PROPOSED KILAUEA SOUTHWEST RIFT GEOTHERMAL RESOURCE SUBZONE (Pahala)

Island of Hawaii

Circular C-115

State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Water and Land Development

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PREFACE

The Board of Land and Natural Resources (BLNR) is charged with the responsibility of designating geothermal resource subzones in the State of Hawaii under authority of Act 296, SLH 1983, and Act 151, SLH 1984.

The objective of this report is to provide information to the BLNR so that it may evaluate the geothermal resource and examine potential impacts from geothermal development on the Kilauea southwest rift zone.

This report identifies the Kilauea southwest rift as a potential geothermal resource area and summarizes the results of a statewide assessment conducted by the staff of the Division of Water and Land Development with participation of an interagency technical committee; federal, state, and county agencies; private industry; and the general public.

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The following community organizations are also acknowledged for their participation and contributions provided at public hearings held on the proposed Kilauea Southwest Rift Geothermal Resource Subzone:

Sierra Club
Kau Sugar Company
Puna Community Council
Puna Geothermal Committee
Ka Ohana O Ka'Lae
Hawaiian Civic Club of Kau
Office of Hawaiian Affairs

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INTRODUCTION

Petroleum provides over 90% of Hawaii's total energy needs. About $1.5 billion annually flows out of the State's economy to finance our petroleum demand. This dependency renders Hawaii vulnerable to disruptions in the supply of foreign oil. Although the present world supply of oil is plentiful with prices declining, this oil situation is politically volatile and uncertain in the long run. Present oil reserves within the State could last about 30 days. Oil from the national Strategic Petroleum Reserve in Texas and Louisiana would take about 60 days to arrive in Hawaii, possibly having major local economic consequences. About one-third of our oil imports are required for producing electricity. This economic backdrop emphasizes the State objective of energy self-sufficiency. The Department of Planning and Economic Development believes that geothermal energy has the largest near-term potential to provide an indigenous base-load electric supply and offers some measure of self-sufficiency.

Act 296, SLH 1983, mandates the Board of Land and Natural Resources to designate geothermal resource subzones (GRS) in the State of Hawaii. The purpose of this Act is to provide a land use designation that will assist in the location of geothermal resource development in areas which demonstrate an acceptable balance between the factors set forth in Act 296. Act 296, specifically states that an environmental impact statement shall not be required and that the method for assessing these factors shall be at the discretion of the Board and may be based on currently available public information. Once geothermal resource subzones are established, all geothermal development activities may be conducted only in these designated subzones. However, subzoning itself does not automatically permit any geothermal development or convey any rights to individuals beyond application for the required permits to conduct geothermal activities in any of these designated areas.

This report represents the assessment of the potential geothermal resource area of the proposed Kilauea Southwest Rift Geothermal Resource Subzone located between the western boundary of the Hawaii Volcanoes National Park and Highway 11.

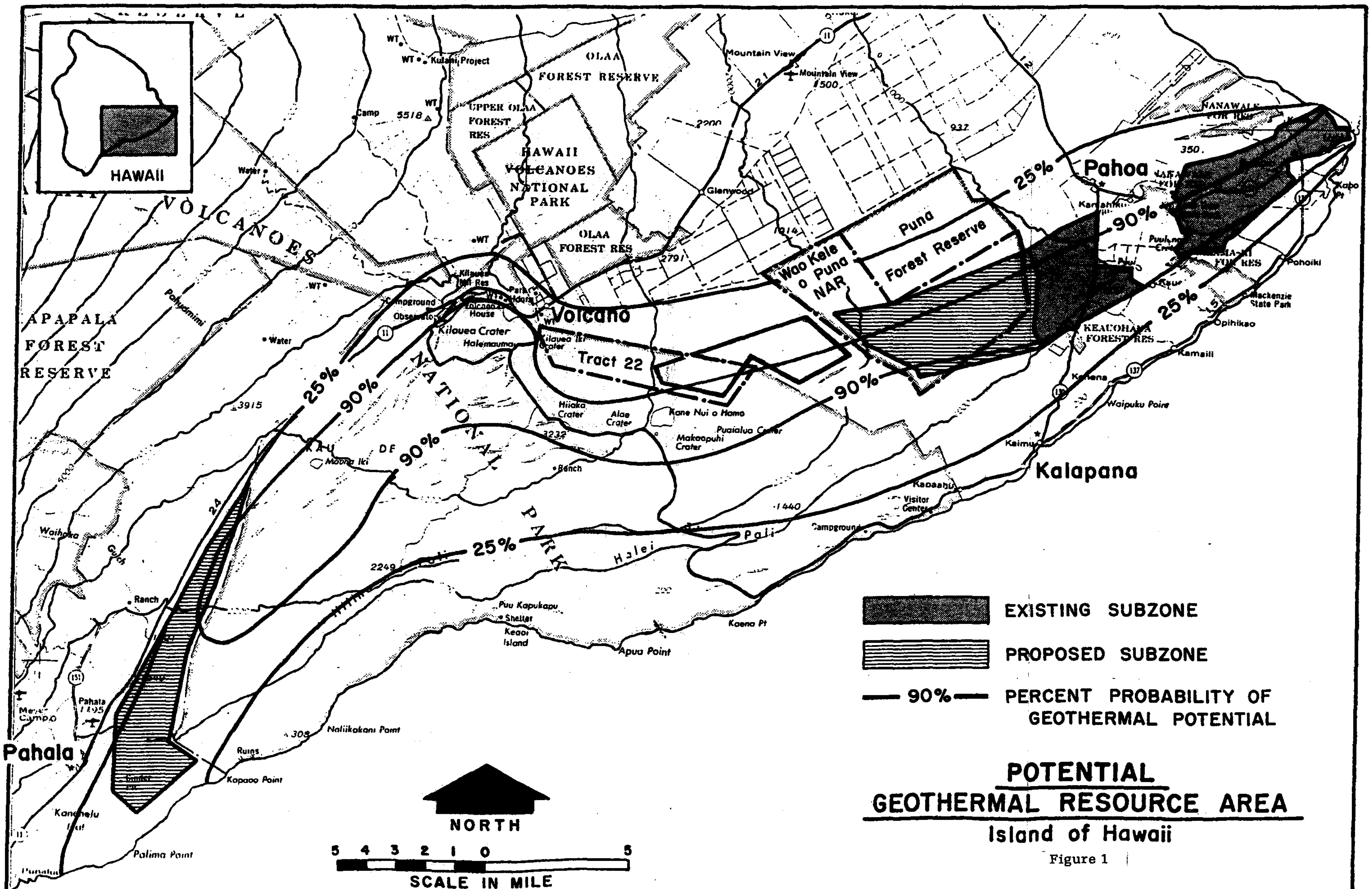
ASSESSMENT OF GEOTHERMAL RESOURCE

A Geothermal Resources Technical Committee was formed by the Department of Land and Natural Resources consisting of experts in the field of geothermal resources in Hawaii. The Technical Committee members met in a series of meetings and made a statewide, county-by-county assessment based on currently available geotechnical data.

The consensus of the Technical Committee was that present day technology requires a geothermal resource to have a temperature greater than 125°C at a depth of less than 3 km to be feasible for production of electrical energy.

The assessment of geothermal resource potential was based on a qualitative interpretation of regional surveys based on the following types of data: groundwater temperature, geologic age, geochemistry, resistivity, infrared, seismic, magnetics, gravity, self-potential, and exploratory drilling.

The geothermal potential for the Kilauea southwest rift zone was evaluated by the Technical Committee on the basis of available geophysical data from surveys conducted during the last two decades. Resistivity anomalies have been identified on both the upper and lower rift areas and groundwater temperature anomalies in areas of steaming ground on the upper and middle rift and in a coastal spring adjacent to the lower rift. Self potential data also indicates the presence of thermal activity on the upper rift and recent intrusions of magma into the upper and middle rift support the presence of at least an ephemeral thermal resource. Aeromagnetic data, however, do not show a significant Curie temperature anomaly associated with the rift zone,



POTENTIAL
GEOTHERMAL RESOURCE AREA
Island of Hawaii

Figure 1

suggesting a much more limited resource than is present on the Kilauea east rift zone. The absence of a significant offshore extension of this rift would also indicate far less magmatic intrusion into the land based portion of the rift.

In assessing the potential geothermal resource area, the committee utilized probability ranges, in that probabilities would be more accurate than other subjective wording. The overall assessment of the Kilauea southwest rift is that there exists a very high probability for a geothermal resource (greater than 90%) in the upper, more active portion of the rift but that this probability gradually declines toward the lower extension of the rift zone. (At the present time no additional data has been presented since the completion of the original assessment by the technical team that would indicate that the 90% resource line should be relocated.)

