identifiable at this early pre-implementation stage and which may have a substantial bearing on environmental acceptability of the project. Included is an evaluation of potential mitigating factors that could effectively reduce or eliminate environmental problems.

1.2 Site Location

The site of the proposed project is in Reno, Nevada, the county seat of Washoe County. A map showing the location of Reno in Washoe County is presented in Figure 1-1. The site is shown in Figure 1-2 and is located in the southeast quarter of Section 23, Township 19N, Range 19E at about 39°29'30" north latitude and 119°48'30" west longitude. Reno is the largest city in Washoe County. The major east-west artery through Reno is I-80 and the major north-south artery is U.S. 395 (Virginia Street).

Reno is at an altitude of about 4,500 feet with the Carson Range of the Sierra Nevadas on the west and the Virginia Range on the east. The basin in which Reno is located is known as the Truckee Meadows after the Truckee River which flows eastward through Reno and into Pyramid Lake. Local irrigation ditches lead from the Truckee River into the surrounding agricultural areas and eventually flow back into the Truckee River.

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Figure 1-1. Map of Nevada Showing the Location of Reno with Respect to Other Major Population Centers. SMSA Refers to Standard Metropolitan Statistical Area.

0 5
SCALE IN MILES

0 1
SCALE IN MILES

Figure 1-2. Map of Reno and Vicinity With An Enlargement of the Project Area.

The chief land use in Washoe County is agriculture which is dependent upon irrigation. Irrigation of the sagebrush-grassland vegetation type in Washoe County provides sufficient water to support pastures for dairy and beef cattle as well as other agricultural pursuits. Tourism is a major source of income for Reno.

2.0 ALTERNATIVES, INCLUDING PROPOSED ACTION

2.1 Alternatives to Proposed Action

Alternative 1

One of the reasonably available alternatives to the proposed action is to abandon the project and continue the use of natural gas and electricity for space and water heating. Use of fossil fuels continues not only a demand on a dwindling supply but also the pollution factors associated with the use of fossil fuels. These pollution factors include increased atmospheric CO₂ levels and other air polluting chemicals as well as release of heat.

Alternative 2

A previously considered alternative of this action was to have different well locations and a different user (Sundance West Apartments). The location of the pipeline routes and probable (P₁ and P₂) and alternative (A₁, A₂, A₃, and A₄) well sites are shown in Figure 2-1.

The environmental description of this alternative was very similar to that of the proposed action. Less disturbance would occur since the pipeline route is shorter if well locations other than A₁ and A₂ were used. This particular alternative is not viable since Sundance West Apartment owners decided not to join the project.

Figure 2-1. Relative Location of the Five Sundance West Apartments, Probable Well Locations (P₁ and P₂), Alternative Locations (A₁ - A₄), and Pipeline Routes.

2.2 Alternative 3: Proposed Action

2.2.1 Project Description

The purpose of this project is to develop a geothermal heating system in the Moana area of southwest Reno. The project involves drilling three geothermal wells, laying pipelines, and retrofitting the five users' facilities for the use of geothermal fluids. The geothermal fluid will be used to replace the use of natural gas and fuel oil for space heating and domestic hot water heating in the five users' buildings as well as heating swimming pool water for three swimming pools.

Reno, Nevada overlies a known geothermal resource area. Detailed geologic, geochemical, and geophysical data plus temperature data from existing wells indicate that the project area is underlain by water hot enough for the project. The thermal waters of the Moana KGRA have been used over several decades in about 30 homes, two motels, a small group of apartments, and several area churches. Geothermal space heating, then, is being successfully operated in the areas surrounding the proposed project. The locations of the five users are shown in Figure 2-2.

2.2.2 Available Geothermal Resource and Project Requirements

The geothermal resource at Moana KGRA underlies the southern portion of Reno. Extensive areas of hydrothermal alteration are visible in the hills surrounding the basin and indicate that geothermal activity has been widespread. Warm water wells occur over a large region outside the Moana area. The Steamboat KGRA lies about eight miles south of Moana. Both KGRAs have been investigated, and there is a considerable body of

Figure 2-2. Relative Location of the Five Users' Facilities, Potential Well Locations, and Probable Pipeline Routes.

literature as well as unpublished data available (2,3). Typically, the geothermal fluid of the Moana KGRA has about 1,000 to 1,100 mg/l total dissolved solids (TDS) which is lower than that of most geothermal fluids in the U.S.

Adequate flows of hot water for nearby low volume geothermal uses are generally obtainable from shallow alluvial aquifers. To ensure large flows, the proposed wells will penetrate the underlying volcanic rocks where fractures and faults may provide high fracture permeability. Larger flows at high temperatures would maximize both the economic advantages of the geothermal system and the amounts of fossil fuels saved by this action. Characteristically, the geothermal fluids of the Moana KGRA range up to 200 degrees F, are typically about 180 degrees F, and have been predicted to reach 250 degrees F on the basis of chemical geothermometry below 1,000 feet, the depth explored to date (2; Dave Atkinson, personal communication).

The five users will require an average year round flow of 100 gallons per minute (gpm) of 180 degrees F water in order for the space, water, and swimming pool heating systems to be maintained within design temperatures. Based on data from nearby wells, water of 180 to 190 degrees F is expected. If the available geothermal fluid were only at a temperature of 140 degrees F, 500 gpm would be required for total project; this is probably the lowest practical temperature for the project. The current plan is to only involve the users that have been defined in the current E.A. They will be used and we will not be adding any others at this time. If any others were to be added then some of those listed in the project will be deleted so there will be no additive impact.

The wells planned have been estimated of being capable

of producing roughly 100 gpm at 140 degrees F. This may or may not (depending on final temperature) be enough for those buildings already outlined in the project, if not we shall use less buildings.

It is extremely unlikely that there will be sufficient volume of hot water to handle those buildings outlined in the E.A. For the record there are no other buildings within the pipeline area that are capable of retro-fit to our geothermal system than those already covered by the E.A. Also total production was based on ideal conditions hoped for. The required flow rates can probably be reduced as much as 30 percent and still have the geothermal system supply 90 percent of annual heat required.

We do not plan to expand this project to use any additional hot water for any other targets. It is reasonably certain in any case that the wells would not have the capacity to handle any larger usages.

The geothermal system has been designed to handle atmospheric temperatures down to -5°F without supplementary heating. This system will supply over 90 percent of the total annual heating requirements of the five users. The natural gas and fuel oil systems will remain in place as back-up systems to ensure that extremely low temperatures or interruption of the geothermal supply would have no effect on the heating of the buildings. If the system is in place for 20 years, about 3,000,000 therms (therm = 10^5 British Thermal Units or Btu) of fossil fuel will be saved by this project.

2.2.3 Existing Water and Space Heating System

Salem Plaza Condominiums, Lakeside Plaza Condominiums, and Country Club Villas Apartments all have similar heating systems. The buildings have a boiler room at ground level (Lakeside Plaza and Country Club Villas) or on the roof (Salem Plaza). These boilers are fired by natural gas. Additionally, there are three pool heaters, one at each site, also fired by natural gas. At Anderson School, the boiler is oil fired. At the Nevada National Bank Building, the fuel is also natural gas, but the unit is on the roof of the building.

In general, the boiler systems are quite similar for the five users. Cold city water enters each boiler room and mixes with still warm returning water before entering the boiler. Water loss in the system is due to drawing off the water for showers, baths, and dishwashing. To heat each apartment, hot water is fed through insulated pipe to a central fan coil array which heats the air via a forced air system. Individual thermostats control the fans.

2.2.4 Production Wells

2.2.4.1 Well Depth and Productivity

In the project area, geologic and geophysical data indicated that the volcanic basement rocks occur at depths of about 600 to 700 feet and are overlain by alluvial sands, gravels, and clays. The two wells for this project may be completed at more or less than 1,000 feet, depending on the exact depth at which the basement is reached and upon the water-bearing characteristics of the volcanic rocks. Optimum depth and well completion details will be determined as drilling and logging progresses.

The wells will be drilled deeper than 1,000 feet if evidence indicates that hotter temperatures are available slightly deeper. Water temperatures over 230°F are high enough to run an air conditioning system by absorption. There would be a great economic advantage in increasing the load factor on the wells with summer cooling as well as winter heating.

A 1,000 foot production well would intersect 300 to 400 feet of productive section in the faulted and fractured volcanics. A single well should yield enough hot water for the five users' buildings. By drilling two wells, a backup capability is ensured in case either well is temporarily inoperable. The two wells should provide enough hot water to handle some additional users as well as the five already planned. An additional advantage of planning two wells for the initial phase is the opportunity to use one for injection of geothermal fluids if other methods of disposal are unavailable.

2.2.4.2. Well Location and Testing

Nine possible well locations are shown in Figure 2-2. Three wells are planned. The most probable well locations are numbers 2, 6, and 8 on Figure 2-2. The criteria used to select these sites include: geology (greatest probability of large quantities of hot water), location of users, and environmental effects. Selection of the first well site will be made on the basis of comprehensive geologic analysis. Selection of the second and third well sites will depend on the results of drilling the first well. The possible well sites are in parking lots, fields, vacant lots, playgrounds, and lawns next to parking lots.

The wells were sited within the properties whose owners we have gotten agreements with in those areas. We used geological information to specifically locate well on and near fault controlled resources. Within the above limits the drilling sites were also located to keep noise to a minimum and to limit impact to residents especially the wells #2, 6, and 8 and the pipeline route as shown in Figure 2-2a.

The pipelines will be routed to link the five users' facilities as shown in Figure 2-2 and are explained in Section 2.2.5. The disposal and supply system will use the same routes, with supply and return lines in the same trench. If injection is required, one of the well sites shown on the figure will be used. The shortest routes possible will be used in order that energy loss is decreased and environmental disturbances minimized.

The wells will be drilled sequentially. A separate

water rights permit from the State Engineer will be required for each one. In each case, a test hole will be drilled prior to drilling a working well. Testing will occur at various stages in construction and will be designed to confirm adequate production capability in terms of volume and temperature. Data from the first well will be carefully analyzed before the second well is drilled. A detailed log will be prepared for each well. The test wells will be drilled to a depth of about 1,000 feet. Logging will, in part, determine the depth or depths at which the water is hottest so that, during actual pumping, the well can be screened to allow only water from the hottest zone(s) to enter the system.

If possible, the bore holes for the test wells will be enlarged for the completion of the wells as is described under well construction (Section 2.2.8.1). If this is not possible, the functional well will be located nearby. The area occupied by the well drilling equipment will be about 450 ft².

When the system is functional, both wells may serve as production wells or one may be a production well and one an injection well. The decision concerning the status of the second and third wells will be determined during the permitting procedure for water disposal as discussed below. The City of Reno Sewer Commission and the State Engineer are involved in the permitting procedures.

2.2.4.3 Description of Functional Producing Wells

The final wells will be covered with a man-hole cover or an attractive small well house depending on the final well design and pump used. Pipeline routes will be returned to their previous condition (lawns, roads, etc.) as rapidly as possible.

2.2.5 Distribution System

The routes for distributing the geothermal fluid are shown in Figure 2-2. The transmission system of pipes will be buried, with supply and return lines in a single trench. The supply line will be insulated, the return line will not. Final decision on material for the piping awaits the results of drilling well No. 1 and obtaining samples of the actual geothermal fluid to be handled. However, fluids similar to those found in

surrounding wells are expected. For this reason, problems of internal pipe corrosion are not anticipated. External corrosion will be handled by sheathing the uninsulated pipes. Effect on the environment should be negligible, with no expectation of leakage from the buried pipes.

Buried carbon steel pipes, 6 inches, 4 inches, and 2.5 inches, will carry hot water from the wellhead to the heat exchangers in the various buildings and pools, and carry spent water to the disposal system. The geothermal system will be deliberately oversized relative to the initial requirements in case fluid temperatures fall with time and greater flows are needed to compensate for the decline. Six streets will be crossed by the pipeline.

A National Pollutant Discharge Elimination System (NPDES) permit from the Nevada Division of Environmental Protection will be required for permanent surface disposal to the storm sewer or the Cochran Ditch. This is discussed more fully in Section 3.2.1. The state water quality standards must be met at the point of discharge, unless the "mixing zone concept" is employed (see Section 2.2.6.2). If direct discharge into the Cochran Ditch occurs, it will involve discharge into the ditch at the intersection of that ditch with Brinkby Avenue. An additional length of buried, uninsulated pipe would be laid down Brinkby, from the north edge of the Anderson School eastward, to carry the cooled return water to that disposal point.

City of Reno standards for discharges to the sanitary sewers will have to be met before this disposal option can be implemented. Also, there is currently a waiting list for use of sanitary sewers since the city treatment plant is functioning at capacity.

The production pump will probably be an air lift pump. This type of pump uses more electricity than submersible pumps, but is cheaper and more reliable. Because the air lift pump will be located above ground, maintenance will also be simpler than for a submersible pump although there is little reason to expect a problem with corrosion.

2.2.6 Fluid Disposal Alternatives

If our well has chemicals greater than anything yet encountered in the Moana area, which seems unlikely, we might be forced to avoid surface disposal of fluids.

Otherwise the option we take will depend on permitting requirements and agreements needed to use storm drain and/or Cochran ditch, so the strategy we shall employ is thus:

1. Pump well.
2. Analyze the water.
3. Apply for permit to discharge into storm drain.
4. If not O.K. then apply for permit to pipe to Cochran ditch.
5. If not O.K. then apply for permit to run treated water into storm drains or Cochran ditch.
6. If not O.K. then we will re-inject.

2.2.6.1 Reinjection

If the fluid is disposed of by injection, a permit from the Nevada Division of Environmental Protection and the State Engineer is required. The quality of the injection water is required to be the same or better than that to which it is added. It is usually (but not always) disposed of in the same stratum from which it is obtained.