The potential high temperature resource area of the Kilauea southwest rift is denoted by the 90% probability lines indicated on Figure 1. The area shown between the 90% and 25% probability lines represent decreasing geothermal resource potential.

The conclusion of the Technical Committee demonstrated that no single geothermal exploration technique, except for exploratory drilling, is capable of positively identifying a subsurface geothermal system; instead it is based on several methods resulting in an estimate of geothermal potential for a given area.

The geothermal resource assessment of the Kilauea southwest rift is the first phase of the overall evaluation process prior to any subzone designation. Subsequent analysis of social, economic, environmental, and hazards impacts are discussed in this report on the site specific area having significant potential for the production of electricity from geothermal energy.

COMMUNITY INPUT

Various channels and methods of community input are involved in the preliminary as well as the future process of geothermal resource development. These channels include political representatives, regulatory agencies, public and contested case hearings, and surveys, such as the community surveys by the Puna Hui Ohana and by SMS Research, Inc.

Throughout the process, from the enactment of Act 296, to the Proposal for Designating Geothermal Resources Subzones by the BLNR, public comments and participation has been invited from various interested parties to assist the Department and the Board.

Two public informational meetings on designating the proposed geothermal resource subzone were held by the State Department of Land and Natural Resources on the island of Hawaii. The dates and places of these meetings are listed below:

~~March 13, 1985 - Keaau, Hawaii~~ MARCH 14, 1985 - PAHALA
~~May 15, 1985 - Pahoa, Hawaii~~ MAY 16, 1985 - PAHALA

The first meeting was to report the most likely locations of geothermal resources; the second meeting focused on the identification of impact issues.

In addition, on July 29, 1985, the Department of Land and Natural Resources mailed letters to concerned parties requesting written comments and information on the proposed GRS.

Issues raised at the second meeting on May 16 on the proposed Kilauea southwest rift GRS included size of 90% probability area, land use compatibility, visual intrusion upon the scenic corridor, geothermal development as a violation of tenets of religious practices dedicated to Pele, Pele's disapproval of proposed geothermal development as expressed by the current eruptive phases at Puu O'o, geothermal effluent disposal, development of other forms of alternate energy resources, and employment opportunities generated by geothermal development.

To ensure full public participation, the time, place and purpose of these meetings were announced in newspaper publications, radio announcements and letter invitations. The objective of these meetings was to open lines of communication between the public and the Department of Land and Natural Resources.

Other sources of community input utilized in the assessment included the planning processes, goals, objectives and development policies formulated and adopted in community plans that become a part of the County General Plans and the State General Plan, as well as policies brought forth by representatives of people and communities in the State Legislature.

In addition, each proposed project must be approved through the existing land use permitting system which requires that certain standards and conditions be satisfied before and during project development activities.

SOCIAL IMPACTS

This section on the social impact analysis of the geothermal resource area along the Kilauea southwest rift gives emphasis to people's perceptions, attitudes, and concerns regarding geothermal resource development activities.

The assessment of social impacts was based on currently available public information concerning health, noise, lifestyle, culture, community setting, aesthetics and community input.

Health Concerns

The health concerns related to geothermal resource development involve the possible effects of chemical, particulate, and trace element emissions on the physical environment and on residents in the vicinity. Hydrogen sulfide (H_2S), due primarily to its "rotten egg" smell at certain concentrations, is the most significant gas found in geothermal emissions.

The study, "Evaluation of BACT for Air Quality Impact of Potential Geothermal Development in Hawaii," January, 1984, prepared for the U.S. Environmental Protection Agency by Dames & Moore on the Best Available Control Technology (BACT) for emission abatement was utilized in this assessment. The H_2S, particulate and trace element emission rates utilized in this study were developed from data gathered at HGP-A and the emission control systems described in the "BACT" report were assumed. EPA-developed air dispersion models were then used to estimate the impact of these pollutant emissions on ambient air quality.

The technology for abatement of hydrogen sulfide emissions to acceptable levels is available and the "BACT" study recommends the Stretford system as the primary on-line abatement. This system can remove over 99% of the H_2S contained in the non-condensable gases.

For control of noise and H_2S emissions during well flow testing, a caustic injection and rock muffler system can be utilized similar to the system that was installed at HGP-A in 1979. This system is now used for standby venting during periodic plant maintenance. The two-phase fluid is separated under pressure in a flash tank and the steam phase is exhausted to the atmosphere through a hooded rock muffler and the liquid is discharged to a second muffler and is released to the percolation pond. Tests of this system at HGP-A have shown it to be 90-95 percent efficient in H_2S removal.

A geothermal plant is expected to be on-line 90-95% of the time. Contingency abatement-systems can be utilized in the event the plant is "down" for maintenance. If maintenance is required, the geothermal steam could be re-routed directly into the main plant condenser utilizing the primary abatement systems. If the primary abatement system is not operational, a secondary abatement system such as NaOH (caustic soda) scrubbing can be used in combination with a rock muffler to achieve 92-95% H_2S removal.

"The Puna Community Survey", prepared in 1982 by SMS, Inc. for the State Department of Planning and Economic Development and the Hawaii County Department of Planning, reported that only one-fifth of the total survey respondents felt that they had been affected by the geothermal wells in Puna, on the Hawaii Island.

In the "Puna Speaks" case, where HGP-A shutdown was requested by some Puna residents, the U.S. District Court Judge ruled that the plaintiffs did not prove their case in suit as no causation was established between the well emissions and alleged maladies.

Noise Concerns

The impact and intrusiveness of noise from geothermal development activities on the surrounding environs is dependent on the meteorological conditions; the intensity of the noise source; the measures taken to reduce the noise level; the sound propagation conditions existing between the source and listener; the ambient or background noise at the receptor; and the activity at the receptor area at the time of the noise event.

As any geothermal project progresses, noise propagation information will be obtained and will serve as guidance for the design of noise mitigation measures required of the power plants, particularly for power plants located close to noise sensitive residential and park areas.

Although noise levels associated with geothermal energy development and operation are comparable with those of industrial or electrical plants of similar size, plant construction and operation in a quiet rural area are a potential noise factor which can be controlled and monitored.

The source of noise impact from the proposed geothermal resource subzone would arise from (a) construction of roads, pipelines, and buildings; (b) geothermal well-drilling and testing or venting; and (c) geothermal power plant operations.

During the initial phases of field development, persons in the immediate vicinity of a geothermal site may be exposed to noise levels varying from 40 to 125 decibels, depending upon the distance from the well site.

Noise generated by construction activity will involve the use of standard construction equipment such as local bulldozers, trucks, and graders operating in the same manner, and over a limited time period as any other typical project. No unusual noise events of long duration are involved.

Within 100 feet of the drill rig, noise varies from 60 to 98 decibels with muffler. Initial venting noise varies from 90 to 125 decibels which may be mitigated using a stack pipe insulator or cyclone muffler. Periodic operational venting noise is about 50 decibels using a pumice filled muffler.

The use of noise abatement procedures during venting, such as portable or in-place rock mufflers, can reduce noise levels from the drill site. Noise levels for proposed power plants are expected to be low and should result in slightly audible or inaudible levels at most receptor sites.

Power plant buildings and barriers can be designed to optimize the orientation and degree of closure to contain noises from the turbine, generator and transformers. Cooling towers have not proven to be dominant noise sources in geothermal plants. Taking all major noise sources into account, the continuous noise level of 75 dBA at 100 feet is considered readily achievable for power plants.

Ambient or background noise refers to the noise levels which presently exist in the environs of the proposed geothermal resource subzone and at locations where people reside, play or work and sometimes is produced by the people themselves. The existing exterior ambient noise levels at residences in the environs of the proposed geothermal operations are dictated largely by the sounds of nature and by traffic on local roads.

Ambient noise levels are often expressed as day-night noise levels (Ldn) where a 10 dB reduction is given for noise levels during the nighttime period between 7:00 p.m. to 7:00 a.m. The long-range strategies of the Environmental Protection Agency (EPA) are to achieve a goal of 55 dBA (45 dBA nighttime) which will ensure protection of public health and welfare from all adverse effects of noise based on present knowledge.

The EPA recommended noise levels as contained in their "Protection Noise Level" document are based on a negotiated scientific consensus that was developed without concern for economic and technological feasibility and is intentionally conservative to protect the most sensitive portion of the American population, and includes an additional margin of safety. The levels should be viewed as levels below which there is no reason to suspect that the general population will be at risk from any of the identified effects of noise.

In May of 1981, the County of Hawaii Planning Department issued a set of "Geothermal Noise Level Guidelines" to provide proper control and monitoring of geothermal-related noise impacts with stricter standards than those prevailing for Oahu, based on lower existing ambient noise levels for the Island of Hawaii.

Geothermal development activities have been required to comply with the Geothermal Noise Level Guidelines of the Hawaii County Planning Department ("Guidelines"). The "Guidelines" specify that the "acceptable geothermal noise guidelines should be at a level which reasonably assumes that the Environmental Protection Agency and U.S. Department of Housing and Urban Development criteria for acceptable indoor noise levels can be met" and that the sound level measurements should take place at the affected residential receptors that may be impacted by the geothermal operation.

For example, the design standard for the HGP-A Wellhead Generator Project specifies that the noise level one-half mile from the well site must be no greater than 65 decibels (comparable to the sound of air conditioning at 20 feet). Construction of a rock muffler at the facility has reduced noise levels to about 44 decibels (equivalent to light auto traffic) at the fence line of the project.

The type of housing normally found near the vicinity of the proposed geothermal resource subzone, will result in noise reduction from outside to inside of at least 15 dB. Thus, an outside noise level of 45 dBA will reduce to an inside level of 30 dBA or less, which is less than the EPA's limiting standard of 32 dBA level to prevent sleep modification.

Lifestyle, Culture, and Community Setting

The lifestyle, culture and community setting or atmosphere of an area are very much inter-related and represent a major consideration in assessing the effects of any introduced changes. Each community, however, will have its own unique background and perceptions and goals. Each community should in the process of considering geothermal resource development contribute its own input into the assessments.

In April 1980, 3,700 persons were living in Kau which constituted roughly 4 percent of the Big Island's population. The Kau district is largest in size and ranks eighth in terms of population. Kau's population density is 3.7 persons per square mile versus 22.8 persons per square mile for the County of Hawaii as a whole. Within the Kau District, roughly 44 percent (1,619) of the residents were living in the town of Pahala.

One of the survey questions discussed in the "Assessment of Geothermal Development Impact on Aboriginal Hawaiians" by the Puna Hui Ohana, regarding Community attitudes toward geothermal development asked respondents how they felt about the quality of life in Puna at the present time. The large majority responded that they were happy with the present quality of life in Puna, while only 9.5% were unhappy and 8.6% were neither happy nor unhappy.

Property within the Kilauea southwest rift zone is owned by the State of Hawaii, the United States of America (Hawaii Volcanoes National Park), Bishop Estate, Kau Agri-Business, International Air Service Co., Seamountain Hawaii, C. Brewer, and a number of small parcel landowners.

The small magnitude of change in lifestyle and social interaction that may be brought about by new residents may be a small part of the lifestyle, culture and community and traffic changes already taking place in the area.

As geothermal development occurs, each new increment of land area should be archaeologically surveyed by a qualified archaeologist after specific sites for development activity are determined and before land clearing begins. If archaeological sites are found, they should be described and assessed as to significance, and measures taken to ensure avoidance or mitigation of potential impacts from geothermal developments.

The practice of Hawaiian religion has included the belief and worship of the volcano goddess Pele. Some Hawaiian Practitioners consider the lands adjacent to Kilauea Crater as sacred and the home of Pele.

These practitioners consider the connections made with Pele in the past by their ancestors and today by themselves and their families, as essential to their daily life activities.

To many native Hawaiians, Pele is regarded as aumakua and akua, and personal offerings have been made to Pele by religious practitioners for many years.

Some Hawaiians also identify themselves as the bloodline of Pele and believe that their existence and theology is threatened by the potential changes that may result from geothermal development. They also believe that geothermal development may forever extinguish or destroy essential parts of Hawaiian heritage, culture and religion.

Certain practitioners interpret the continuous eruptions at Puu O'o as signs of Pele's disapproval of geothermal activity and that Pele in her manifestation as steam cannot be sold for monetary gains. They are concerned about traditional Hawaiian beliefs regarding the use of steam, suggesting that Pele would be offended by geothermal development.

However, the recognition and use of geothermal energy has been recorded in the history of the Hawaiian Islands by the Reverend William Ellis whose journal has been published in many editions. Explorers identified numerous fumaroles and thermal features on Kilauea and Mauna Loa volcanoes as early as 1825. Early Hawaiians are recorded using steam emanating from fissures along the rift zone for cooking. William Ellis notes in his Journal published in 1825 that offerings to Pele consisting of hogs, dogs, fish and fruits were frequently made on heiau altars at Kilauea-Iki, and that these offerings were always cooked in the steaming chasms or the adjoining ground, least Pele reject them. Ellis also notes that the ground in the vicinity of Kilauea, throughout the whole plain was so hot that those who came to the mountains to gather wood and to fell trees and hollow them for canoes "always cooked their own food, whether animal or vegetable, simply by wrapping it in fern leaves and burying it in the earth", a method quite similar to the Hawaiian imu. At Kilauea on

Hawaii, Handy and Handy's "Native Planters in Old Hawaii" describes how whole trunks of hapu'u pulu (fern trees) were thrown into steam fissures, covered with leaves, and when cooked, were split open and the starch core used as food for pigs.

The use of warm springs also was not unknown, since Ellis notes that at Kawaihae at the shore, warm springs provided a refreshing morning bath. Although the citation indicates a location removed from the Kilauea rift zone, the spring water is described as being "comfortably warm" and "probably impregnated with sulfur". He also notes medicinal qualities were ascribed to it by those who used it.

Aesthetics

"The Puna Community Survey" by SMS Research Inc. reported that of the negative impacts perceived relating to the geothermal development, 5% felt that it "looks bad". The area respondents with the greatest percentage were Keaau residents, with 25% of the factors mentioned being under the category of negative appearance.

In some areas with potential geothermal resource development, the plant installation may be relatively unobtrusive--where scenic view corridors are not damaged in the eye of nearby or medium-distanced residents and visitors--however, consideration of aesthetic aspects should include careful siting, tasteful design, and effective landscaping.

Techniques of preserving aesthetic aspects of the landscape and natural vistas include attractive design, painting of structures, towers and plants with colors to blend in with the natural setting.

Drill rigs, including a platform, may reach to heights of approximately 150 feet. Rigs at various locations within a subzone may be visible above the tree line from view corridors into the development area.

It is possible that the moist warm air from the cooling towers will condense as it rises under certain atmospheric conditions to form a small cloud mass similar to that often observed near cracks and puu's along the remote part of the Kilauea east rift zone east of Mauna Ulu under the same conditions. During normal atmospheric conditions, some visible vapors are expected from the cooling towers.

In areas where development activity is close to National or State Parks, or recreation areas, estimates of potential visual impacts along sensitive view corridors should be made. Terrain analyses can be conducted to determine locations outside the project area from which drilling rigs, powerlines, power plant facilities, etc., can be seen and to assess the visual impacts in relationship to size, distance, color, shape and other related factors.

Depending upon the terrain within and adjacent to a proposed project site, such an analysis may be required in environmental impact assessments for the development of specific sites within a geothermal resource subzone during the subsequent permitting process.

Ownership of Geothermal Resources

All mineral substances and ore deposits whether solid, gaseous, or liquid, including all geothermal resources, in, on, or under any State owned or reserved lands, fast or submerged; are reserved to the State of Hawaii.

Reserved lands are defined as those lands owned or leased by any person in which the State or it predecessors in interest has reserved to itself expressly or by implication the minerals or right to mine minerals, or both.

A purchaser or lessee of any such lands shall acquire no right, title, or interest in or to the minerals. Such minerals are reserved from sale or lease except as provided in Chapter 182 (HRS).

However, some mineral rights to geothermal resources in Hawaii may be in question. Although a 1974 State statute defines geothermal resource as a "mineral", there is some debate as to whether mineral reservations expressed in grants before 1974, apply to geothermal resources. Furthermore, grants issued between 1900 and 1955 failed to include the standard provision reserving all mineral rights to the State. Therefore, another challenge is presented as to whether mineral reservations are to be implied in grants which contain no express reservation.

POTENTIAL ECONOMIC BENEFITS

Development of geothermal resources would provide numerous job opportunities during the construction, maintenance, and operation of the roads, wells, and power generation facilities. The total number of employment opportunities will depend on specific development proposals. However, most jobs would be temporary construction jobs.

If we assume 25 project employees, direct wages may be about \$560,000 annually, having a multiplier effect totalling an estimated \$1.3 million. This would result in some impact on the state and county economy, but not a significant impact. A greater potential for permanent jobs for local residents may be provided by direct use applications of geothermal heat.

Various sources of public revenue may result from a geothermal facility, including property tax, fuel tax, general excise tax, corporate and personal income tax, and possibly royalty income.

Direct Use Applications

Direct use of geothermal heat should offer local residents many economic opportunities. The warm water effluent from a geothermal electric facility can provide an inexpensive source of process heat for various uses.