2.2.6.2 Surface Disposal

Geothermal fluid may also be disposed of by release to the storm or sanitary sewer system of Reno, by a pipeline into the Cochran Ditch, or by a combination of these methods with treatment. Temporary discharge of clear thermal water from test pumping may involve the storm drains or sanitary sewer. During this well testing, fluid discharge will be contained in a storage and settling tank system. This will prevent sediments normally present from reaching receiving waters. In order to evaluate the acceptability of the disposal option of permanent disposal to surface waters, the Nevada Division of Environmental Protection may permit temporary disposal to storm sewers and the Cochran Ditch. As an alternative, the Reno Sewer Department might agree to disposal via the sanitary sewer on a temporary testing basis. Although it is expected that one of these

procedures will be satisfactory, it is also possible to build structures to retain and evaporate test water if necessary.

Storm Sewer Disposal

Release of geothermal fluids to the storm sewer system sometimes occurs in Reno. However, some of these discharges were begun before existing agencies and regulations were established. Information gained by contacting the City of Reno and Nevada Environmental Protection Division (EPD) indicates that discharge to the storm sewers (which ultimately is the same as discharge to natural channels, since the fluids will reach the Truckee River) may be difficult to justify.

Discharges to storm sewer systems or natural channels will require a National Pollutant Discharge Elimination System (NPDES) permit from the Nevada EPD. Probable requirements of the NPDES permit are discussed more fully in Section 3.2.1. However, at this point it should be mentioned that in the Truckee River Basin, water quality standards have been applied to the effluent at the "point of discharge" or "end of the pipe."

Even though water quality standards have been applied at the end of the pipe in the past, the Nevada EPD has recently instituted a policy allowing use of mixing zone concept. This concept allows the use of the receiving stream to act as a diluting medium as the discharge and receiving stream are mixed. The standards will be applied to the mixed waters at some point downstream of the discharge. If it can be shown that the receiving streams are not adversely affected by the discharges, then alternatives involving discharges to storm sewers or natural channels are feasible.

Discharge to Natural Channels

Relative to surface waters, this alternative is similar to discharging to the storm sewer system. Discharge is not feasible (without treatment), if the standards are applied at the end of the pipe. However, the newly adopted mixing zone concept could allow discharges to Cochran Ditch or Virginia Lake, depending on the amount of fluid to be discharged and its quality.

Discharge to Sanitary Sewer

Discharges to sanitary sewer systems by point source industrial clients require an NPDES permit which sets forth pretreatment requirements. The City of Reno has published requirements for discharge into their sanitary system. However, officials consider the standards to be somewhat negotiable through a mechanism called "removal credits." The standards may be relaxed if the discharger can show that through dilution factors at the treatment plant, and plant removal efficiencies for particular constituents, no adverse impacts on the plant or sludges will result.

The capacity of the Reno treatment plant has nearly been reached. There is currently a waiting list for hookups to the system. Completion of another treatment plant that should alleviate the problem is scheduled for 1983. In addition, there is a \$0.62/1000 gallon charge for discharging to the plant. Depending on the ultimate flow from the geothermal system, the cost of this disposal alternative may be prohibitive.

Treatment

The final alternative for disposal of the fluids includes the above options with treatment prior to disposal. The treatment techniques would be used to improve the quality of

the geothermal fluids such that discharge standards are not violated.

The silica content of Moana waters of other nearby wells and from all wells in Moana area has been relatively low in silica content (ranging from low of 27. ppm to 134.7 ppm). (Source: Nevada Bureau of Mines and Geology Report #25; "Evaluation of Geothermal Activity in the Truckee Meadows, Washoe County, Nevada" Page #35)

Since treatment technologies for the removal of dissolved solids (the primary contaminants in geothermal fluids) are often complex or require large amounts of land, they are usually expensive. These techniques include evaporation, dialysis, reverse osmosis, or removal of dissolved constituents by algae.

2.2.7 Utilization: Conceptual Design

Since the space, domestic water, and swimming pool water are presently heated by natural gas and fuel oil in recirculating hot water heating systems, it is a relatively simple matter to retrofit the gas and oil fired boilers to the geothermal system. A schematic of the type of system to be used is shown in Figure 2-3. There is sufficient room in the boiler-chiller areas for the additional piping, valves, controls, and heat exchangers which will be located between the line carrying the mixed return water plus makeup water, and the boiler inlet.

2.2.8 Construction Activities

2.2.8.1 Well Construction and Testing

The project wells will be drilled with mud, and a large diameter hole (18 inches) will be drilled to 200 feet. The drilling rig is a Speedstar KS9. This hole will be set with 14 inch conductor pipe. A blowout preventer will be installed when needed. From 200 feet, a pilot hole 6.8 inches will be drilled to 1,000 feet and temperature and electric logs run to determine which zones to test. Using this slim hole, several alternative

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Figure 2-3. Schematic of Retrofitting the Five Users for Use of Geothermal Energy.

methods may be used to determine available flow rates and water temperatures in different production zones: straddle packer drill-stem tests, some form of dual string air lift system, or possibly using heat resistant submersible pumps and sacrificing some of them in the test. Drilling will require about 200 gallons of city water per day for 10 to 12 days. Loss will occur only due to evaporation. The water is obtained by the driller at his business daily. About 2,000 gallons of diesel fuel will be used to drill each well.

Step drawdown tests, constant flow tests, and chemical analyses will be performed at this stage. Following these tests, the hole will be reamed out to 12.2 inches and 8 inch production casing set with perforations and gravel packed in discrete zones. Final design of the production system depends on pressure conditions and temperatures encountered; the temperatures will determine the required flow rates.

A permit from the Building and Health Departments is required for any construction job within city limits. The ownership and right-of-way situations are relatively simple because the wells and most of the piping will be on the user's land if the most probable well sites are chosen.

The well sites will be in an urban setting close to residences and probably in parking areas. Well pressure is anticipated to be hydrostatic. The construction plan will be essentially that of a deep water well but with a blowout preventer to contain possible high pressure hot water or steam.

Although a blowout is not expected, no wells in the Moana area ever encountered steam and we don't anticipate doing so, blowout prevention equipment has never been required for drilling in the area, blowout equipment would contain any spill. The spill containment measures in case of a blowout are, flanged gate valve on top, use of heavier drilling fluids if temperatures rise near flash point, portable mud pit for any excess fluids and a standby 8000 gallon water truck for excess fluid disposal. Special provisions will be made for site preparation and cleanup, disposal of drilling mud and water (using 8,000 gallon tanker trucks available locally), reduction of noise and disturbance (24 hour operation will not be possible),

and restoration afterwards to original condition except for the below ground level well head structure.

2.2.8.2 Pipeline Construction

Pipe laying will involve the use of back hoes and trucks. Pipe laying will entail getting easements. This process is eased by the fact that Nevada Water Law allows that a water right, when awarded, is awarded due to the public's benefit. Thus, if the execution of a "beneficial use" entails encroachment or easements, the holder of a water right has for that use the power of eminent domain. The power of eminent domain will be no problem as the pipe lines will run either on the properties of those participating in the project or down the street so that eminent domain would only be a question of city streets and we don't consider this a problem in any case. The needed Water Rights permits have been granted for the wells as shown in Figure 2-2. Any protests from earlier issued water rights holders had to have been made previously during the official five weeks of public notices from the State Engineer at the State Engineer's office before our permits were awarded. Spot surveys and meetings with residents' groups by Hydrothermal Engineering Corporation, however, show that they are in favor of geothermal retrofitting. Also as evidenced by the agreement with the Residents Association. We base this on our client survey to date of the owner-residents that have been surveyed by phone during this last month and the following is a brief summary of stated attitudes and comments:

1. 90% reached were for the project and had only questions of when project is to be done, and will it be in by winter, glad that no cost to owners and that discount on heat used. 20% of this 90% wanted to know about drilling hours and were happy that it would only be at day hours and location was away from buildings.

2. The only complaints to date have been over what kind of profit Hydrothermal Energy Corporation will make and that being funded in part by the government seemed unfair. The only questions have been over this one point for which 10% of those talked to had some interest in our position on it.

2.2.8.3 Construction Employment

Local people will be employed for the construction activities. The well drilling activities will employ two people for 10 to 12 days on each well. Pipe laying and retrofiting will involve ten or fewer people for less than 75 days.

2.2.9 Known Environmental Issues

Geothermal exploration and development in many areas of the United States to date has established that there are several environmental issues of concern. These are discussed in Section 3.0 and 4.0.

3.0 DESCRIPTION OF AFFECTED ENVIRONMENT

3.1 Physiography, Geology, and Soils

The land environment in the site areas has been well characterized, especially as a result of studies conducted by the Desert Research Institute of the University of Nevada System, by the Nevada Department of Conservation and Natural Resources, and by the U.S. Geological Survey. The following data are summarized primarily from the work of Bateman and Scheibach (2), Cooley et al (4), Cohen and Loeltz (5), and White (6).

3.1.1 Physiography and Topography

The site of the proposed action is located in the Truckee Meadows area of Washoe County, Nevada. The Truckee Meadows is one of a broad series of north trending topographic basins that border the Sierra Nevadas in northwestern Nevada. The Truckee Meadows area is bordered on the west by the Carson Range, on the east by the Virginia Range, on the north by spurs of these ranges, and on the south by Pleasant Valley.

The Truckee Meadows area is on the western margin of the Great Basin Section of the Basin and Range Physiographic Province. The valley is a down-dropped fault block (graben) that is partly filled with unconsolidated and partially consolidated subaerial, alluvial, and lacustrine deposits. A map of the area, showing the location of the proposed site, is shown in Figure 3-1.

The mountains bordering the Truckee Meadows area are deeply dissected, complex, fault-block mountains that have been

Figure 3-1. Map of the Truckee Meadows Area Showing the Proposed Project Site.

Source: Bateman and Scheibach (2)

broken into troughs and ridges by faults. The topographic relief of the mountains has resulted principally from uplift and gentle warping associated with movement along the faults. Remnant planar erosional surfaces (terraces) occur along the mountain fronts. Some of these terraces are quite laterally continuous, but most can be traced only for short distances. Distinct alluvial fans do not occur along the base of the Carson Range. Rather, the alluvial apron bordering this range is a prominent terrace with an elevation of about 5000 feet above sea level (about 600 feet above the valley floor). A few small but distinct alluvial fans have been formed at the mouths of streams draining the Virginia Range on the eastern flank of the valley.

The Truckee Meadows lie at elevations ranging from about 4,490 to 4,520 feet above sea level on the valley floor. The land slopes down gently to the east at about 90 feet per mile. A topographic map of the site is shown in Figure 3-2.

3.1.2 Geology

The Truckee Meadows basin is a down-dropped fault block (graben) mantled with alluvial and lacustrine deposits. The oldest rocks in the area are metamorphosed rock of Mesozoic age. These and most of the overlying consolidated rocks of Cenozoic age are broken by many normal faults. Displacements on these faults range from less than a few tens of feet to perhaps as much as several thousand feet.

The region as a whole is quite seismically active. The area is located in Seismic Risk Zone 3, indicating a potential for major structural damage from earthquakes (see Figure 3-3) (7).

Figure 3-2. Topographic Map of the Area Surrounding the Project Site.

Reno is within a Zone III earthquake area and thus there are prespecified standards for this type of construction and these standards will be met with particular attention to vibration isolation where the pipelines enter, or are near habitation or areas of sensitivity to leakage from broken or cracked lines. It is standard well and pipeline engineering to have expansion capability in the lines to allow for line movement due to heat changes and expansions. In this respect with the designed thrust blocks and expansion capability the geothermal lines will have greater resistance to earthquake damage than the comparable gas lines in the area.

- [0]** No damage: Earthquakes range from not being felt to being felt by many; some sleeping people may be wakened. Standing motorcars rocked noticeably; dishes, windows disturbed.
- [1]** Maximum damage from earthquakes is generally slight. They are felt by nearly everyone or by all; many people are frightened and run outdoors. Plaster may fall, some chimneys may be damaged.
- [2]** Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars.
- [3]** Damage from earthquakes may range from extensive damage only to poorly constructed buildings to total destruction on a widespread basis. Underground pipes may be broken and rails bent.

This map is based on the known distribution of damaging earthquakes and the Modified Mercalli intensities associated with these earthquakes, evidence of strain release, and consideration of major geologic structures and provinces believed to be associated with earthquake activity. The probable frequency of occurrence of damaging earthquakes in each zone was not considered in assigning ratings to the various zones.

Figure 3-3. General Seismic Risk Map of the United States.
Source: Algermissen (7)

The Carson Range west of the Truckee Meadows area consists primarily of granitic rocks that have intruded into a diverse assemblage of metavolcanic and metasedimentary rocks. These rocks are, in turn, covered to a large extent by Tertiary volcanic flows. The Virginia Range is similar to the Carson Range, but extrusive flows almost completely cover the granitic core of this range. The Tertiary volcanics extend across the Truckee Meadows in the subsurface. In composition, they range from basalt to rhyolite, but are predominantly andesitic flows.

Within the Truckee Meadows, the volcanic rocks are overlain locally by as much as 3,000 to 4,000 feet of lacustrine and alluvial sediments derived from the adjacent mountains. The oldest of these valley fill deposits has been mapped as the Truckee Formation of Pliocene age. The Truckee Formation consists of unconsolidated and partly consolidated diatomite, diatomaceous clay and silt, sand, and gravel. Outcrops are limited to the basin margins, primarily along the western border and upstream along the Truckee River.

There are three major types of Quaternary valley fill deposits:

- relatively coarse grained (sand, gravel) fluviatile deposits associated with channel shifts of the Truckee River, generally restricted to the portion of the basin north of the Huffaker Hills (see Figure 3-1);
- "fanglomerate" deposits around the margin of the basin, consisting of sands, gravels, and fine grained slope wash; and

- reworked older alluvial and fine grained clastic material, including lacustrine deposits of clay and silt, deposited throughout the central part of the Truckee Meadows.