Some agricultural activities which can be supported by geothermal heat include: sugarcane processing, drying and dehydration of fruits and fish, fruit and juice canning, production of livestock feed from fodder, freeze drying of food and coffee, aquaculture and fishmeal production, refrigeration and ice making, soil sterilization, and fruit sterilization by dipping in hot water.

Industrial applications of direct geothermal heat may include extraction of potentially marketable minerals, such as silica or sulfur from geothermal fluids, production of cement building slabs, and production of liquid combustion fuels from biomass, e.g. bagasse or other agricultural by-products.

The Puna Geothermal Research Facility will explore the feasibility of some of the above direct use applications in Hawaii. The research facility, scheduled to be in operation in late 1985, is state funded and administered by the Hawaii Natural Energy Institute. It will be located adjacent to the HGP-A geothermal electric plant.

Other direct uses include hot geothermal mineral water spas which have proved to be of major commercial value in producing tourist revenue in Japan, Europe, U.S.S.R., and mainland United States, where millions visit these facilities annually. In places where fresh water is scarce, geothermal heat can be used to distill fresh water from saline water.

The transportability of geothermal heat is a significant limiting feature of direct use applications. Factors which influence transportability include initial and end-use temperatures, climate conditions, and whether steam or hot water is transporting the heat. Hot water can be transported much farther than steam. Depending on the direct use application, hot water can be transported about ten miles. Thus direct use facilities should be situated in close proximity to electric generation facilities.

The proposed Kilauea southwest rift GRS is almost entirely zoned agricultural. It must be determined during subsequent permitting processes whether direct use applications of geothermal heat is an appropriate use in this proposed GRS (see section on compatibility). However, direct use activities are not legally restricted to geothermal resource subzones (Act 296 only restricts electrical uses to subzones).

If the benefits of direct use applications are to be available in several areas, then small decentralized geothermal facilities should be encouraged. Decentralized developments owned and operated by various developers may also promote competitive pricing for both electricity and process heat. With imaginative marketing, Big Island processed farm products can be sold world-wide.

Other Considerations

Current peak electrical demand on the Big Island is about 100 MW, with nighttime base demand of about 40 MW. An annual load growth of about 1% is expected. Electrical generation capacity on the Big Island is about 130 MW (including reserve capacity), with about 60% generated by oil, 33% by biomass, 5% by hydro, and 2% by geothermal. Biomass' significant contribution may change as sugar production (bagasse availability) is being reduced; however, this may be offset by woodchipping. The Hawaiian Electric Light Company is seeking proposals from geothermal developers to provide future generation capacity.

As described above, the Big Island's demand for electricity is expected to be fairly stable. Considering existing electric generation capacity, the demand for geothermal electricity may be somewhat limited. However, two possible long-term scenarios would significnatly increase the demand for geothermal electricity: (1) a deep water electrical transmission cable connecting the islands and/or (2) an energy intensive industry on the Big Island, e.g., manganese nodule processing. Either of these scenarios could increase demand by 250 MW. However, each of these projects require a thorough analysis of many issues, including environmental and social impacts and technical and economic feasibility. These issues are beyond the scope of this report. The State Department of Planning and Economic Development has been coordinating investigations in these areas.

ENVIRONMENTAL IMPACTS FROM GEOTHERMAL DEVELOPMENT

Geothermal factors with a possible effect on the environment include air emissions, liquid effluent, noise, visual aesthetics, and physical disturbance during construction.

Air Emissions

The most significant geothermal emission is hydrogen sulfide (H_2S). Chemical analyses on unabated, undispersed, geothermal steam at the Hawaii Geothermal Project - well A (HGP-A) indicate H_2S concentrations of 900 parts per million by weight (ppmw)* (Thomas, 1983). Other potential geothermal reservoirs in Hawaii may vary. H_2S abatement systems and normal air dispersion will drastically reduce the concentration of any emissions from a point source.

The State Department of Health (DOH) has proposed Ambient Air Quality Standards to control H_2S emissions from geothermal wells and power plants (Chapters 11-59 and 11-60 of the DOH Administrative Rules). The developer must obtain from the DOH an "authority to construct" prior to geothermal well or power plant construction and a "permit to operate" prior to connecting a well to a power plant (§11-60-23.1(d)). Geothermal wells and plants would have to show compliance with the State standards adopted. Current technology indicates that geothermal development activities can occur while meeting either the standards being considered or California standards which govern emissions from the largest geothermal development in the world.

(Note: The proposed DOH ambient air quality standards quoted in the draft Circulars C-114 and C-115 have subsequently been retracted by the DOH for further study and a new draft regarding air quality standards is forthcoming.)

A preliminary assessment of the levels of H_2S which can be expected from geothermal developments in Hawaii has been prepared by

*One ppm is approximately equivalent to one drop in 15 gallons. One part per billion (ppb) is approximately equivalent to 1 drop in 15,000 gallons.

J. Morrow (1985). He concludes that under the most unfavorable atmospheric conditions a 25 MW plant with at least 98% H_2S removal efficiency appears capable of meeting the proposed state increment and ambient standard under normal and abnormal (steam stacking) operating conditions. A higher level of abatement efficiency by H_2S control systems may be necessary for larger plant sizes or when weather conditions work against normal dispersion of emissions.

The State DOH will set all standards necessary to protect the public health. Geothermal developers must demonstrate that these standards will be met both prior to construction and during operation. Technologies exist which have demonstrated abatement of H_2S emissions by approximately 99%. (For general information on geothermal wells, power plants, and abatement see DLNR Circular C-108 "Geothermal Technology" and also U.S. Environmental Protection Agency Publication "Evaluation of BACT and Air Quality Impact of Potential Geothermal Development in Hawaii.")

Effects of Hydrogen Sulfide in Humans

The National Research Council Committee on Medical and Biological Effects of Environmental Pollutants issued a report in 1979 titled "Hydrogen Sulfide". They report that "the odor of H_2S is nothing more than an unpleasant nuisance...yet at higher concentrations it is a deadly poison...its typical 'rotten egg' odor is detectable by olfaction at very low concentrations [0.035 ug/liter or 25 ppb] in the air. Exposures to these low concentrations have little or no importance to human health. Thus, this olfactory response is a safe and useful warning signal that a hydrogen sulfide source is nearby. However at higher concentrations [280ug/liter or 200 ppm] H_2S is distinctly dangerous...(At sufficient concentrations) hydrogen sulfide is an irritant gas. Its direct action on tissues includes local inflamation of the moist membranes of the eye and respiratory tract."

The California Deparment of Health Service (1980) reported that "we have not become aware of any complaints of ill health due to H_2S where the 30 ppb standard has been enforced in California...there is no evidence that a more restrictive standard would achieve a perceptible improvement in the public health."

The World Health Organization (1981) reported that "H_2S in concentrations of the order of the odor threshold has not been shown to have any significant biological activity in man or animals." Human responses to H_2S are listed in Figure 2.

In February 1984, the Hawaii DOH conducted a door-to-door health interview survey of a residential community, Leilani Estates, located near the 3 MW HGP-A geothermal power plant in the Puna District. The primary purposes of this survey were to establish the health status of Leilani Estates and to compare it to Hawaiian Beaches Estates and other areas of Hawaii. The rates of chronic respiratory conditions including bronchitis/emphysema, asthma, hayfever, sinusitis, and other respiratory system disease were found to be similar in Leilani Estates and Hawaiian Beaches Estates from January 1983 to January 1984. These conditions have been most often associated with long-term exposure to air pollutants.

Most H_2S information pertains to its short-term effects. Information on long-term, low-level effects of H_2S is limited. The following report on H_2S levels in New Zealand considers long-term effects.

S.M. Siegel (1984), in a preliminary report for the Hawaii Natural Energy Institute, investigated the effects of H_2S at Rotorua, New Zealand. The air in Rotorua contains emissions from volcanic vents and has a 200 MW geothermal electric plant (unabated H_2S emissions) situated nearby. Within Rotorua 32 sites were sampled for H_2S. Some sites having high H_2S concentrations include: two school sites at 30-50 ppbv, two hospitals at _50 ppbv and two hotels at 50 ppbv. Hospital records from an area with a relatively high level of H_2S were compared with hospital records from an area with very low H_2S levels (no volcanic or geothermal plant emissions in latter area). Siegel found that "the incidence of diseases sampled, whether potentially related to H_2S exposure or not is not significantly different in the two Hospital Board Districts. Especially important are the absence of extra cases relating to blood-forming organs; central or sensory nerve

Effects of hydrogen sulfide exposure at various concentrations in air

Effect	Concentration mg/m³	Concentration ppm	Duration of exposure	Reference
Man Approximate threshold for odour	0.0007—0.2	0.0005—0.13	A few seconds to less than 1 min	Yant (1930); Ryazanov (1962); Adams & Young (1968); Leonardos et al. (1969); Lindvall (1970); Thiele (1979); Winneke et al. (1979)
Threshold of eye irritation	16—32	10.5—21	6—7 h	Elkins (1939) Nesswetha (1969)
Acute conjuctivitis (gas eye)	75—150	50—100	> 1 h	Yant (1930)
Loss of sense of smell	225—300	150—200	2—15 min	Sayers et al. (1925)
Animals * Local irritation and slight systemic symptoms; possible death after several hours	750—1050	500—700	< 1 h	Haggard (1925)
Systemic symptoms; death in less than 1 h	1350	900	< 30 min	Haggard (1925)
Death	2250	1500	15—30 min	Haggard (1925)

* These observations were made in experimental animals. However, there are no better quantitative data available concerning man with respect to exposure to hydrogen sulfide at high concentrations. Source: Hydrogen Sulfide (1981), World Health Organization.

Note: The above concentrations are stated in parts per million (ppm). The Hawaii Department of Health incremental standard has been stated in parts per billion, i.e. 25 ppb or .025 ppm which is within the range of the odor threshold stated in the above table.

Figure 2

functions; respiration; or dermatitis." He also compared infant mortality rates in three areas and found that their mortality rates were "not in any way concerned with H_2S exposure." Siegel concludes that "there is no question that Rotorua is odorous and objectively high in H_2S, often well above the California (and Hawaii) air quality standard of 30 ppbv. Rotorua and its environs have, by U.S. standards, such high levels of H_2S in residential, hospital, school, recreational and resort locations, yet reveal no evidence of health impairments."

Effects of Hydrogen Sulfide on Plants

Thompson and Kats (1978) report pronounced stimulation of growth with alfalfa, sugar beets, and lettuce at low dosages of H_2S (30-100 ppb). At higher dosages (300-3000 ppb), H_2S fumigation caused leaf lesions, defoliation, and reduced growth in some plants. They noted that the "use of continuous, unvarying fumigation levels for exposing plant species may be unrealistic when compared to the exposures experienced by vegetation in the field, where the vagaries of wind, convection, etc., cause varying dilution effects."

The Hawaii Natural Energy Institute (HNEI) will administer the Puna Geothermal Research Facility which will be operational by late 1985. It will accommodate geothermal research which will investigate the effects of H_2S on food crops and native Hawaiian plants.

Direct physical disturbance by geothermal construction activities should be carefully planned to minimize damage in prime environmental areas. Native forests may be susceptible to invasion by exotic species along roadways or other cleared areas. Weed control programs may be required which can minimize these impacts.

Liquid Effluent from Geothermal Development

Significant elements in geothermal brine include silica, chloride, and sodium (see Figure 3 for listing of elements in HGP-A brine). If not disposed of properly these elements have the potential to pollute potable water. Disposing of or minimizing the solids from silica deposition is a subject of concern whether the brine is discharged into

Element	Concentration, ppm[a]
Arsenic	0.01 - 0.001[b]
Barium	2
Boron	2
Calcium	218
Cadmium	<1.0[c]
Carbonate	75
Chloride	7200
Cobalt	0.014
Copper	<0.004
Gold	<0.00004
Iron	0.02
Lead	<1[c]
Lithium	0.034
Magnesium	0.131
Manganese	0.034
Mercury	<0.001
Molybdenum	0.067
Nickel	<0.02
Niobium	<0.4
pH	7.4[d]
Phosphorous	0.2
Platinum	<0.006
Potassium	600
Silica	800
Silver	<0.02
Sodium	3700
Strontium	2.0
Sulfate	50
Sulfide	17
Tantalum	<0.001
Thallium	<1[c]
Tin	<0.2
Titanium	0.006
Uranium	0.16
Vanadium	0.016
Zinc	0.012

[a] Liquid samples taken from cyclone separator (Thomas, 1983a).
[b] Rough estimate based on preliminary analysis, Thomas, 1983b.
[c] Thomas, 1982b. 'Less than' signs indicate detection limit of analyzer.
[d] Before atmospheric flashing, Thomas, 1982a.

Particulate Composition of HGP-A Brine.
(Source: Dames & Moore, 1984)

Figure 3

a surface percolation pond or reinjected into deep rock strata. Some future projects at the Puna Geothermal Research Facility will investigate solutions to the problem of silica deposition. Aesthetic considerations may require brine disposal by reinjection. Geothermal development permits should indicate what method of brine disposal will be required.

The State DOH has established an Underground Injection Control program designed to protect the state's underground sources of drinking water (Chapter 11-23). These laws will regulate underground injections of geothermal fluids such that underground sources of drinking water are not polluted.

Groundwater monitoring and control can be required by development permits. The Board of Land and Natural Resources (BLNR) Decision and Order which allowed limited geothermal exploration at Kahaualea included the following sections: §9.2.6 requires water analyses during intial well drilling; §9.6.9 prohibits pollution of ocean and rivers by geothermal brine; and §9.6.10 states that no substances from geothermal wells shall be allowed to flow on the ground in such a manner as to create a health hazard.

Noise Impacts

The County of Hawaii Planning Department has issued Noise Level Guidelines which have been attached to county permits controlling geothermal activities (in areas zoned urban, agricultural, or rural). These guidelines include the following:

a. That a general noise level of 55 dBA during daytime and 45 dBA at night not be exceeded except as allowed under b. for the purposes of these guidelines, night is defined as the hours between 7:00 p.m. and 7:00 a.m.;

b. That the allowable levels for impact noise be 10 dBA above the generally allowed noise level. However, in any event, the generally allowed noise level should not be exceeded more than 10% of the time within any 20 minute period; and

c. That the noise level guidelines be applied at the existing residential receptors which may be impacted by the geothermal operation.

The BLNR has also similarly controlled noise associated with geothermal activities in areas zoned conservation. The BLNR Decision and Order of February 25, 1983 which allowed limited geothermal exploration on a portion of the Kahaualea land parcel in Puna, Hawaii included the following noise level restrictions:

§9.3.5 - A general noise level of 55 dba during daytime and 45 dba at night shall not be exceeded except as allowed for impact noise. For the purposes of these guidelines, night is defined as the hours between 7:00 p.m. and 7:00 a.m. These general noise levels may be exceeded by a maximum of 10 dba for impact noise; however, in any event, the generally allowed noise level shall not be exceeded more than 10 percent of the time within any 20-minute period with the exception of venting operation in accordance with Chapter 183 of Title 13 of the Board's Administrative Rules and this order.

The above decibel limits are related to everyday sounds noted in Figure 4.

The State DOH has issued noise regulations for Oahu. Presently the DOH does not control noise on a state-wide level.

Aesthetic Concerns

Visual impacts of geothermal developments in or near National Parks, recreation areas, etc., may be minimized by considering sensitive view corridors during site selection. Sites close to forest areas will minimize development visibility; however, this advantage must be balanced with possible damage that may occur to the forest. Aesthetics may also be improved by tasteful development design, landscaping, and painting of structures in colors to blend with the background.

Sound Levels and Human Response

Common Sounds	Noise Level (dB)	Effect
Air raid siren	140	Painfully loud
Jet takeoff (200 ft) Auto horn (3 ft) Discotheque	120	Requires maximum vocal effort
Alarm clock (2 ft) Hair dryer	80	Annoying
Freeway traffic Man's voice (3 ft)	70	Telephone use difficult
Air conditioning (20 ft)	60	Intrusive
Light auto traffic (100 ft)	50	Quiet
Living room Bedroom	40	
Library Soft whisper (30 ft)	30	Very quiet

This decibel (dB) table compares some common sounds and shows how they rank in potential harm to hearing. Note that 70 dB is the point at which noise begins to harm hearing. To the ear, each 10 dB increase seems twice as loud. (Source: U.S. Environmental Protection Agency)

Figure 4

Visibility of steam emissions from cooling towers will vary with output and atmospheric conditions; however, use of drift eliminators can reduce the size of the vapor plume. Silica deposition from surface disposal of geothermal brine can also create an aesthetic problem. Brine could be reinjected into deep rock strata. As an alternative, research may provide an aesthetic and environmentally acceptable brine treatment process.

Air and Water Conditions

Under trade wind conditions during the day, moderate to moderately strong northeast trade winds are expected to flow through the proposed Pahala GRS. At night moderate drainage winds from the upper slopes of Mauna Loa should flow through the area from the north.

Under non-trade wind condition, during the day, light to moderate southerly sea breeze-upslope winds are expected. At night, the light to moderate drainage winds from the north are expected.

There is great variation in the amount of rainfall over the Kilauea southwest rift--from about 100 inches a year near Hawaii Volcano National Park Headquarters to about 20 inches a year at the southern end of the rift zone near Hilina Pali in the Kau Dessert. The greatest variation in rainfall is in the northern area where in the short distance of about a mile from the National Park Headquarters to Halemaumau, the rainfall drops from 100 inches a year to 50 inches a year. There are no rainfall stations in the Kau Desert.