Differentiating these deposits often depends on recognizing differences in structural deformation and soil profile development. It is therefore difficult or impossible to differentiate between units in the subsurface from drill cuttings.

A geologic cross-section of the valley fill in the vicinity of the site is presented in Figure 3-4. The line of the section is oriented east-west and is located about one-half mile south of the proposed well locations, as shown on Figure 3-2. The valley fill in this area consists of 75 to 100 feet of variable soils, sands, clays, and gravels, underlain by 100 to 175 feet of "blue" clay. The "blue" clay is an extensively recognized unit in the Moana geothermal area (see Section 3.2.3). The "blue" clay is generally underlain by fractured and altered Tertiary andesite from which geothermal fluids may be withdrawn as in this project.

3.1.3 Soils

The soils in the Truckee Meadows are formed from the alluvium and include clay loams, light sandy loams, and gravelly sandy loams. Mappable soil units are highly variable over the area, reflecting variations in the underlying substrate. Lacustrine, stream channel, and slope wash deposits are irregularly distributed over the area. Crop raising in the valley requires irrigation.

Figure 3-4. Simplified Geologic Cross-Section Through the Valley-Fill, 0.5 Miles South of the Proposed Site. See Figure 3-2 for Line of Section. Source: Bateman and Scheibach (2)

3.1.4 Prime Farmlands

Prime farmlands are those whose value derives from their general advantage as cropland due to soil and water conditions. Unique farmlands are those whose value derives from their particular advantages for growing specialty crops. Paragraph 101(b)(4) of the National Environmental Policy Act (NEPA) establishes a federal policy to preserve and maintain, wherever possible, an environment which supports diversity and variety of individual choice, including the preservation of highly productive farmland.

The proposed well sites and pipeline routes are located about 0.8 miles northwest of 2.5 acres of prime farmland as is shown in Appendix B (Gerald Thola, personal communication). The soil map unit within which the prime farmland is identified is the Idlewild gravelly sandy loam (Unit 602).

3.2 Hydrology

3.2.1 Surface Water

The project area, within the Reno city limits, lies within the Truckee River Basin. The Truckee flows from Lake Tahoe, on the Nevada-California border, generally eastward to Pyramid Lake, Nevada. The drainage area of the Truckee River above Reno is approximately 1,067 mi².

The project site is located in south Reno and is in the drainage basin of Virginia Lake/Cochran Ditch. Water from Virginia Lake eventually flows to the Truckee River via the Cochran Ditch and Steamboat Creek.

Surface water quality records are available for the Truckee River at Lockwood, Nevada which is about seven miles east of Reno at a U.S. Geological Survey (USGS) sampling point. A stream gauging station is also maintained in downtown Reno. The data in Table 3-1 are water quality records from the Lockwood station with flow records from the Reno station. No data are available on Virginia Lake/Cochran Ditch.

The Nevada Environmental Protection standards for the Truckee River, both east and west of Reno, are presented in Table 3-2. It is evident from these data that the Truckee water does not always meet all the standards. Specifically, concentrations of dissolved solids, chloride, pH, temperature, dissolved oxygen, and nitrate have all deviated from the standards in water years 1976, 1977, or 1978. In the Truckee River drainage area, these standards have been applied at the end of the pipe in an effort to protect the river water quality. As discussed in Section 2.2.6.2, a mixing zone concept has recently been instituted. The Truckee is especially sensitive because of its low flow, its importance as a drinking water source, its use in irrigation for agriculture, and the existence of two endangered fish species in the river.

3.2.2 Ground Water

In the Truckee Meadows, most of the recoverable ground water occurs in the alluvial valley fill deposits. The most permeable deposits are genetically related to channel shifts of the Truckee River, and are therefore largely restricted to the area north of the Huffaker Hills. Neighboring and/or underlying deposits of the Truckee Formation are generally too fine-grained to yield much water to wells. The volcanic rocks in the area are permeable only where fractured or jointed.

TABLE 3-1. WATER-QUALITY DATA FOR TRUCKEE RIVER AT
LOCKWOOD, NEVADA (USGS Station No. 10350000;
Drainage Area - 1433 mi²)

Parameter	Oct. 77-Sept. 78		Oct. 76-Sept. 77		Oct. 75-Sept. 76	
	Mean Value	Range	Mean Value	Range	Mean Value	Range
Flow (cfs)*	452.0	24-2860	257.0	29-469	499.0	296-934
Sulfate (mg/l)	31.3	4.5-60	21.0	16-24	13.0	8.1-15
Chloride (mg/l)	23.8	4.0-42	15.3	10-21	9.6	5.1-13
Nitrate (mg/l)	0.7	0.1-6.2	0.5	.18-1.5	0.3	0.1-0.68
Total Phosphorous (mg/l)	1.1	0.1-11.0	0.8	0.17-6.3	0.3	0.2-0.46
Total Dissolved Solids (mg/l)	174.0	70-305	159.0	134-188	120	89-139
pH	7.9	7.2-8.5	8.1	7.3-8.7	8.0	79-8.3
Temperature (°C)	10.7	2.5-21.5	11.5	1.0-23.0	10.2	2.5-19.5
Dissolved Oxygen (mg/l)	10.6	9.2-12.7	7.9	6.2-9.6	9.4	8.0-10.8
Fecal Coliform (no./100 ml)	358.0	21-580	33.0	<2-210	--	--
Hardness (mg/l)	81.0	38-130	75.8	68-86	55.7	44-65

*Flow values are from USGS Station No. 10348000 at Reno; all other values are from Station No. 10350000 at Lockwood, Nevada.

Sources: U.S. Geological Survey (8,9,10).

TABLE 3-2. NEVADA STATE WATER QUALITY STANDARDS FOR
THE TRUCKEE RIVER

Parameter	West of Reno	East of Reno
Dissolved Solids (mg/l)	100 annual average 125 single event	125 annual average 150 single event
Sulfate	No standard	No standard
Chloride (mg/l)	10	10
Nitrate as NO ₃ (mg/l)	2	2
Phosphate as PO ₄ (mg/l)	0.1 annual average 0.3 single event	0.25 annual average 4.0 single event
pH	7.5-8.0 annual 6.5-8.5 single	7.5-8.0 annual 6.5-8.5 single
Temperature (°C)	June-Sept. - 17.0 average 21.0 single Winter - 14.0 single ΔT 3.0° rise in receiving stream	June-Sept. - 17.0 average 22.0 single Winter - 14.0 single ΔT 3.0° rise in receiving stream
Dissolved Oxygen (mg/l)	June-Sept. - 8.0 average 7.0 single	June-Sept. - 8.0 average 7.0 single
Turbidity (JTU)†	Maximum Δ = 10 over natural	Maximum Δ = 10 over natural
Fecal Coliform	(1) The annual mean cannot exceed 1,000/100 ml and more than 20 percent of the total sample shall not exceed 2,400/100 ml. or (2) The annual mean shall not exceed the characteristic natural conditions by more than 200/100 ml, nor shall the number of fecal coliform in a single sample exceed natural conditions by more than 400/100 ml.	

†JTU = Jackson Turbidity Units.

TABLE 3-2 (Continued). NEVADA STATE WATER QUALITY STANDARDS FOR
THE TRUCKEE RIVER

Parameter	West of Reno	East of Reno
Arsenic* (mg/l)	.05	.05
Barium* (mg/l)	1.0	1.0
Beryllium* (mg/l)	.011	.011
Boron* (mg/l)	1.0	1.0
Cadmium* (mg/l)	.0004	.0004
Chromium (mg/l)	.05	.05
Copper* (mg/l)	.01	.01
Fluoride* (mg/l)	1.8	1.8
Lead* (mg/l)	.05	.05
Mercury* (mg/l)	.00005	.00005
Nickel* (mg/l)	0.1	0.1

*Proposed standards; adoption expected in September, 1979.

Source: Department of Conservation and Natural Resources (Nevada; 11).

Cooley et al (4) conducted hydrologic investigations and computer model simulations of the ground-water system in the Truckee Meadows. Part of their work resulted in the trend surface plot of (hydraulic) conductivity indices shown in Figure 3-5. The values shown reflect the variation in "average" conductivity over the basin. The values are weighted to reflect the relative abundances of materials in different conductivity classes over the area. They are useful in comparing general conductivity characteristics from one part of the basin to another. One of the most significant features to be observed from the plot is the east-west trend of high conductivity indices along the Truckee River. This trend reflects the relative abundance of coarse grained channel deposits in the area.

Ground water movement through the area is controlled by the hydraulic gradient in the area. Figure 3-6 shows the general configuration of the water table. Movement is perpendicular to the water elevation contours shown on the map. A particular feature to note on the map is the change in the Truckee River regimen from effluent (water flowing out of the aquifer into the river) to influent (water flowing into the aquifer from the river) from west to east.

Recharge to the aquifer is derived from infiltration of streamflow and precipitation, from infiltration of water diverted for irrigation, and to a small extent, from underflow from tributary valleys. Nearly all of the recharge ultimately is derived from precipitation in the high mountains west of the valley. Direct precipitation within the valley is very minor.

Ground water discharge in the valley results primarily from evapotranspiration and seepage to streams and ditches of the extensive irrigation system. Underflow out of the valley via the alluvium of the Truckee River Canyon to the northeast is negligible.

Figure 3-5. Trend Surface of Conductivity Indices In the Truckee Meadows. Source: Cooley et al (4)

Figure 3-6. Map of the Water Table and Ground-Water Discharge Areas in the Truckee Meadows
Source: Cooley et al (4)

The quality of water in the valley fill is highly variable. Water quality is reduced where shallow non-thermal waters mix with the thermal waters of the Moana and Steamboat Springs geothermal areas (see Section 3.2.3). High sulfate concentrations are also found in some areas around the margins of the valley, where the water chemistry is affected by bleached, hydrothermally altered bedrock. The sulfate is derived from the weathering of secondary pyrite. Average chemical quality data for the Truckee Meadows area are presented in Table 3-3.

TABLE 3-3. AVERAGE CHEMICAL QUALITY OF NON-THERMAL GROUND WATER IN THE TRUCKEE MEADOWS.
Source: Bateman and Scheibach (2).

Parameter	Average Value	Range
Temp. (°C)	14.8	9.4 - 19.4
pH	7.7	7.0 - 8.8
SEC*	609.	236. - 3780.
TDS (mg/l)	482.	117. - 3278.
HCO ₃ (mg/l)	180.	68. - 435.
Cl (mg/l)	23.	1.4 - 315.
SO ₄ (mg/l)	111.	2.4 - 1680.
Na (mg/l)	51.	6.0 - 400.
K (mg/l)	6.	1.0 - 39.
Ca (mg/l)	48.	7.4 - 354.
Mg (mg/l)	17.	3.0 - 137.
SiO ₂ (mg/l)	51.	15. - 101.

*Specific electrical conductance (μmhos/cm @ 25°C).

3.2.3 Geothermal Resources

The Moana KGRA is situated along the western margin of the Truckee Meadows at the southern edge of Reno, as shown in Figure 3-7. The presence of the thermal system here is thought

Figure 3-7. Areas of Known Thermal Ground-Water Occurrence in the Truckee Meadows.

Source: Bateman and Scheibach (2)

to be controlled by faulting that parallels the front of the Carson Range. Although recent vulcanism is not evident near Moana, the heat source is presumed to be a cooling magmatic body at an unknown depth of possibly several miles.

The thermal waters at Moana are largely, if not entirely, of meteoric origin. This is indicated by geochemical factors: Moana waters contain relatively low chloride, lithium, and boron concentrations compared to those expected of waters with a large juvenile water contribution. The operation of the system is postulated to operate as follows: 1) cool recharge waters originating in the Carson Range to the west percolate downward, probably via faults or joints; 2) the waters are heated at depth by a presumed magmatic heat source; and 3) with the resulting decrease in density, the warmed waters rise convectively along fault planes.

The Moana thermal waters are associated with the "blue" clay (described in Section 3.1.2 and shown in Figure 3-4) and are not generally found above this unit. It is postulated that the "blue" clay layer acts as a relatively impermeable cap over the postulated fault zone in the underlying andesite, forcing the water to diffuse laterally. Water temperatures encountered at depths of 100 feet or more range from 170 to 205°F (approximately boiling at this elevation).

The chemical quality of the Moana waters is compared to that in non-thermal waters from elsewhere in the Truckee Meadows, and to waters from the Steamboat Springs Geothermal System to the south, in Table 3-4. Chemistry data on Moana waters are presented by Bateman and Scheibach (2). They found that Moana waters are dominated by sodium sulfate, with somewhat high levels of silica.

TABLE 3-4. COMPARISON OF MOANA GEOTHERMAL WATERS, WATERS FROM STEAMBOAT SPRINGS GEOTHERMAL AREA, AND NON-THERMAL GROUND WATERS IN THE TRUCKEE MEADOWS. Source: Bateman and Scheibach (2).

Location	Steamboat Springs 18N 20E 33AB		Moana area 19N 19E 26ADDD		Non-Thermal Wells 19N 20E 8DDD	
	mg/l	epm	mg/l	epm	mg/l	epm
HCO ₃	305	5.00	85	1.39	116	1.90
CO ₃	0	—†	0	—	0	—
Cl	865	24.39	50	1.41	7	0.20
SO ₄	100	2.08	457	9.51	57	1.19
F	1.8	0.09	4.8	0.25	0.2	0.01
Br	0.2	—	<0.1	—	—	—
I	0.1	—	0.2	—	—	—
H ₂ S	4.7	—	0.2	—	—	—
B	49	—	2.0	—	—	—
Total anions	1,326	31.6	599	12.6	180	3.3
Na	653	28.41	243	10.58	43	1.87
K	71	1.82	7.4	0.19	—	—
Ca	5.0	0.25	23	1.15	22	1.10
Mg	0.8	0.06	0.2	0.02	3.9	0.32
Al	0.5	—	<0.04	—	—	—
As	2.7	—	0.10	—	—	—
Fe	0.05	—	0.02	—	0.05	—
Hg	—	—	<0.0005	—	—	—
Li	7.6	1.10	0.19	—	—	—
Mn	0.05	—	0.01	—	0.02	—
Sb	0.4	—	<0.01	—	—	—
Se	—	—	<0.005	—	—	—
Sr	0.5	—	0.5	—	—	—
Total cations	742	31.6	274	11.9	69	3.3
SiO ₂ (mg/l)	293		102		39	
SEC*	3,210		1,367		325	
TDS (mg/l)	2,361		975		288	
pH	7.9		8.3		8.0	
Temp. (°C)	89.2		89.9		23.3	
Depth (ft.)	—		150		752	

*Specific electrical conductance (μmhos/cm @25°C)

†Not reported.

The concentration of silica shown in Table 3-4 (102 mg/ℓ) is equivalent to saturation with respect to amorphous silica at a temperature of 48°F. The Moana waters contain far less than the amorphous silica saturation concentration at their temperature of 194°F, as given in Table 3-4. At this temperature, the amorphous silica saturation concentration is on the order of 350 mg/ℓ SiO₂. Even at a temperature of 100°F, a temperature on the order of that expected for the spent geothermal fluids, the amorphous silica saturation concentration is above 150 mg/ℓ. Thus, no problems with silica precipitation are expected.

Significant trace elements include fluoride, boron, arsenic, and lithium. Arsenic and fluoride concentrations commonly exceed maximum contaminant levels for the National Interim Primary Drinking Water Standards, while boron frequently exceeds the recommended water quality criterion level of 0.75 mg/ℓ for long term irrigation of sensitive crops (12).

3.3 Atmospheric Characteristics

The Reno, Nevada area is considered to have a dry continental climate.

3.3.1 Temperature and Relative Humidity

The mean annual temperature at Reno is 49°F, according to data for the period 1941-1970. Monthly mean temperatures range from 32°F in January to 69°F in July. Daily maximum temperatures average near 91°F in August. January has the lowest average daily minimum temperature with 18°F. Reno has an averaging growing season of 141 days (13).

Relative humidity is normally quite low in the Reno area. Average annual early morning (4 a.m., PST) and afternoon (4 p.m., PST) relative humidities are 69 percent and 32 percent, respectively (13).

3.3.2 Precipitation

Data for the period 1941-1970 show that the mean annual precipitation at Reno totals 7.20 inches. Average monthly rainfall ranges from a January maximum of 1.21 inches to an August minimum of 0.22 inches (13). Data for the period 1931-1960 show that the annual snowfall total averages 26.2 inches. Maximum expected rainfall amounts over given periods of time for selected return periods are shown in Table 3-5. For example, a one hour rainfall of 0.7 inches is expected to occur once every five years. A twenty-four hour rainfall of 5.0 inches is expected to occur once every 100 years

3.3.3 Severe Weather Occurrences

Thunderstorms occur on the average of 13 days during the year in the Reno area. More thunderstorm days occur on the average in July (with four) than in any other month (13).

Sustained winds up to 50 mph can be expected about once every two years, while sustained winds up to 80 mph can be expected only about once every 100 years (15).

Tornadoes are very rare over the entire state of Nevada. Based on the period 1955-1967, the average annual number of tornado occurrences in Nevada is less than one (16). Likewise, hailstorms are rare in Nevada. During the period 1955-1967, there were only seven reports of hail with a diameter of 0.75 inch or greater (16).

TABLE 3-5. MAXIMUM EXPECTED RAINFALL AMOUNTS PER DURATIONS FOR
SELECTED RECURRENCE INTERVALS FOR THE RENO, NEVADA
AREA (cm, inches)

Rainfall Duration (Hours)	Rainfall Recurrence Interval (Years)						
	1	2	5	10	25	50	100
1/2	0.8, 0.3	1.0, 0.4	1.3, 0.5	1.5, 0.6	1.8, 0.7	2.3, 0.9	2.5, 1.0
1	0.8, 0.3	1.3, 0.5	1.8, 0.7	2.0, 0.8	2.3, 0.9	2.8, 1.1	3.3, 1.3
2	1.3, 0.5	1.5, 0.6	2.3, 0.9	2.8, 1.1	3.3, 1.3	3.8, 1.5	4.3, 1.7
3	1.8, 0.7	2.3, 0.9	3.0, 1.2	3.6, 1.4	4.1, 1.6	4.6, 1.8	5.3, 2.1
6	2.5, 1.0	3.3, 1.3	4.6, 1.8	5.8, 2.3	6.6, 2.6	7.6, 3.0	8.4, 3.3
12	3.8, 1.5	4.1, 1.6	6.1, 2.4	7.6, 3.0	8.6, 3.4	10.2, 4.0	10.7, 4.2
24	4.3, 1.7	5.1, 2.0	7.1, 2.8	8.1, 3.2	10.2, 4.0	12.2, 4.8	12.7, 5.0

Source: Hershfield (14).

Because water supplies are primarily dependent on runoff from the mountains, droughts in the immediate Reno area are of much less concern than the amount of snow that falls in the surrounding mountains during the fall, winter, and spring. During 1975-1976, water supplies were adversely affected by an unusually small amount of snowfall in the mountains.

3.3.4 Air Quality and Dispersion Conditions

The Reno area is in Environmental Protection Agency (EPA) Air Quality Control Region (AQCR) No. 148.

Federal ambient air quality standards for particulates, sulfur dioxide, and nitrogen dioxide are presented in Table 3-6. Data provided by the Washoe County District Health Department indicate that, for the Truckee Meadows area of AQCR No. 148, total suspended particulate (TSP) annual averages are just below the primary federal ambient air quality standards for particulates and above the secondary standard. The unweighted annual average for total suspended particulates for the six stations in the Truckee Meadows (period 1972-1977) was $71 \mu\text{g}/\text{m}^3$. Sulfur dioxide levels in the area are generally very low (no averages are available). The average annual nitrogen dioxide concentration for the period 1974-1976 was $59.5 \mu\text{g}/\text{m}^3$ which is well below the federal standard. Nitrogen dioxide is measured at only one station which is located in downtown Reno.

Unfavorable dispersion conditions (particularly during the night and early morning) are fairly common in the Reno area due to its location in a valley surrounded by mountains and the common presence of high pressure over the region. On a regional basis, nighttime and morning temperature inversions and/or

TABLE 3-6. FEDERAL ANNUAL AMBIENT AIR QUALITY
STANDARDS FOR PARTICULATES, SULFUR
DIOXIDE, AND NITROGEN DIOXIDE

Pollutant	Concentrations ($\mu\text{g}/\text{m}^3$)	
	Annual Primary Standard	Annual Secondary Standard
Particulates	75	60
Sulfur Dioxide	80	--
Nitrogen Dioxide	100	100

Source: U.S. Department of Energy (17).

isothermal layers based at or below 500 feet are present during about 43 percent of the hours during the year. These inversions or isothermal layers are most frequent during the fall (about 50 percent of the total hours) and least frequent during the summer (about 36 percent of the total hours; 18).

Dispersion conditions are normally good during the afternoon because of the vertical mixing created by heating and increased transport wind speeds. Seasonal and annual average afternoon mixing heights and transport wind speeds for the Reno region are presented in Table 3-7. Mixing height is defined as the height to which strong vertical mixing of the air takes place, while transport wind speed is defined as the average wind speed in the mixed layer. As shown in Table 3-6, afternoon vertical mixing in the region is strongest during the summer and weakest during the winter. Transport wind speeds are also strongest during the spring and weakest during the winter (19).

During air stagnation episodes, dispersion conditions are poor even during the afternoon. Annually, there are about 40 air stagnation episode days in the region for episodes

TABLE 3-7. AVERAGE AFTERNOON MIXING HEIGHTS
AND TRANSPORT WINDS IN THE RENO,
NEVADA REGION*

Season	Afternoon Mixing Height (feet)**	Afternoon Transport Wind (mph)
Spring	7,500	13
Summer	9,000	12
Fall	6,000	10
Winter	3,500	9
Annual	6,500	11

*Based on data for the period 1960-1964.

**Nearest 500 feet above ground.

Source: Holzworth (19).

lasting at least two days with maximum mixing heights of no more than 4,900 feet and maximum transport wind speeds of no more than 9 mph. The most likely season of occurrence is the winter (19).

Hydrogen sulfide is found in the geothermal fluids (Table 3-4) of the Moana KGRA in fairly small amounts. Odors are not noticeable at the geothermal wells near the project site. City officials do not consider this to be a serious problem. The project wells and pipeline contain the fluids until release at the point of disposal. Therefore, gaseous release of hydrogen sulfide is not expected.

3.4 Noise

This section presents results of a study to determine the acoustical noise distribution and impacts of the Reno Geo-Thermal Well Operations. Detailed baseline noise measurements throughout the Moana section were conducted and drilling noise

emissions predicted. This inhabited area was of primary concern due to its close proximity to the geothermal well sites.

3.4.1 Existing Environmental Noise

To establish representative baseline sound fields in the areas of the geothermal development site, an intensive survey (20) was performed on Tuesday night, Wednesday, and Thursday morning; 7-9 July 1980. A-weighted sound level (ASL) measurement locations were preselected based on the probable and alternate drilling locations and the land use in the surrounding area. The baseline levels were measured ten times at each sampling location at ten second intervals and then aggregated to give the average meter indication. Measurements were centered around 0730, 1000, 1500, 1700, 2100, 0200. These time periods were selected as representative of the activity patterns in this section of Reno by comparison with traffic flows documented by the City of Reno, Traffic Engineer Division (Figure 3-8). The A-weighted sound level readings are provided in Appendix C together with a map showing the measurement locations. Data from each grid point were approximately time weighted and used to calculate daytime equivalent sound levels (L_d), nighttime equivalent sound levels (L_n) and day-night sound levels (L_{dn}) for the ambient noise existing in the concerned area over a 24-hour period. These calculations are discussed in Appendix C. The resulting L_d , L_n , and L_{dn} isopleths are shown in Figures 3-9, 3-10, and 3-11.

The baseline ambient results show a definite influence from traffic on Moana Lane and Plumas Street. The variations in the 24-hour ASL measurements are caused by changes in traffic density. The conditions under which the survey was made were normal to the area.

Figure 3-8. Traffic Count on Moana Lane and Plumas Street, Reno, Nevada
Source: City of Reno, Transportation Engineering Section.

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Figure 3-9. Daytime Equivalent Sound Level (L_d) in dBA; 8-9 July 1980 (0700-2200 hr).

Figure 3-10. Nighttime Equivalent Sound Level (L_n) in dB(A); 8 July 1980 (2200-0700 hr.).ⁿ

Figure 3-11.. Day-Night Equivalent Sound Level (L_{dn}); 8-9 July 1980.

The dominant noise source near all of the occupied apartment buildings was traffic. Traffic on both Plumas and Moana is consistently heavy, because these routes offer fast, easy access to downtown Reno. For this reason, traffic exits US 395 (Virginia Street) at Moana Lane, travels east to Plumas Street, and reaches the downtown area without encountering congestion on US 395. This observation was confirmed by conversations with local residents.

Earlier (1979) measurements within the hallways and courtyards of a typical apartment complex in the project area were performed during the heavy afternoon traffic and the transmission loss through windows of the apartment buildings was calculated. The results of interior sound measurements and calculations are given in Table 3-8. During the recent survey, an opportunity to measure the change in sound level from outside the Anderson School to inside the teacher's lounge while City of Reno Engineering personnel were operating a jackhammer presented itself, and these results are also in Table 3-8.

Typical transmission loss through glass is shown in Figure 3-12. The presence and use of windows may differentially affect inhabitants of the users' buildings.

Although calculations of noise transmission loss through windows may not be relevant during the mild summer climate (warm days, cool nights) for certain occupants, the apartment buildings in this area are designed to be climate controlled. The ability to close their windows will present residents with a method of controlling unwanted noise impact.

TABLE 3-8. INTERIOR SOUND LEVEL, dBA MEASUREMENTS AND CALCULATIONS

Location	Measured	Calculated
Apartment Courtyard	55	NA
Hallway	45	NA
Apartment Interior	NA ¹	30 ²
School playground (with jackhammer)	84	NA
School interior (with jackhammer)	62	NA

¹NA = Not applicable; no unoccupied apartments were available for obtaining "in room" measurements.

²The interior sound level was calculated using typical transmission loss values for glass walls and windows. These values should be considered approximations only. In the absence of actual measurements and specific definitions of construction methods, the transmission loss values selected from the Industrial Noise Control Handbook (21) give reasonably safe criteria.

NOTE:

1. Special laminated safety glass containing one or more visco-elastic layers sandwiched between glass panels will yield 3-8 dB higher values than given here for single thicknesses of glass; available in approximately 1/4 in. to 5/8 in. thicknesses.

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Figure 3-12. Typical Transmission Loss of Glass Walls or Windows (22).

3.4.2 Noise Emissions

Noise emissions from drilling equipment necessary for the completion of the geothermal wells will be dominated by the drilling rig itself. Other equipment such as trucks are a transient source of noise of secondary impact. Measurements were taken of an operating drilling rig identical to the one which is to be used for the development of this geothermal site. An octave-band sound pressure level (OBSPL) and an A-weighted sound level (ASL) survey were performed to define the noise emission levels. The drilling rig, a Speedstar KS9, is a self-propelled system, including a 220-horsepower diesel engine, pumps, and associated rigging. For the purpose of the survey, the rig was operated under simulated drilling conditions because it was not located at an actual drilling site. This testing occurred in August 1979.

The diesel engine is exposed on two of its sides and the exhaust is muffled. The OBSPL and ASL measurements taken on four azimuths of the rig at distances of 17 and 30 feet from the center of the engine. The azimuths were separated by 90 degrees and were referenced to the engine by exhaust direction. The OBSPL and ASL measurements at greater distances were not possible because the rig was being operated within a restricted area of the equipment yard. The vector "A" values represent measurements that were performed directly in line with the diesel exhaust direction. Vectors "B" and "D" represent values measured at 90 and 270 degrees counterclockwise from the exhaust.