There are few streams in the Kilauea southwest rift zone because the water quickly percolates into the young and highly permeable lava flows. A few well-defined stream channels are found between Waiahaka Gulch, near Kapapala Ranch, and Hilea Gulch. No stream has continous flow into the sea, and flood flows reach the sea infrequently and only for short periods. Ground water in the coastal areas of the rift zone is brackish; at higher elevations dike confined water is present.

Flora and Fauna in the Proposed Kilauea Southwest Rift GRS

A forest map of the Kilauea southwest rift zone area has been prepared by the State Deprtment of Land and Natural Resources, Division of Forestry and Wildlife (Figure 5). It shows that land in the proposed Kilauea southwest rift GRS is primarily non-forest grassland area mostly comprised of introduced broomsedge grass. The area also contains some scattered native and introduced shrubs and trees with small pockets of forest area. Agricultural uses include macadamia nut, sugarcane, and grazing areas.

Endangered birds include the I'o (Hawaiian Hawk) and the Nene (Hawaiian goose). The distributional area of these birds for the island of Hawaii is depicted in Figure 6. Distributional areas indicate those areas where these birds have been sighted. Possible reasons for the declining population of Hawaii's endangered birds include avian disease, animal competition, collecting and hunting, elimination or degradation of habitat, and predation.

The endangered I'o or Hawaiian hawk is a roaming bird which has been sighted throughout the Kilauea area over a wide range of ecosystem types, including agricultural lands. The I'o population is currently estimated to be 1400-2500 birds, all on the Big Island. Light and dark color variations exist for the I'o. The light phase I'o has a generally dark brown head and back with a white chest and belly. The dark phase I'o is generally dark brown all over. Part of the I'o distributional area is to the northwest of the proposed Kilauea southwest rift GRS.

The Hawaii Division of Fish and Game has conducted a project for the last 30 years to propogate Nene for release into the wild. Once plentiful, the endangered Nene population had dwindled to an estimated 30 birds in 1952. Through controlled propagation efforts their population on the island of Hawaii had increased to 300 birds in 1980. Their primary range is to the northeast of the proposed Kilauea southwest rift GRS at elevations from 3800 to 8000 feet on the slopes of Mauna Loa.