Results of the measurements are shown in Figure 3-13 for a predicted level of 120 feet. The sound pressure level spectra for all measurements peaked at 63 Hz. The "A" vector,

DRILL RIG ORIENTATION

Figure 3-13. Measured Sound Pressure Level Spectrum at 120 feet; Speedstar KS9 Drilling Rig.

the direction of the exhaust, and the "C" vector had the highest noise emissions. The levels at vector "C" were higher than at vector "A" because the engine was completely exposed on that side of the rig. All measurements tended to drop 3 to 9 dBA per octave as the frequency increase from 63 to 8,000 Hz. The 1,000 Hz measurement of vectors "C" and "D" showed a 3 to 4 dBA increase above 500 to 2,000 Hz measurements. The most significant sound pressure level drops were between 63 Hz and 125 Hz for vectors "B," "C," and "D."

A directivity pattern in dBA for a 120 foot radius was prepared from calculations using measurements taken at 30 feet. Results (Figure 3-14) showed a major lobe in the direction 180 degrees from the exhaust, vector "C," a maximum level of 9 to 11 dBA higher than vectors "A" and "B", respectively, and a level of 5 dBA higher than vector "D." Typical levels of noise emission from other equipment in terms of ASL are shown in Figure 3-15.

Testing operations will involve test pumping hot water at rates up to about 500 gpm. No unusual noise is expected during these operations; the noise level should be below the noise level during drilling.

We have chosen the well sites on those properties we have agreements with in such a manner to be sufficiently far away from residents to keep noises within acceptable limits. "Project noise will be mitigated using baffles and rig orientation to maintain the ambient level outside residences, apartments, schools and other noise sensitive areas below 55dBA during the hours of construction operations (8:00 a.m. to 6:00 p.m.)."

Figure 3-14. Directional Characteristics of a 220 hp Drilling Rig at a Radius of 120 Feet.

Figure 3-15. Typical Noise Levels Reported for Various Geothermal Resource Developments. Source: Robert Craig, Oak Ridge National Laboratory, personal communication.

3.5 Biology

3.5.1 Site Description

The proposed site for the location of the two geothermal wells in the city of Reno described in this report is a highly urbanized area. The area has a high density of apartment houses, a school, a shopping center, city streets, vacant lots, and a large golf course. Lawns, planted trees, and flower gardens provide the primary plants of the area. Reno is in an agricultural region consisting of irrigated fields in the Truckee Meadows. As the elevation increases in the surrounding foothills and mountains, desert vegetation gradually gives way to the Ponderosa pine forests of the Sierra Nevada range on the west.

3.5.2 Native and Introduced Biota

The native biota of the Truckee Meadows are the biota of the Great Basin Desert and of the Truckee River. The climatic climax of this desert region is the sagebrush-grass vegetation. Much of the farmland in the Great Basin Desert has been claimed from this vegetation zone. Big sagebrush (Artemisia tridentata) is the main shrub of the region (23). Agropyron spicatum and Poa sandbergii are grasses which are often co-dominants with the shrubs. In many areas, overgrazing has decreased the grasses in the sagebrush-grass vegetation and encouraged the spread of the shrubs. Some of the common annual and perennial forbs include Mimulus spp., Eriogonum spp., and Phlox longifolia. A table of some of the plant species important in this vegetation zone are given in Table 3-9.

Common mammals, birds, and fishes of the Truckee Meadows Region are listed in Tables 3-10, 3-11, and 3-12, respectively. Many of the sport fishes of the lakes and rivers

TABLE 3-9. IMPORTANT PLANTS OF THE SAGEBRUSH-GRASSLAND VEGETATION

Shrubs	Perennial Grasses	Perennial Forbs*	Annual Forbs	Weeds
<i>Artemisia arbuscula</i>	<i>Agropyron spicatum</i>	<i>Agoseris</i> spp.	<i>Collinsia parviflora</i>	<i>Amaranthus retroflexus</i>
<i>Chrysothamnus nauseosus</i>	<i>Aristida longiseta</i>	<i>Allium acuminatum</i>	<i>Eriogonum</i> spp.	<i>Apocynum cannabinum</i>
<i>Chrysothamnus viscidiflorus</i>	<i>Elymus cinereus</i>	<i>Astragalus</i> spp.	<i>Mimulus</i> spp.	<i>Bromus tectorum</i>
<i>Ephedra viridis</i>	<i>Festuca idahoensis</i>	<i>Castilleja chromosa</i>	<i>Phacelia adenophora</i>	<i>Chenopodium album</i>
<i>Grayia spinosa</i>	<i>Oryzopsis hymenoides</i>	<i>Chrysopsis villosa</i>		<i>Convolvulus arvensis</i>
<i>Leptodactylon pungens</i>	<i>Poa sandbergii</i>	<i>Crepis acuminata</i>		<i>Cynoglossum officinale</i>
<i>Purshia tridentata</i>	<i>Poa nevadensis</i>	<i>Delphinium andersonii</i>		<i>Descurainia sophia</i>
<i>Ribes velutinum</i>	<i>Sitanion hystrix</i>	<i>Eriogonum</i> spp.		<i>Helianthus annuus</i>
<i>Symphoricarpos</i> spp.	<i>Sporobolus airoides</i>	<i>Hymenoxys richardsonii</i>		<i>Lactuca serriola</i>
<i>Tetradymia glabrata</i>	<i>Stipa comata</i>	<i>Lomatium</i> spp.		<i>Lamium amplexicaule</i>
		<i>Lupinus caudatus</i>		<i>Lepidium perfoliatum</i>
		<i>Phlox hoodii</i>		<i>Polygonum aviculare</i>
		<i>Viola beckwithii</i>		<i>Salsola kali</i>
				<i>Taraxacum officinale</i>
				<i>Verbena bracteata</i>
				<i>Veronica</i> spp.

*Forbs are herbaceous species other than grasses.

Source: Cronquist, *et al.*, (23).

TABLE 3-10. MAMMALS OCCURRING IN THE SONONORAN DESERT
OF WASHOE COUNTY

Scientific Name	Common Name
<i>Ammospermophilus leucurus</i>	Whitetail antelope squirrel
<i>Antrozous pallidus</i> *	Pallid bat
<i>Canis latrans</i>	Coyote
<i>Castor canadensis</i>	Beaver
<i>Citellus beecheyi</i>	California ground squirrel
<i>Citellus townsendi</i>	Townsend ground squirrel
<i>Dipodomys microps</i>	Great basin kangaroo rat
<i>Dipodomys ordi</i>	Ord kangaroo rat
<i>Dipodomys panamintinus</i>	Panamint kangaroo rat
<i>Eptesicus fuscus</i> *	Big brown bat
<i>Euderma maculata</i>	Spotted bat
<i>Eutamias minimus</i>	Least chipmunk
<i>Lagurus curtatus</i>	Sagebrush vole
<i>Leupus californicus</i>	Blacktail jackrabbit
<i>Lutra canadensis</i>	River otter
<i>Lynx rufus</i>	Bobcat
<i>Marmota flaviventris</i>	Yellow-bellied marmot
<i>Mephitis mephitis</i> *	Stripped skunk
<i>Microdipodops megacephalus</i>	Dark kangaroo mouse
<i>Microtus montanus</i>	Mountain vole
<i>Mus musculus</i> *	House mouse
<i>Mustela frenata</i>	Longtail weasel
<i>Mustela vison</i>	Mink
<i>Myotis lucifugus</i> *	Little brown myotis
<i>Myotis subulatus</i> *	Small-footed myotis
<i>Myotis thysanodes</i> *	Fringed myotis
<i>Myotis volans</i> *	Long-legged myotis

(Continued)

*Rural and possible urban dwellers

TABLE 3-10 (Continued). MAMMALS OCCURRING IN THE SONONORAN DESERT
OF WASHOE COUNTY

Scientific Name	Common Name
<i>Neotoma lepida</i>	Desert woodrat
<i>Ondatra zibethica</i>	Muskrat
<i>Onychomys leucogaster</i>	Northern grasshopper mouse
<i>Ovis canadensis</i>	Bighorn sheep
<i>Perognathus parvus</i>	Great basin pocket mouse
<i>Peromyscus maniculatus</i>	Deer mouse
<i>Plecotus townsendi</i> *	Western big-eared bat
<i>Procyon lotor</i>	Raccoon
<i>Rattus norvegicus</i> *	Norway rat
<i>Reithrodontomys megalotis</i> *	Western harvest mouse
<i>Scapanus latimanus</i> *	California mole
<i>Sorex merriami</i>	Merriam shrew
<i>Sorex palustris</i>	Northern water shrew
<i>Sorex vagrans</i>	Vagrant shrew
<i>Spilogale putorius</i> *	Spotted skunk
<i>Sylvilagus idahoensis</i>	Pygmy rabbit
<i>Sylvilagus nuttalli</i>	Mountain cotton tail
<i>Taxidea taxus</i>	Badger
<i>Thomomys bottae</i>	Valley pocket gopher

*Rural and possible urban dwellers

Source: Hall (24).

TABLE 3-11. BIRDS OF THE RENO AREA

Scientific Name	Common Name
<i>Ardea herodias</i>	Great blue heron
<i>Buteo jamaicensis</i>	Red-tailed hawk
<i>Cardinalis cardinalis</i>	Cardinal
<i>Cathartes aura</i>	Turkey vulture
<i>Chordeiles minor</i>	Common nighthawk
<i>Circus cyaneus</i>	Marsh hawk
<i>Falco peregrinus</i>	Peregrine falcon
<i>Gavis immer</i>	Common loon
<i>Lophortyx californicus</i>	California quail
<i>Melospiza melodia</i>	Song sparrow
<i>Mimus polyglottos</i>	Mockingbird
<i>Nycticorax nycticorax</i>	Black-crowned night heron
<i>Pelecanus erythrorhynchos</i>	White pelican
<i>Pica pica</i>	Black-billed magpie
<i>Podiceps auritus</i>	Horned grebe
<i>Rallus limicola</i>	Virginia rail
<i>Selasphorus rufus</i>	Rufous hummingbird
<i>Steganopus tricolor</i>	Wilson's phalarope
<i>Sturnella neglecta</i>	Western meadowlark
<i>Tyrannus verticalis</i>	Western kingbird
<i>Zenaida macroura</i>	Mourning dove

Source: Ryser (25).

TABLE 3-12. FISH OF THE TRUCKEE MEADOWS REGION

Scientific Name	Common Name
<i>Catostomus tahoensis</i>	Tahoe sucker
<i>Chaomistes cujus</i> †	Cui-ui lakesucker
<i>Ictalurus catus</i> *	White catfish
<i>Lepomis cyanellus</i> *	Green sunfish
<i>Oncorhynchus nerka</i> *	Sockeye or Blueback salmon
<i>Pantosteus lahontan</i>	Lahonton mountainsucker
<i>Richardsonius egregius</i>	Lahonton redshiner
<i>Rhinichthys osculus robustus</i>	Lahonton speckle dace
<i>Salmo clark</i>	Cutthroat trout
<i>Salmo clarki henshawi</i> †	Lahonton cutthroat trout
<i>Salmo gairdneri</i> *	Rainbow trout
<i>Salmo gairdneri irideus</i> *	Southcoast rainbow trout
<i>Salmo gairdneri kamloops</i> *	Kamloop rainbow trout
<i>Siphateles bicolor</i>	Tui chub
<i>Salvelinus fontinalis</i> *	Eastern or Speckled brook trout

*Introduced species.

†Rare and endangered species.

Source: LaRivers (26).

of this area have been introduced as indicated in Table 3-12. These lists include animals found in the city itself as well as in surrounding areas.

Within Reno, characteristic plants and animals of urban areas may be found. Species of Poa are common grasses in the lawn of the area. A large variety of trees and shrubs are commonly planted in the lawns of the project area, including white fir (Abies concolor), cottonwood (Platanus racemosa), and paper birch (Betula papyrifera). Birds in Reno include the song sparrow, mockingbird, cardinal, black-crowned night herons, western kingbird, and mourning dove (see Table 3-11). Mammals in Reno include squirrels, mice, and rabbits as well as pets; Table 3-10 includes some of these species.

3.5.3 Threatened and Endangered Species

Two species of fish, the cui-ui and the Lahonton cut-throat trout, are found in Pyramid Lake or the Truckee River and are listed by the federal government as rare and endangered species (27). The black-crowned night heron roosts in tall trees in Reno, and, although it is not listed as rare and endangered, this part of its habitat is considered quite important.

We consider that the tall trees in the area might be subject to the rousting of the night Heron and have chosen to honor the Heron even though they are not rare, or endangered or known to be in project area, by routing our pipelines through paved areas, streets, sidewalks, and parking lots in such a way to not go near or disturb any trees.

3.5.4 Unique Habitats or Natural Areas

There are no unique habitits in Reno. Washoe Lake is the nearest designated natural area. Pyramid Lake has been nominated to become a national landmark.

3.6 Land Use

The possible sites for the three wells are located in parking lots, lawns, a vacant lot, fields, and a playground (Figure 2-2). Pipelines will be under lawns, parking lots, and fields.

The five users are located in an area of Reno with a high concentration of apartment houses. Vacant lots, the Washoe County Golf Course, Anderson School, Virginia Lake Park, individual homes, and a small shopping center are located in the project area. Zoning of this area is shown in Figure 3-16. This is a fairly densely developed area in Reno.

The State of Nevada is the driest state in the United States with an average of 3.7 inches of precipitation per year. Agriculture and lawns in the Truckee Meadows are dependent on irrigation (28). The dominant land use in Washoe County includes general farming, special crops, and raising livestock (29).

3.7 Demographic and Socioeconomic Setting

Reno, the site of the proposed geothermal wells, lies 4,500 feet above sea level at the base of the Sierra Nevada mountain range, and in the Nevada desert. A city of 99,483 persons (April 1978 estimate), Reno is in Washoe County in the State of Nevada (see Figure 1-1). It is 30 miles north-northwest of Carson City, the Nevada state capitol. Sparks, a city of 41,274 persons (April 1978 estimate) shares a common boundary with Reno on Reno's eastern edge. The two cities form a single trading and market area. The city of Reno covers 24,420 acres and has 55 percent of Washoe County's population while Sparks has 23 percent of the county's residents.

Data for selected demographic characteristics of the City of Reno and Washoe County are presented in Table 3-13. Data for the State of Nevada are included for comparative purposes.

The population of Reno, Washoe County, and Nevada have been increasing from 1960-1979 (Table 3-13). The population of Reno, on the average, is older and has more education than the population of the state. The Reno population is predominantly white (95.6 percent) and 50.4 percent female (1970 figures).

Selected employment and labor force characteristics of Reno, of Washoe County, and of the state are given in Table 3-14. The Washoe County labor force consists of 101,600 persons of whom 3.4 percent are unemployed (1979 estimate, with unemployment rate seasonally adjusted). Labor force participation rates of both county and city residents are above the state-wide average. The county's work force is composed of approximately 47 percent white collar workers, 23 percent blue collar workers, and 30 percent service workers (Table 3-14).

Tourism is the mainstay of Washoe County's and especially Reno's economy. Gambling, nighttime entertainment, and varied recreation due to the area's abundant natural resources, attract roughly 10 million visitors to the area annually. According to the Nevada Employment Security Department, the Reno area economy appears to now be slowing slightly following a rapid growth rate in the recent past.

The service industry directly accounts for 39 percent of total employment in the county of Washoe (hotel, gaming, and recreation - 27 percent); trade - 19.9 percent; government - 13.4 percent; contract construction - 7.9 percent; manufacturing - 7.4 percent; transportation and public utilities - 6.6 percent;

TABLE 3-13. EXISTING SOCIOECONOMIC ENVIRONMENT: SELECTED
DEMOGRAPHIC CHARACTERISTICS OF THE CITY OF RENO
AND WASHOE COUNTY, NEVADA

	City of Reno	Washoe County	Nevada
<u>Population Total</u>			
1979 ¹	NA ²	196,680	722,210
1978 ³	99,483	180,454	694,932
1975	78,097	144,750	590,268
1970	72,863	121,068	488,738
1960	51,470	84,743	285,278
<u>Population, Percent Change</u>			
1970-75, Total	7.2	20.0	21.1
1970-75, Natural Increase	NA	3.4	5.3
1970-75, Net Migration	NA	16.5	15.7
1960-70, Total	41.6	42.9	71.3
<u>Population Density, 1975</u>			
	1206/sq. mi.	30/sq. mi.	42.7/sq. mi.
Land Area, 1975 (square miles)	36.9	6,366	109,889
<u>Percent Female</u>			
1979	NA	50.3	49.3
1970	50.4	50.3	49.3
<u>Percent by Race, 1970</u>			
White	95.9	95.7	92.0
Black	2.2	1.6	5.7
Other	1.9	2.7	2.3
<u>Percent by Age, 1970⁴</u>			
Under 5	7.3	7.9	9.0
5-19	24.9	27.2	28.7
20-29	16.9	15.6	15.7
30-44	17.9	18.9	19.8
45-64	23.6	22.4	20.5
65 and over	9.5	7.9	6.3
<u>Median Age, 1970</u>			
Total Population	30.8	29.5	27.8
Male	30.4	29.4	28.0
Female	31.2	29.6	27.6
<u>Median School Years Completed, 1970</u>			
Total Population	NA	12.5	12.4
Male	12.6	12.5	12.4
Female	12.5	12.5	12.4
<u>Place of Residence, 1970</u>			
% of Population Living In:			
- Urban Areas	—	82.2	80.9
- Rural Areas	—	17.8	19.1
% of Population Change, 1960-1970			
- Urban Areas	41.6	42.0	97.0
- Rural Areas	—	46.9	10.4

¹Estimates obtained from Nevada Employment Security Department, "Nevada Affirmative Action, State and Counties", Carson City, Nevada, February 1979.

²NA = Not available.

³Estimates obtained from Greater Reno Chamber of Commerce, "Reno! Living", Reno, Nevada, April 1978.

⁴May not add to 100% due to rounding.

Sources: Greater Reno Chamber of Commerce (30), Nevada Employment Security Department (31), U.S. Bureau of the Census (32,33).

TABLE 3-14. EXISTING SOCIOECONOMIC ENVIRONMENT: EMPLOYMENT AND
LABOR FORCE CHARACTERISTICS OF THE CITY OF RENO AND
WASHOE COUNTY, NEVADA

	City of Reno	Washoe County	Nevada
<u>Employment Characteristics,¹ May 1979</u>			
Total Employment	NA ²	112,800	375,900
% Employed, By Sector: ³			
- Mining	NA	.5	1.0
- Construction	NA	7.9	7.6
- Manufacturing	NA	7.4	5.1
- Transportation and Public Utilities	NA	6.6	6.1
- Trade	NA	19.9	19.9
- Finance, Insurance, Real Estate	NA	5.1	4.2
- Service Industries	NA	39.0	41.7
- Government	NA	13.4	14.4
<u>Labor Force Characteristics, CY 1978⁴</u>			
Total Labor Force	NA	98,030	334,150
- % Unemployed	NA	2.9	4.5
Males in Labor Force	NA	58,280	208,730
- % Unemployed	NA	2.9	3.9
Black Males in Labor Force	NA	900	8,980
- % Unemployed	NA	3.3	4.0
Females in Labor Force	NA	39,750	125,420
- % Unemployed	NA	2.9	5.4
Black Females in Labor Force	NA	830	7,140
- % Unemployed	NA	3.3	6.0
<u>Labor Force Characteristics, 1970</u>			
Males 16 and Older	26,666	42,690	169,720
- In Labor Force	20,635	33,773	140,358
% of Total	77.4	79.1	82.7
- Civilian Labor Force	20,555	33,598	131,375
% Unemployed	6.0	6.1	4.7
Females 16 and Older	27,672	44,051	165,299
- In Labor Force	14,631	22,944	77,739
% of Total	52.9	52.1	47.0
- Civilian Labor Force	14,631	22,944	77,621
% Unemployed	6.2	6.4	6.4
<u>Labor Force Participation Rate⁵</u>	48.4	46.8	44.6

¹Reflects employment by place of work. Includes multiple job holders.

²NA = Not Available.

³May not add to 100 due to rounding.

⁴Percentage from 1970 Census figures applied to CY 1978 labor force.

⁵Defined as size of labor force as a percentage of total population in an area.

Sources: Nevada Employment Security Department (31, 34, 35), U.S. Bureau of Census (32, 33).

and finance/insurance/real estate - 5.1 percent. Mining and agriculture are relatively insignificant employers; they constitute about one percent of all jobs (Table 3-14).

Income and poverty data for Reno, for Washoe County, and for Nevada are presented in Table 3-15. The incidence of poverty in Reno and Washoe County is 9.3 percent (1969 figures), slightly higher than the state's 9.1 percent. Per capita income is higher in Reno than in either Washoe County or the state (\$5,954, \$5,683, and \$5,149 respectively, in 1974).

3.8 Historical and Archaeological Resources

There are no identified archaeological sites in Washoe County. The national and state historic places located in Reno are listed in Table 3-16 and are all outside a one-half mile radius of the proposed project site.

TABLE 3-15. EXISTING SOCIOECONOMIC ENVIRONMENT: INCOME
CHARACTERISTICS OF THE CITY OF RENO AND
WASHOE COUNTY, NEVADA

	City of Reno	Washoe County	Nevada
Per Capita Income, 1977 ¹	NA ²	\$ 9,368	\$ 7,980
Per Capita Income, 1976 ¹	NA	8,284	7,202
Per Capita Income, 1975 ¹	NA	7,445	6,628
Per Capita Income, 1974	\$ 5,954	5,683	5,149
Per Capita Income, 1969	4,035	3,898	3,570
Median Family Income, 1969	11,072	11,144	10,687
% of Families in Poverty	6.1	5.9	7.0
Persons in Poverty, %, 1969	9.3	9.3	9.1

¹Courtesy of Nevada State Office of Employment Security Research.

²NA = Not Available

Sources: U.S. Bureau of the Census (32, 33)

TABLE 3-16. NATIONAL AND STATE HISTORIC PLACES
IN RENO, NEVADA

National

Billinghurst, Benson Dillon House	729 Evans Avenue
Glendale School	South Virginia Street and Kietzke Lane
Lake Mansion	Adjacent to the Centennial Coliseum on U.S. 395
Morrill Hall, University of Nevada - Reno	University of Nevada Campus
Mount Rose Elementary School	915 Lander Street
Newlands, Senator Francis G. House	17 Elm Center
Odd Fellows Building	133 North Sierra Street

State

Junction House - The First Settlement	U.S. 395 at Peckham Lane
Powning Park	South Virginia at Pine
G.A.R. Tree	Southeast corner East 9th and North Center Streets

Sources: Federal Register (36); Nevada State Park System (37); Nevada Historic Preservation Office, Carson City, personal communication; Reno Chamber of Commerce, personal communication.

4.0 ENVIRONMENTAL CONSEQUENCES

4.1 Impacts on Geology and Soils

Seismicity and subsidence are the primary geologic impacts of concern with respect to geothermal projects. In the case of this project in the Truckee Meadows, the existing hazard posed by seismic activity may be significant. As was discussed in Section 3.1, the area is located in Seismic Risk Zone 3 which indicates a potential for heavy damage from naturally occurring earthquakes. These potential effects will be mitigated by taking seismicity into account in engineering design and construction practices.

If injection is selected as the method for disposing of spent geothermal fluids, there is some possibility that induced seismic activity could result. The degree of risk of increased seismic activity cannot be estimated without some knowledge of the existing distribution and magnitude of accumulated in-situ stresses in the rocks and a more detailed knowledge of the hydrogeologic conditions around the injection zone.

Injection of fluids into stressed, faulted rocks has induced earthquake activity in other parts of the country (Raleigh et al, 38); However, in the documented cases where this has occurred, much larger volumes of fluid were injected to much greater depths and at higher pressures than are anticipated to be necessary for this program.

A key factor in the triggering of seismic activity is the in-situ fluid pressure that results from fluid injection. At the Reno site it is possible that gravity flow will be sufficient to dispose of the spent geothermal fluids (i.e., pumped-

pressure injection may not be necessary). The in-situ pressure increase associated with gravity flow is probably small enough that induced seismic activity will not be a problem in this case. If high pressure injection is required, it is still considered unlikely that induced seismic activity would result, due to the very shallow depths (about 1,000 feet) at which injection would take place. If it appears likely that injection is the preferred disposal option, injection tests of the wells will take place before the final decision on disposal option is made. If very high injection pressures are required, more study of the induced seismicity issue may be warranted. If seismic effects occur and require mitigation, storage tanks and a continuous low injection rate could be used to minimize such effects. The main alternative to injection, however, is disposal to the Cochran Ditch.

None of the other disposal options will have any impact on geologic conditions or processes in the area. However, the withdrawal of fluids for use may in itself have an impact in the form of land subsidence. The valley fill in the Truckee Meadows is geologically young and is largely unconsolidated. If the proposed peak withdrawal rate of about 425 gpm is sufficient to significantly dewater the valley fill in the area, some compaction of the sediments and subsidence of the land surface could possibly result. There are a number of factors which make the possibility of dewatering and subsidence relatively unlikely: the valley fill is relatively thin, the blue clay layer is of low permeability except where cracks or faults exist, and cementing the well casing through the valley fill and blue clay layers will tend to isolate the water of the fill from the volcanics. Since even a slight differential compaction of the sediments could be sufficient to cause some building foundation problems or cracking of masonry, the extent of possible dewatering will be evaluated via pumping tests on the new well. Other nearby wells have apparently not shown subsidence (David Atkinson, personal communication).

The state conservationist for the USDA, Gerald Thols, has stated that "impacts on prime farmland would be expected to be minimal due to the small area involved and its location within the project" (Appendix B; personal communication). Disposal of spent geothermal fluids by storm sewers or the Cochran Ditch could reduce water quality and have an adverse effect on irrigation including that of prime farmland. Of concern in this respect are the relatively high levels of boron in the geothermal waters. These levels are about 2.7 times the maximum contaminant level recommended by EPA for irrigation on sensitive crops (e.g., pecans). However, the amounts of water that would be released are relative small, and some dilution would occur. Meeting the NPDES permit levels (to be set up by the State of Nevada) for any regulated parameters should ameliorate problems.

4.2 Impacts on Surface Waters

4.2.1 Impacts During Construction

During construction and testing, runoff from the site and geothermal fluids from the testing could reach the local storm drainage system if provisions for containment are not made. Usually runoff contaminants from construction projects consist primarily of suspended solids which originate in areas where soil has been exposed and from the drilling mud. During well testing, fluid discharge will be contained in a storage and settling tank system. This will prevent sediments normally present from reaching receiving waters. The mud will be hauled to a disposal site upon well completion. Temporary permits or letters of permission for any discharge of hot water during the test pumping of the wells shall be obtained. In addition, the

low precipitation levels experienced in Reno decrease the probability of there being an impact on the surface waters by runoff from the drilling site. The impact of drilling mud and its additives on the surface waters will be eliminated.

The primary contaminant present in the geothermal fluid will most likely be dissolved solids (including some undetermined amounts of boron and arsenic); hydrogen sulfide may also be present. It is anticipated that the concentration of dissolved solids will be around 1,000 to 1,100 mg/l. If these fluids are permitted to discharge to local surface waters during well testing, temporary deterioration of water quality may result. Depending on the quantity of water, discharge to the surface waters without a permit may be approved for test holes. However, if well testing is restricted to 48 hours and if the fluids are contained in an evaporation pond, the state will not require an NPDES permit.