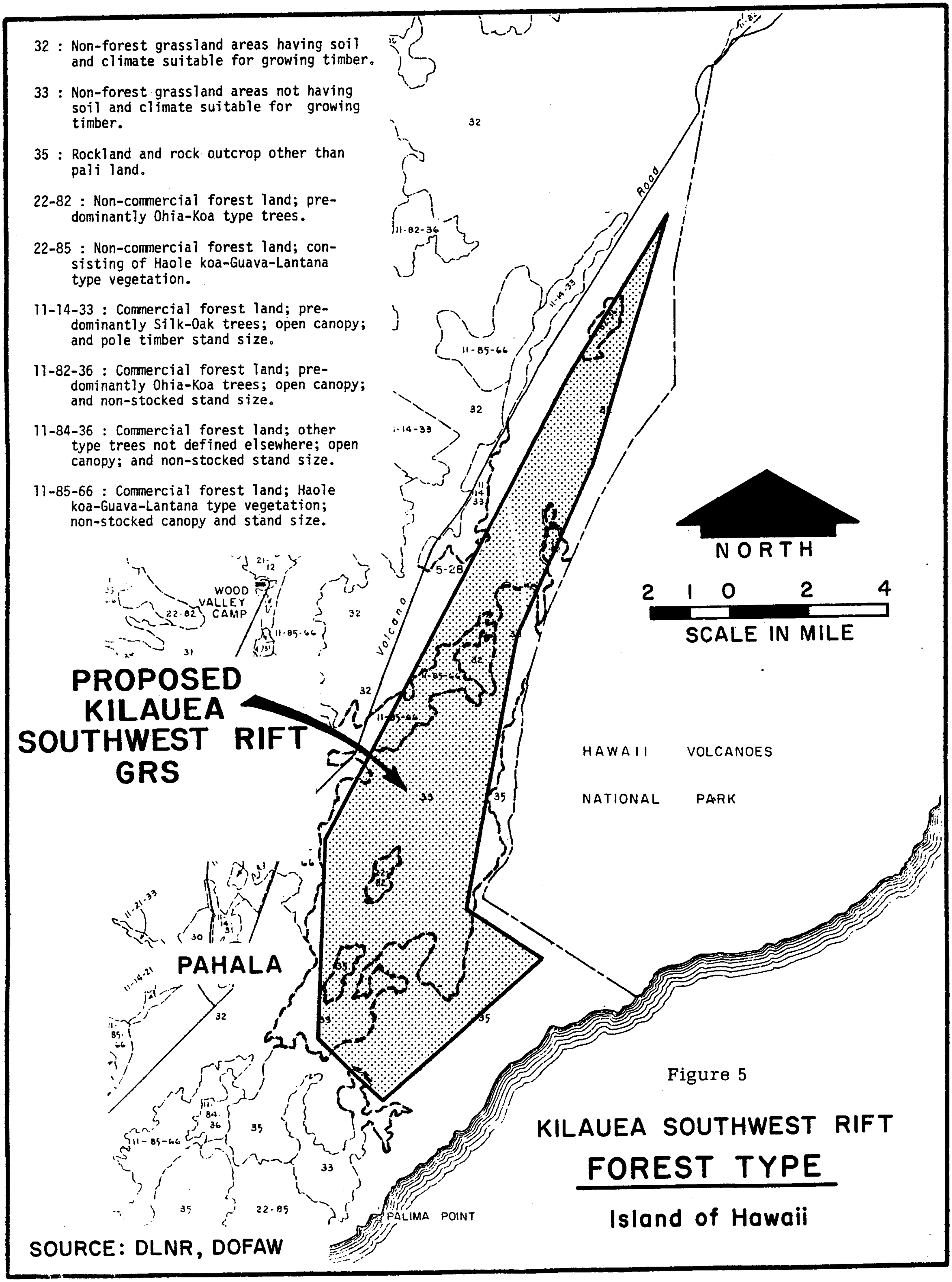


Figure 5

KILAUEA SOUTHWEST RIFT

FOREST TYPE

Island of Hawaii

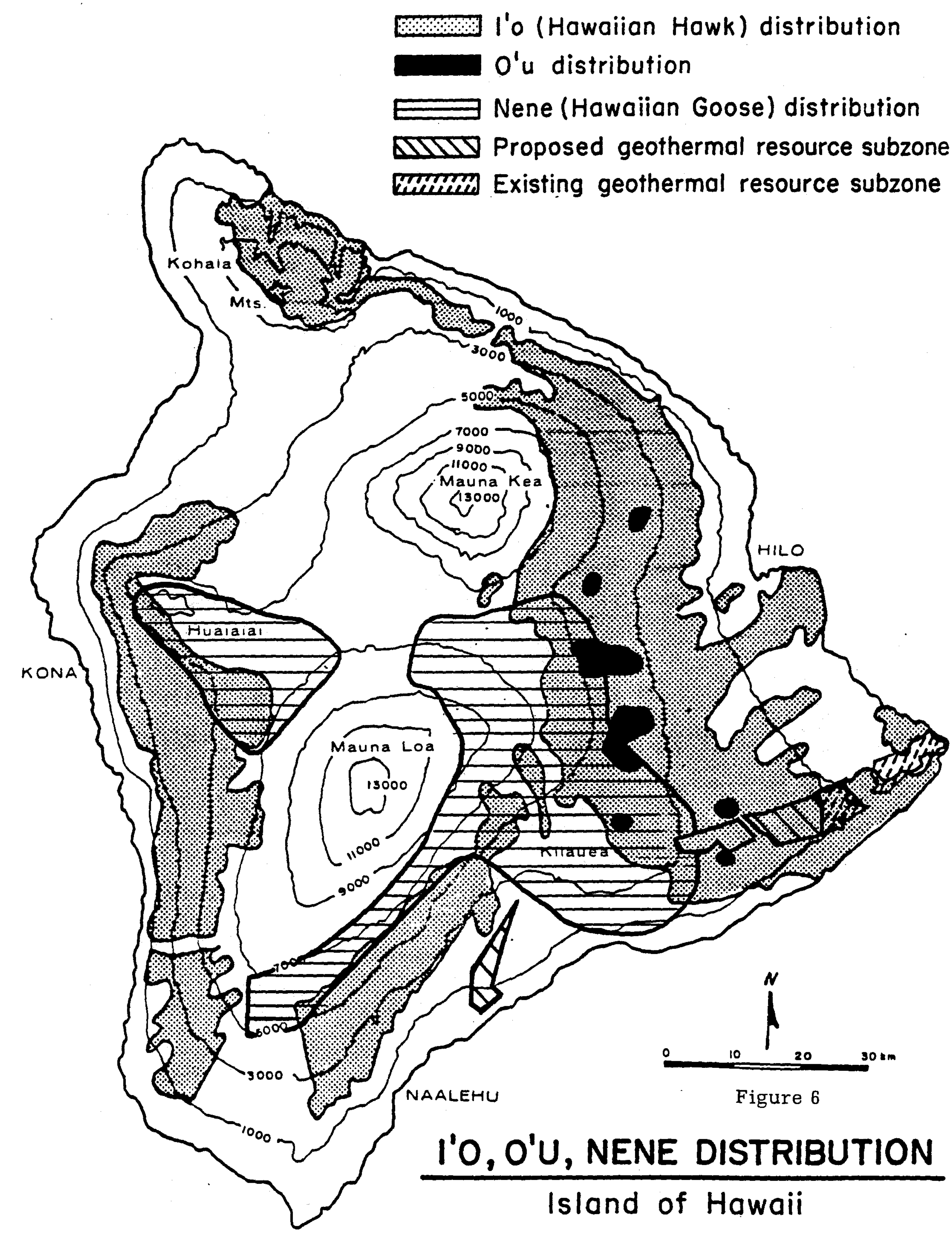


Figure 6

I'O, O'U, NENE DISTRIBUTION

Island of Hawaii

Source: U.S. Fish & Wildlife Service

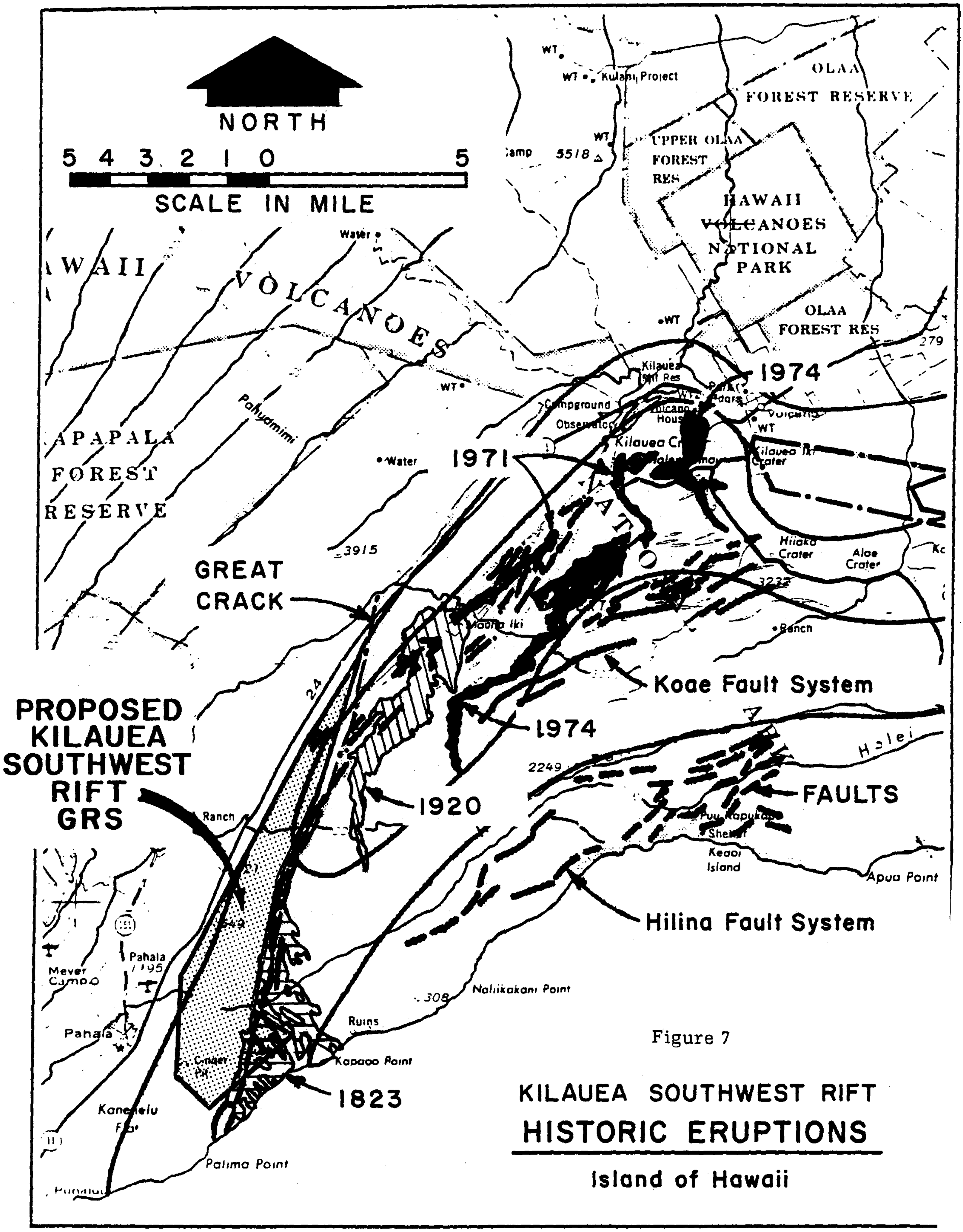
GEOLOGIC HAZARDS

An analysis of Hawaiian geologic hazards and their possible effects on geothermal developments has been provided in Circular C-107, "Geologic Impact Analysis of Potential Geothermal Resource Areas", published by the Department of Land and Natural Resources, Division of Water and Land Development. The report also describes several mitigation measures which may reduce the risk from geologic hazards.

The following paragraphs supplement Circular C-107 providing a description of the geologic activity which has occurred in or near the Kilauea southwest rift zone.

Lava Flows

Kilauea is one of the world's most active volcanoes. The Kilauea eruption of 1823 is the only historic eruption which flowed into the proposed Kilauea southwest rift GRS. Other historic flows occurred at Kilauea's southwest rift zone, but north of the proposed GRS, in 1868, 1919, 1971, and 1974 (see Figure 7 and the table below). The largest flow, in 1919, covered an area of 13 km^2. An average flow covered about 7 km^2. The most recent volcanic activity occurred in 1982, when magma moved into the upper southwest rift zone. This caused ground cracking but no lava erupted. The southeastern flank of the rift zone may be more prone to be covered by lava flows than the northwestern flank due to its sloping topography. It is not possible to predict the precise time and place of future volcanic activity. Intervals between historic eruptions in the southwest rift zone have varied from 3 years (1971 to 1974) to 52 years (1919 to 1971).


NORTH
5 4 3 2 1 0 5
SCALE IN MILE
OLAA FOREST RESERVE
UPPER OLAA FOREST RES
HAWAII VOLCANOES NATIONAL PARK
OLAA FOREST RES
HAWAII VOLCANOES
KAPAPALA FOREST RESERVE
Pahyamimi
1974
1971
GREAT CRACK
Koae Fault System
1974
PROPOSED KILAUEA SOUTHWEST RIFT GRS
1920
FAULTS
Hilina Fault System
1823
Kilauea Crater
Hiiaka Crater
Alae Crater
Apua Point
Keaoi Island
Naliikakani Point
Kapaoo Point
Palima Point
Pahala
Ruins
Ranch
Kulani Project
Figure 7
KILAUEA SOUTHWEST RIFT
HISTORIC ERUPTIONS
Island of Hawaii

Historic Eruptions of Kilauea Southwest Rift

Date	Duration (days)	Repose since last eruption (months)	Altitude of vent (m)	Area of flow (km^2)	Volume (m^3)	Average thickness (m)
May 1823	Short	--	400	10	11,000,000	1.1
Apr. 1868	Short	539	770	.1	183,000	1.8
Dec. 1919	221	620	900	13	45,300,000	3.5
Sep 1971	5	615	1000	3.9	7,700,000	2.0
Dec. 1974	1	38	1080	7.5	14,300,000	1.9
Total		1812		34.5	78,483,000	
Average	Short	453 (38 yrs)	830	6.9	16,000,000	2.7 (9 ft)

Source: Modified after Macdonald, et al, (1983).

Geothermal facilities on locally elevated ground on upslope areas of the proposed GRS may offer some protection from lava flows, provided that a geothermal resource is discovered at such a site.

Decentralized facilities, strategic siting, and prudently constructed lava diversion platforms and barriers can be expected to mitigate the hazard risk from future flows. However, nothing can eliminate the substantial hazard from lava flows.

Pyroclastic Fallout

Weight and depth of proclastic fallout is greatest around an eruptive vent. However, fallout can be appreciable 500 to 1000 m downwind of a vent. In 1959, a light pumice blanket extended 4000 m southwest southwest from Kilauea Iki vent. In February 1985, high fountaining during the 30th phase of the Puu O'o eruption and strong NE Kona winds resulted in an appreciable amount of Pele's hair falling out over Hilo.