4.2.2 Impacts During Operation

During operation the impact of this geothermal system on the surface waters is highly dependent on the disposal technique used for the geothermal fluids. Currently, several technical options exist and they are as follows:

- discharge to surface waters,
- discharge to sanitary sewer, and
- injection.

4.2.2.1 Discharge to Surface Waters

Geothermal fluids disposed of at the site to surface waters (either storm sewers or natural channels) will eventually drain into the Truckee River. As mentioned in Section 3.2, in the Truckee River Basin, state water quality standards are applied at the end of the pipe. Although no actual test data exist describing the quality of the geothermal fluids at the subject site, it is anticipated that several constituents (e.g., total dissolved solids, boron, and arsenic) will exceed the standards presented in Section 3.2.1.

If the standards are exceeded at the end of the pipe, the newly instituted mixing zone concept can be emphasized to justify a discharge to a storm sewer or natural channel. The use of the mixing zone concept requires further analyses using the specifics of receiving stream flow and water quality, and discharge quantities and quality to show there is minimal impact on the receiving stream. The difficulty in meeting the requirements of the mixing zone concept will be dependent on the characteristics of the receiving stream. For example, it could be much easier to show a minimal impact on Virginia Lake than on the Truckee River, due to probable differences in existing water quality.

The impact of many of the constituents that may be present in the geothermal water (e.g., total dissolved solids, boron, etc.), on water quality is dependent on the ultimate use of the water. For example, there should be little concern over probable boron levels if the water is not to be used directly for irrigation on boron sensitive crops. A detailed assessment of the impacts of all possible constituents is not possible without some knowledge of their levels of concentration in a sample of the water.

4.2.2.2 Discharge to Sanitary Sewer

The impacts on surface waters of discharge to the sanitary sewer are minimal, assuming the treatment plant is properly removing or diluting the constituents.

However, Reno's treatment plant is operating near capacity. To obtain access to the plant, a potential discharger must get on a waiting list under the current allocation system.

4.2.2.3 Treatment

The impacts of discharges after treatment should be minimal. The flow to the receiving stream will be increased, but not substantially. Otherwise, assuming the treatment process is adequate, there should be no impact on the surface waters.

4.3 Impacts on Ground Water

The proposed geothermal heating project could have an effect on both the quality and quantity of ground water in the area. Some interference with nearby wells could occur as a result of pumping. The extent of this impact cannot be quantified until pumping test data are available. However, any impacts on ground-water availability and flow patterns are expected to be minor due to the small volumes of water to be extracted.

Water level and composition will be monitored in six existing observation wells north, east, and south of the demonstration both before drilling begins and again during and after test pumping. Observations made at three month intervals will determine what effect, if any, the volume withdrawn, and possibly injected, in the project operations is having on the local ground-water flow.

We will monitor the ground water using the six wells shown of figure 4-1 by testing for existing water levels, temperatures, water quality before our pump testing, during test and after, and every 3 months thereafter until certain of no effect or exactly what effect there is. The wells listed are the closest and they are from 1100' to 2500' away. As the map shows, most are shallow and are using waters from different aquifers than the deep one we are going for. This will be fully investigated, and able to be shown by the drilling logs and chemical differences in the deeper water. On the map the only well that is at our target depth of 1000' is #2 which hasn't been used and the owner has no current plans for use, other than for observation.

In the unlikely event that owners of existing wells nearby complain of drops in water level in their wells, we shall begin by establishing whether or not the effect is really a result of our production pumping. If that is so, we shall choose the best way of handling their complaint and/or compensating them for any losses attributable to our actions. However, since our wells will be a considerable distance from any other well, and will draw its production from much greater depth, we expect that there will be no such effects on other existing wells.

The primary area of concern is the potential impact on water quality. There are two aspects to this issue. The first is related to the ground water flow regime in the Moana area. At present, geothermal waters of relatively poor quality (i.e., high in boron and arsenic) are mixing with non-thermal waters. Pumping thermal waters from the area could be beneficial because the surrounding non-thermal waters contain less arsenic and boron. However, the neighboring non-thermal waters which will be drawn into the area may be high in sulfate. Thus, as the proportions of thermal and non-thermal waters are altered, a trade-off in undesirable parameters might result: reductions in trace contaminants may be accompanied by increases in sulfate content. Whether a net benefit will result from this trade-off will depend on the actual levels of boron and arsenic encountered in the geothermal waters.

The second way in which ground-water quality could potentially be affected is through injection, if this disposal method is selected. The injection well will be located, designed, and operated in such a way as to minimize contamination of neighboring or overlying freshwater aquifers. The State of Nevada requires that fluids only be injected into zones containing water equal to or poorer in quality of the injected fluid. None of the other disposal options will have any significant impact on ground-water quality. Seepage from Cochran Ditch or leakage from pipelines (including distribution lines) would be in small quantities and would not likely cause any significant degradation of ground water.

4.4 Impacts on Atmospheric Characteristics

The proposed geothermal activity will have a negligible impact on the climate and meteorology of the area even on a localized basis. The amounts of hydrogen sulfide are relatively

small, and the fluids will be contained in the well and pipes until disposal. No odor problem is expected if injection is the chosen option. No odor problem is expected if surface disposal is selected since existing wells are not noticeable by odor.

The impacts on air quality that will result from construction activities of this project should be slight and of short duration. Expected air emissions will be from vehicle and drilling rig exhausts during construction. No emissions are expected during operation of the heating system if injection is used since it will be completely closed. Surface disposal would not adversely affect the atmosphere unless hydrogen sulfide levels are higher than from nearby wells.

Atmospheric hydrogen sulfide concentrations in the Reno area are not currently considered a significant problem, and none of the proposed disposal options (storm sewer disposal, sanitary sewer disposal, injection) are expected to significantly affect atmospheric hydrogen sulfide concentrations in the area.

Vehicle and rig exhausts will be emitted during the well drilling and construction phase. The levels of exhaust cannot be quantified because the number and type of vehicles that will be present is not known. It is likely to be small, however. For example, a construction crew of ten people would bring at most ten automobiles to the area. Construction equipment requirements should also be slight since the major construction activities are drill site preparation and pipe laying. Equipment and drilling rig exhaust emissions should be essentially undetectable in the semi-urban setting of the site since the adjacent streets are major thoroughfares.

4.5 Noise Impacts

No noise problems are anticipated during operation of the geothermal wells. However, the development of the geothermal site will involve several sources of noise, as described in Section 3.4.2. The drill rig will be the only noise source that is operated for extended periods. Drilling operation will occur between 0800-1800 hours. The discussion that follows will focus on the potential effects of noise associated with the drilling operation.

4.5.1 Change in Ambient Noise Level

Based on source data taken from the drilling rig, reported in Section 3.4.2, an estimate of the altered noise field was made with the rig operating at each of the nine potential sites. Figures 4-1b through 4-9 are approximate levels expressed as L_{dn} of this altered noise field. These predictions assume that the noise radiation character of the measured rig is similar to the actual rig used and that the rig is positioned to direct the major noise lobe away from occupied buildings. No attempt was made to include attenuation of the sound level that would certainly occur due to the buildings (trees, change in relief, etc.) in this area.

Obviously, when considering the noise impacts, there are somewhat preferred well locations, including well locations 1, 2 and 6. These locations have open quiet unoccupied spaces to which the major lobe of noise can be directed. Conversely, there are well locations (3,4, and 8) at which heavy traffic noise and densely occupied streets combine to produce more noise impact. Well locations 7 and 9 are

Figure 4-1b Estimated Altered Noise Field
in L_{dn} Well Location #1.

Figure 4-2. Estimated Altered Noise Field
in L_{dn} Well Location #2.

Figure 4-3. Estimated Altered Noise Field in L_{dn} Well Location #3.

Figure 4-4. Estimated Altered Noise Field in L_{dn} Well Location #4.

Figure 4-5. Estimated Altered Noise Field
in L_{dn} Well Location #5.

Figure 4-6. Estimated Altered Noise Field
in L_{dn} Well Location #6.

Figure 4-7. Estimated Altered Noise Field
in L_{dn} Well Location #7.

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Figure 4-8. Estimated Altered Noise Field in L_{dn} Well Location #8.

Figure 4-9. Estimated Altered Noise Field in L_{dn} Well Location #9.

intermediate. Well location 5 is located very close to an individual home from which complaints could be expected to arise. In general, the sound levels during drilling along the most impacted structures will range from about 63 to 68 dBA* near a well site. This contrasts with typical ambient sound levels in the range 58 to 65 dBA. Figure 4-10 is an aerial photograph taken in 1979 that shows the locations of the dwellings and open spaces.

Sound levels that may be expected within the apartments were estimated from knowing the approximate insertion loss* of a typical apartment window that is the predominant path of acoustical energy transmission from outside to outside. It was found (Section 3.4.1) that the windows can provide approximately 20 dBA sound level reduction in intruding external noise.

Applying this value to the expected external sound levels, as discussed above, an estimated internal room level can be obtained for the dwellings most affected as follows:

	<u>External/Internal Sound Level (dBA)</u>	
	<u>Daytime During Drilling</u>	<u>Daytime Ambient</u>
Ambient Sound Level	63 to 68	58 to 65
Insertion Loss	20	20
Approximate Room Level	43 to 48	38 to 45

Consequently, sound levels inside the dwellings are estimated to range from 43 to 48 dBA. Again, the actual sound levels will be a function of well location and quality of window seal construction.

* "dBA" values are not equivalent to L_{dn} values shown in figure C-1, see Appendix C.

* "Insertion loss" used in this discussion means the measured reduction in sound level from the outside to the inside of an apartment room with the window closed and is not intended to precisely conform with its technical definition.

Sound-sensitive Structures
 Multiple Level Structures
 Possible Retro-fit Bldgs.

figure 4-10

4.5.2 Response to Noise

Evaluation of human response to noise has been studied extensively over the past decade and many measures for predicting reaction to a particular noise level and character have been developed. The physiological and psychological effects of noise are well documented and will not be addressed here.

This assessment focuses on two criteria of impact on human habitations; sleep interference and EPA community noise criteria. The scope of analysis is quite limited and conclusions should be regarded only as "clues" to whether significant adverse reaction may be expected.

No attempt is made to precisely forecast the acceptability of a level of noise inside occupied rooms because a response is very resident specific, dependent on attitudinal outlook, annoyance judgment and many other factors. It seems reasonable to assume, however, that resident responds to a degree at least equal to that which may interfere with sleep and the basis for conclusions will be in these terms.

From Welch (39), ". . . interference with sleep is traditionally regarded as the most serious of disturbances . . . the indications of our experiments are that much lower levels of noise disturb the sleep pattern of the subjects than was believed to be the case heretofore. Levels of 40 to 45 dBA have a 10 to 20 percent probability of shifting the level of sleep for a subject picked at random, but individual differences are very great."

Quantitatively, results of the study reported by Welch indicate that the most probable reaction of sleeping subjects will conform generally to the following introduced sound levels:

<u>Sound Level (dBA)</u>	<u>Sleep Reaction (Probability)</u>	
	<u>Significant Change in Sleep Level</u>	<u>Awaken</u>
55	8%	10%
60	10%	13%
65	15%	18%
70	15%	50%

These data (developed from subjects with average auditory senses under laboratory test conditions) indicate that the 63 to 68 dBA levels that are predicted to occur during drilling operations (assuming windows are open) could cause significant adverse effects on some residents. The 43 to 48 dBA levels that could occur with the windows closed could, but are not expected to, cause a slight adverse effect on the apartment residents. Also, drilling will occur during daytime hours and should interfere only minimally, if at all, with residents' sleep.

The data necessary to make a reasonable estimate of the number of night workers (i.e., those who would be sleeping during the 0800-1800 drilling operations) are not available. A crude estimate can be made from data obtained from the Nevada Employment Research Agency and the University of Nevada Bureau of Economic Research. This information indicates that of the 30,200 persons employed by the Hotel/Gaming industry approximately 6,000 are employed during the late night shift (2400-0800). This is approximately six percent of the county-wide labor force of 101,600 persons. Since there are mostly rental units in this area, perhaps the percentage of night workers in this area is higher than six percent.

For evaluation of noise impacts in the community, criteria developed by EPA (40) were used as a basis. These criteria were simplified and presented graphically in Figure 4-11.

Figure 4-11. Expected Day-Night Human Responses at Various Noise Levels.

The day-night average noise L_{dn} is a measure based on continuous exposure by an individual and will provide clues about reaction to various levels of noise. From the figure, it is seen that levels below 55 dB are not expected to stimulate any reaction. At about 60 dB, sporadic complaints can be expected. About 65 dB, complaints will become more widespread. From the noise predictions, it can be seen that residents near each of the potential well sites will be exposed to average noise levels of 60-65 dB. If occupants were to be exposed to these levels for extended periods, complaints could be expected.

It should be noted that both apartment dwellers and residential inhabitants within the concerned area are subjected to high levels of traffic noise during daylight hours. From the 24-hour observation, it can be seen that traffic along Plumas and Moana Lane provide background noise that may partially mask the concerned drilling operation noise.

However, because inhabitants spend much time inside, the continued exposure will be much less than the outside levels. Also, these inhabitants are subject to noise levels frequently that approach those caused by drilling operations. Given the relatively short (two weeks) duration of drilling operations, no major adverse reaction is expected although some complaints are likely depending on specific situations and attitudes towards the drilling operations. Recently, several favorable articles and news stories have appeared in the local press. Residents and local officials are generally positive towards geothermal energy.

4.5.3 Mitigation Measures

The primary noise impacts are the generation of noise during drilling operations. Although these will be of short

duration, several approaches to mitigate the impact of noise are available.

Because there is interest in the use of geothermal resources in Reno, one mitigation measure may be to completely inform proximal residents of the purposes and timing of the activity. Studies have shown that residential inhabitants are much more tolerant of intruding noise if they have a positive attitude about the cause and source of noise.

A second mitigation measure that can be applied, should it be found necessary, is the addition of acoustical baffle panels selectively positioned to attenuate specific sources. This measure is not expected to be required, but can be readily incorporated. Although the strategy for impact abatement is to direct the major noise lobe away from the affected residences, this results in the exhaust noise directed at the residences and, even though muffled, is usually responsible for the noise impact that does occur. By equipping the rig with a more effective muffler, a further reduction of noise, from 10 to 30 dBA, depending on the type and class of muffler chosen can be achieved. Such reduction will significantly mitigate or even eliminate the noise impact from exhaust noise.

Finally, an alternative that would reduce the noise impact would be to relocate the site of the well to one of the "noise preferred" sites, although there is no guarantee that the adverse publicity of having to move would not generate negative attitudes towards the project at the next site. If well site 5 is drilled, it may be necessary to move the well further from the nearby home.

4.6 Impacts on Biology

The proposed wells are located entirely in the urban area of Reno, Nevada so that disturbance to the native biota is considered to be minimal as long as certain mitigating procedures are followed. Wells and pipelines will be placed in such a way as to cause minimal or no damage to established trees which are important to the black-crowned night heron as a roost and for aesthetic reasons. Surface disposal of the geothermal fluid will occur only if the water quality is such that the two rare and endangered species of the Truckee River and Pyramid Lake (the cui-ui and the Lahonton cutthroat trout) will not be endangered by its addition. Since addition of the geothermal fluid would increase the amount of surface water, this action could actually help these species if the water quality is satisfactory.

4.7 Impacts on Land Use

The location of the geothermal wells and pipelines will not significantly change current land use practices. A small attractive well house or man-hole cover will be needed at the pump operation sites. Lawns and roads will be replaced as rapidly as possibly. Trees will be avoided both by drilling and pipe-laying operations.

4.8 Demographic and Socioeconomic Impacts

Neither the drilling of the three wells, installation of buried pipes, nor the operation of the geothermal system by the five users in Reno, Nevada will have a significant impact on the socioeconomic environment. Besides the small scale of the project, it is merely an addition to over 200 existing geothermal

wells operating within approximately a five-mile radius of the proposed site. Drilling of the first two wells is to be sequential and to occur over a two month period. The drilling of the third well, if needed, would happen on a subsequent date. Construction of the pipeline and retrofitting of the apartments is expected to require two to three months and involve fewer than ten people. All workers will be local people.

4.9 Impacts on Historical and Archaeological Resources

The national and state historic sites located in Reno are all beyond a one-half mile radius of the project site, and the project is not expected to have any impact on them. There are no identified archaeological resources in Washoe County. Because of the extensive urban development surrounding the project site, it is doubtful that any archaeological remains would be discovered during a site survey. If this occurs, however, the State Historic Preservation Officer would be contacted (see Appendix D).

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APPENDIX A
APPLICATION FOR PERMIT TO
APPROPRIATE THE PUBLIC WATERS OF
THE STATE OF NEVADA

APPLICATION FOR PERMIT TO APPROPRIATE THE PUBLIC WATERS OF THE STATE OF NEVADA

THIS SPACE FOR OFFICE USE ONLY

Date of filing in State Engineer's Office.....

Returned to applicant for correction.....

Corrected application filed.....Map filed.....

The applicant..... Hydrothermal Energy Corporation.....
2519 Horseshoe Canyon Road..... of Los Angeles.....
Street and No. or P.O. Box No. City or Town
California 90046....., hereby make..S application for permission to appropriate
State and Zip Code No.

the public waters of the State of Nevada, as hereinafter stated. (If applicant is a corporation, give date and place of incorporation; if a copartnership or association give names of members.).....

Hydrothermal Energy Corporation was incorporated in the state
of Delaware in May 1978

1. The source of the proposed appropriation is..... underground.....
Name of stream, lake, spring, underground or other source.

2. The amount of water applied for is..... 2.5.....second feet.
One second foot equals 448.83 gallons per minute.

(a) If stored in reservoir give number of acre-feet.....

3. The water to be used for..... Geothermal.....
Irrigation, power, mining, manufacturing, domestic or other use.

4. If use is for:

(a) Irrigation.....
State number of acres to be irrigated.

(b) Stockwater.....
State number and kinds of animals to be watered.

(c) Other use (describe fully under "No. 12. Remarks").....

(d) Power:

(1) Horsepower developed.....

(2) Point of return of water to stream.....

T.19N., R.19E., M.D.B.&M.

survey, and by course and distance to a section corner. If on unsurveyed land, it should be so stated.

(to be amended upon completion of water rights survey)

6. Place of use. SE $\frac{1}{4}$ SE $\frac{1}{4}$ Section 23 T.19N., R.19E., M.D.B.&M.

Describe by legal subdivision, if on unsurveyed land, it should be so stated.

7. Use will begin about January 1 and end about December 31 of each year.
Day and Month Day and Month

8. Description of proposed works (Under the provisions of NRS 535.010 you may be required to submit plans and specifications of your diversion or storage works.) Water to be diverted from well with
State manner in which water is to be diverted, whether by dam or other works.
pump and transported to heat exchanger and returned to the ground
whether through pipes, ditches, flumes, or other conduits.
via pipes.

Estimated cost of works \$50,000.00

10. Estimated time required to construct works 2 years

11. Estimated time required to complete the application of water to beneficial use 5 years

12. Remarks: For use other than irrigation or stock watering, state number and type of units to be served or annual consumptive use.

Annual consumptive use will be 0 acre-feet.

Water to be returned to the same zone from which it is extracted.

Hydrothermal Energy Corporation

Applicant

By William E. Nork (Agent)

950 E. Greg Street

Street and No., or P.O. Box No.

Sparks, Nevada 89431

City, State, Zip Code No.

2888 (Rev. 11-72)

APPLICATION MUST BE SIGNED
BY THE APPLICANT OR AGENT

\$35 FILING FEE MUST ACCOMPANY APPLICATION

APPENDIX B

LETTER FROM
THE UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

United States
Department of
Agriculture

Soil
Conservation
Service

P. O. Box 4850
Reno, Nevada
89505

August 9, 1979

Mr. Timothy J. Wolterink
Staff Geologist
Radian Corporation
8500 Shoal Creek Blvd.
P. O. Box 9948
Austin, Texas 78766

Dear Mr. Wolterink:

This will respond to your request, July 27, 1979 pertaining to the existence of prime farmland within the geothermal heating project area, Reno, Nevada.

We are attaching a soil map for the project area which is located on a portion of Mt. Rose NE Quadrangle. Irrigated farmland within the area is located only in the southeast portion and has been hachured. Within the farmland, soil map unit 602--Idlewild gravelly sandy loam, approximately 2.5 acres, qualifies for prime farmland.

Adverse impacts on the prime farmland would be expected to be minimal due to the small area involved and its location within the project.

Gerald Thola
State Conservationist

Attachment

cc: without attachment to -

C. McKenna, NV Agr. Ext. Ser., U of N, Reno, NV
R. Hill, State Plan. Coord., Carson City, NV
R. Westergard, NV Cons. & Nat. Resources, Carson City, NV
D. Bohmont, College of Agr., U of N, Reno, NV
T. Ballow, NV Dept. of Agr., Reno, NV
A. Pasquale, ASCS, Reno, NV
R. Page, FmHA, Fallon, NV
F. Ferrarelli, USDA-FS, Reno, NV
J. Hafterson, USDA-FS, Elko, NV
J. Shaw, State Land Use Planning, Carson City, NV

Figure B-1. Soil Map of the Area Surrounding the Proposed Heating Project. The Hachured Area is Irrigated Farmland. Within the Farmland, Soil Map Unit 602 Qualified for Prime Farmland.

APPENDIX C
NOISE METHODOLOGY AND DATA

APPENDIX C
NOISE METHODOLOGY AND DATA

Noise source data can be displayed as contours of sound pressure level (dB) given the directivity pattern and the power level of the noise source. The sound-pressure level can be predicted at any distance, since the sound-pressure varies inversely as the distance from the source. But, the sound-pressure level for a given distance is different in different directions from an actual source. Therefore, from data taken from four sides of the source, the power level in each direction is calculated by knowing the level and distance from the source.

$$PWL = SPL + 20 \log \gamma + .5 \text{ dB} \quad (A-1)$$

where

PWL = power level
SPL = sound-pressure level
 γ = distance in feet

With this relationship, the directional nature of the noise contours around the drilling rig can be forecast essentially by radiating a different power level in each of four directions and then contouring equal pressure levels.

Additionally, source contours can be superimposed upon ambient contours by addition of sound-pressure levels using the relationship

$$SPL = 10 \log (10^{L_1/10} + 10^{L_2/10}) \quad (A-2)$$

where

SPL = altered sound pressure level
L₁ = ambient " " "
L₂ = source " " "

This will give an estimate of the altered noise field if the additions are made at grid points and the contours redrawn to reflect the forecast noise levels.

As discussed in Section 3.4.1, the day-night sound level (L_{dn}) is defined as the equivalent A-weighted sound level during a 24-hour time period with a 10 decibel weighting applied to the equivalent sound level during the nighttime hours of 2200 to 0700 hours. It may be expressed by the equation:

$$L_{dn} = 10 \log \frac{1}{24} \left[15 (10^{L_d/10}) + 9 (10^{\frac{L_n + 10}{10}}) \right] \quad (A-3)$$

where

L_{dn} = day-night sound level
L_d = equivalent sound level for daytime
(0700 - 2200 hours)
L_n = equivalent sound level for nighttime
(2200 - 0700 hours)

Sampling rational, also discussed in Section 3.4.1, allows calculation of L_d by:

$$L_d = 10 \log \frac{1}{15} \sum_{i=1}^n (t_i 10^{L_i/10}) \quad (A-4)$$

where

L_d = daytime equivalent sound level
 t_i = sampling interval of representation activity
period (i.e., 0700-0900 t = 2 hours)
 L_i = sample sound level value
 n = number of discrete activity patterns

Nighttime equivalent sound level (L_n) is based on the one sample value taken at 0200 hours.

Figure C-1 is the noise source contours expressed as L_{dn} . This was done by assuming that the drilling rig noise contours represent the L_d for the source and an ambient background of 45 dB represents the L_n . As can be seen from Figure 3-10, this is a conservative assumption, since the nighttime equivalent sound level, L_d , never exceeds 45 dB.

Finally, measured data are displayed (Table C-1) along with a location map (Figure C-2) for reference.

C107

Figure C-1. Contours of L_{dp} from Drilling Rig Referenced to the Four Orientations.

TABLE C-1. AMBIENT NOISE DATA SHEET (dBA)

Station No.	Hour							L _d	L _n	L _{dn}
	0730	1000	1200	1500	1700	2100	0200			
1	64	64	64	62	67	60	45	64	45	62
2	52	44	50	45	50	39	36	48	36	47
3	44	42	46	47	54	38	39	48	39	48
4	62	56	39	56	60	58	39	58	39	56
5	64	64	59	63	67	60	47	63	47	62
6	53	46	45	52	50	39	35	49	35	48
7	45	45	52	59	55	45	35	54	35	52
8	59	56	61	58	60	59	52	59	42	57
9	63	63	61	60	68	60	48	63	48	62
10	52	47	52	56	51	48	36	52	36	50
11	41	44	51	51	45	48	35	48	35	47
12	63	60	67	59	62	56	40	62	40	60
13	64	61	59	62	66	59	48	62	48	61
14	53	50	49	50	53	45	41	50	41	50
15	54	44	49	53	52	47	40	50	40	50
16	62	65	50	57	65	57	44	62	44	60
17	64	61	59	59	65	57	46	61	46	60
18	56	45	51	55	52	47	42	52	42	52
19	53	48	54	57	55	50	35	54	35	52
20	65	63	62	60	65	56	42	62	42	60
21	61	64	58	60	65	55	49	61	49	60
22	49	48	53	54	52	48	49	51	49	54
23	47	50	52	54	55	47	38	52	38	51
24	64	60	62	62	63	59	47	61	47	60
25	60	60	60	63	62	59	49	61	49	60
26	63	64	64	68	65	59	36	64	36	62
27	64	67	62	60	66	60	50	63	50	62
28	64	54	61	61	64	61	50	61	50	61
29	54	54	54	52	52	48	40	52	40	51
30	48	49	53	50	57	45	35	49	35	48
31	48	49	53	51	51	46	35	50	35	48
32	67	65	60	60	59	58	38	62	38	60

5 • Sampling Locations

0 500 1000
FEET

C112

Figure C-2. Map Showing Noise Survey Measurement Points.

APPENDIX D
CONTACT REPORTS

THE NEVADA DIVISION OF HISTORIC PRESERVATION AND ARCHEOLOGY

201 South Fall Street — Nye Building — Room 113 — Carson City, Nevada 89710

MIMI RODDEN, Administrator

Telephone (702) 885-5138

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

ROLAND D. WESTERGARD, Director

ROBERT LIST
GOVERNOR

August 20, 1980

Mr. Marc Pack, Manager
Hydrothermal Energy Corporation
210 Marsh Street
Reno, NV 89509

Dear Mr. Pack:

This office has received your letter of August 19, 1980 regarding a proposed project in the area of Anderson School. The project, to be assisted by the Department of Energy, consists of the construction of nine well locations and associated pipelines.

No properties listed on or pending nomination to the National Register of Historic Places are located in or are immediately adjacent to the area of the proposed undertaking.

Given that all construction activities will be undertaken in areas previously disturbed by road, housing or commercial development, it will have "no effect" on any properties of National Register quality.

A copy of this letter should be retained in the project file to document consultation with the State Historic Preservation Office as required by 36 CFR, Part 800.4.

Sincerely,

MIMI RODDEN, Administrator
(State Historic Preservation Officer)

By: Charles D. Zeier, Alternate
State Historic Preservation Officer

D-3

CDZ:vh

Recycling
Nevada's Heritage