Protecting structures or machinery against damage by pyroclastic fallout may be achieved by enclosing those parts vulnerable to abrasion or contamination.

Ground Cracks

Volcanic cracking is concentrated along the rift zone axis (e.g. the Great Crack). There is considerable tectonic cracking and faulting associated with the Koae and Hilina fault systems (Figure 7). Contingency planning should include the best available methods for sealing a well bore should a crack intercept a producing well.

Earthquakes

Most earthquakes in Hawaii are volcanic, which are small in magnitude and cause little direct damage. Larger tectonic earthquakes tend to be situated in the saddle area between the calderas of Kilauea and Mauna Loa, and also in the Koae and Hilina fault systems--south of Kilauea's caldera. Recent earthquakes above magnitude 6 have occurred in the saddle area, e.g. the Kaoiki earthquake in November, 1983 (magnitude 6.7). The largest recent earthquake (magnitude 7.2) occurred in 1975 about 5 km southwest of Kalapana.

Subsidence

On the mainland, subsidence due to contraction of clay or sand formations may result from the withdrawal of geothermal fluids in those formations. In Hawaii, subsidence from geothermal fluid withdrawal is not likely to be a problem; since the islands are generally composed of dense, yet porous, self-supporting basaltic rock, especially in geothermal production zones. Of more concern is the volcanic or tectonic subsidence which may occur on or about active rift zones.

As a result of volcanic activity, small to large grabens may result with the subsidence of rock blocks (usually rectangular) which are downthrown along or between cracks, e.g. 1960 Kapoho graben. Subsidence may also be associated with tectonic earthquakes, collapsing lava tubes and pit craters.

Tsunamis

Tsunami hazard is probably localized to a zone of land at most 2 km wide around the coast, and at elevations below about 75 feet. This will not be a hazard to developments in the proposed Kilauea southwest rift GRS as elevations are generally above 400 feet.

LAND USE COMPATIBILITY

Under the provisions of Chapter 205-2 of the Hawaii Revised Statutes, Districting and Classification of Lands, there are four major land use districts in which all lands in the State are be placed: (1) urban, (2) rural, (3) agricultural, and (4) conservation.

Urban districts include activities or uses as provided by ordinances or regulations of the county within which the urban district is situated.

Rural districts include activities or uses as characterized by low density residential lots of not more than one dwelling house per one-half acre in areas where 'city-like' concentration of people, structures, streets, and urban level of services are absent, and where small farms are intermixed with the low density residential lots. These districts may include contiguous areas which are not suited to low density residential lots or small farms by reason of topography, soils, and other related characteristics.

Agricultural districts include activities or uses as characterized by the cultivation of crops, orchards, forage, and forestry; farming activities or uses related to animal husbandry, and game and fish propagation; services and uses accessory to the above activities including but not limited to living quarters or dwellings, mills, storage facilities, processing facilities, and roadside stands for the sale of products grown on the premises; agricultural parks and open area recreational facilities.

Conservation districts include areas necessary for protecting watersheds and water sources; preserving scenic and historic areas; providing park lands, wilderness, and beach; conserving endemic plants, fish, and wildlife; preventing floods and soil erosion; forestry; open space areas whose existing openness, natural condition, or present state of use, if retained, would enhance the present or potential value of abutting or surrounding communities, or would maintain or enhance the conservation of natural or scenic resources; areas of value for recreational purposes; and other related activities; and other permitted uses not detrimental to a multiple use conservation concept.

The DLNR's administrative rules define conservation to mean:

> "A practice, by both government and private landowners, of protecting and preserving, by judicious development and utilization, the natural and scenic resources attendant to land...to ensure optimum long-term benefits for the inhabitants of the State." (DLNR Rule 13-2-1)

The great majority of the land within the proposed Kilauea southwest rift GRS is zoned Agricultural with a very small portion zoned conservation. This area presently includes grazing and macadamia nut and sugarcane farming.

Act 296, SLH 1983 and as amended by Act 151, 1984, specifically states that "geothermal resource subzones may be designated within the urban, rural, agricultural, and conservation land use districts established under section 205-2. Only those areas designated as geothermal resource subzones may be utilized for geothermal development activities in addition to those uses permitted in each land use district under this chapter."

Methods for assessing the compatibility of geothermal development within a conservation district, shall be left to the discretion of the Board and may be based on currently available public information.

The authority of the Board to designate geothermal resource subzones shall be an exception to those provisions of Chapter 205 and of Section 26-4 authorizing the land use commission and the counties to establish and modify land use districts and to regulate uses therein. The provisions of this section shall not abrogate nor supersede the provisions of Chapters 182 and 183 (HRS).

If geothermal development activities are proposed within a conservation district, then, after receipt of a properly filed and completed application, the Board of Land and Natural Resources shall conduct a public hearing and, upon appropriate request, a contested case hearing pursuant to Chapter 91 to determine whether, pursuant to Board regulations, a conservation district use permit shall be granted to authorize the geothermal development activities described in the application.

In granting a conservation district use permit (CDUA No. HA 3/2/82-1463) for geothermal exploration, the Board of Land and Natural Resources (BLNR) stated that "the State recognizes that conservation lands vary in their use and importance in accordance with a wide variety of criteria. Both the federal government and the State of Hawaii recognize that conservation lands involve multiple uses which range from absolute preservation to regulated uses...The range of activity permitted depends upon the ecological importance of the resource in the overall environment and the relative need for human activity within a restricted context." This balancing test may also be applied by the BLNR to conservation lands contained within the proposed Kilauea southwest rift GRS when subzoning is determined.

The counties control land use within agricultural districts. The County of Hawaii has already permitted the drilling of several geothermal wells on land zoned agricultural near the HGP-A geothermal facility. With regard to agricultural zoned land within the proposed Kilauea southwest rift GRS, the County will assess the propriety of geothermal development before granting their geothermal permits.

Potential geothermal direct use applications (see economics section) may complement present agricultural uses such that both uses may become more profitable. The potential for ecological disturbance is minimal since the area within the proposed Kilauea southwest rift GRS does not contain any prime native forest nor any endangered plants or animals. Air quality should not be significantly affected as the State DOH proposed air quality standards will require high levels of abatement. The County Planning Department can control noise levels through conditions attached to any future development permits. Considering all of the above, it is expected that geothermal development can be compatible with present land use in the proposed Kilauea southwest rift GRS.

CONCLUSION AND RECOMMENDATION

The Department of Land and Natural Resources under the authority of Act 296, SLH 1983, and Act 151, SLH 1984, conducted an assessment of the Kilauea southwest rift zone, island of Hawaii.

This land area located between the western boundary of the Hawaii Volcanoes National Park and Highway 11 was examined for resource potential and evaluations were made on geologic hazards, social, economic, and environmental impacts and compatibility of geothermal development. The potential geothermal resource area was evaluated on the basis of potential and real impacts which may occur within the identified area and considered the statutory state energy objectives and policies.

The potential geothermal resource area was assessed to have a 25% to 90% probability of locating a high temperature resource. Potential impacts were identified and considerations given to mitigation measures and other requirements that may be imposed on a site-specific, case-by-case basis during subsequent State and County permitting.

Geologic hazards are present throughout the entire Kilauea southwest rift zone. Decentralization of facilities, strategic siting, and lava diversion platforms and barriers may mitigate damage from future lava flows. Development permits should require that all potential economic losses are to be assumed by developers.

The State Department of Health has proposed air quality standards and promulgated underground injection control regulations which will control geothermal emissions and effluent injections. Development permits should either prohibit or control surface water disposals. Geothermal noise levels have been regulated in exploration permits and such noise regulation is expected to continue throughout the development process.

The proposed Kilauea southwest rift GRS will provide a 1000-foot buffer between the GRS and the Hawaii Volcanoes National Park to mitigate any possible effects on the existing flora and fauna in the National Park. Scenic view corridors along Highway 11 should be protected throughout the permitting process by requiring tasteful development, design, landscaping, and painting of structures.

The State has established an objective of energy self-sufficiency and geothermal energy is viewed as a key to attaining this objective. The protection of the environment is also an area of high priority. The Division of Water and Land Development believes that both goals of geothermal development and environmental protection can be attained by permitting controlled development within the proposed Kilauea southwest rift GRS. This assessment has resulted in the identification of approximately 8,090 acres of the Kilauea southwest rift zone as a potential geothermal resource area and recommends that the proposed Kilauea southwest rift GRS be considered for designation by the Board of Land and Natural Resources under authority of Act 296, SLH 1983, and Act 151, SLH 1984.

APPENDIX A

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