A REPORT ON GEOTHERMAL RESOURCE SUBZONES FOR DESIGNATION BY THE BOARD OF LAND AND NATURAL RESOURCES

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

Honolulu, Hawaii
August 1984

GEORGE R. ARIYOSHI
Governor

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PREFACE

The Board of Land and Natural Resources is charged with the responsibility of designating geothermal resource subzones in the State of Hawaii under authority of Act 296, SLH 1983, signed into law on June 14, 1983 by Governor George R. Ariyoshi. Once subzones are established, all geothermal activities including the exploration, development, and production of electrical energy may be conducted only in the designated geothermal resource subzones.

The objective of this report is to provide information to the Board of Land and Natural Resources so that it may designate geothermal resource subzones in the State of Hawaii as prescribed in Act 296. To the extent provided by Act 296, SLH 1983, all existing statutes, ordinances, and rules are to be respected and are not superseded by this effort.

The State of Hawaii was assessed for geothermal resource potential and an estimate was made for each island and presented on a county-by-county basis as provided by Act 296, SLH 1983. The various studies were prepared using currently available public information. The existing information was examined and incorporated into technical reports, where applicable and relevant. This report represents a compilation of the various technical reports.

Department of Land and Natural Resources

ACKNOWLEDGEMENTS

The following organizations are acknowledged for their contribution toward the this proposal:

Puna Community Council
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Maui Electric Company, Ltd.
Barnwell Geothermal Corporation
Puna Geothermal Venture
True Geothermal Energy Company
Mid-Pacific Geothermal, Inc.
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Department of Planning & Economic Development
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Environmental Center, University of Hawaii
Hawaiian Volcano Observatory, USGS
U.S. Department of Energy
Planning Office, DLNR
Division of Land Management, DLNR
Division of State Parks, DLNR
Division of Forestry and Wildlife, DLNR
Division of Water and Land Development, DLNR

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Background

Act 296, SLH 1983, designated the Board of Land and Natural Resources with the responsibility for designating geothermal resource subzones in the State of Hawaii. The Chairperson assigned the subzone task to the Division of Water and Land Development and designated the office of the Deputy to the Chairperson to coordinate Departmental activities. The Division of Land Management was designated to provide assistance in the area of leasing of state geothermal resources and the Department's Planning Office was designated to assist in matters dealing with conservation land use districts. Other Divisions were asked to provide staff assistance as appropriate.

The Division of Water and Land Development began work soon after Governor Ariyoshi signed Act 296, SLH 1983, into law on June 14, 1983. A Plan of Study was completed outlining the designation strategy. The principle elements of this strategy included a literature review of available information, assessment of geothermal resources in the State, the identification of potential geothermal resource areas for electrical power generation, examination of impact analysis of social, economic, environmental, geologic hazard factors, and compatibility with land uses. Included in the designation process was a public information and participation effort by the Department's staff to obtain community concerns. Several public information meetings were held in the areas most likely to be affected by geothermal resource developments. A departmental target for completing the initial designation of geothermal resource subzones was set at December 1984.

The Legislature in mandating the subzone effort by the Department of Land and Natural Resources did not provide any financial and manpower resources. The shortcomings, however, was relieved by the State Department of Planning and Economic Development who provided funds to the Department for temporary hires and for necessary supporting services for the project. The Department sought and obtained the assistance of organizations including federal, state, and county agencies. The acknowledgments listed in other parts of this report list the many organizations and agencies who participated in this effort.

During the assessment process, the 1984 State Legislature enacted Act 151, SLH 1984, amending Act 296, SLH 1983. A significant amendment related to the grandfathering of two sites in Puna, Hawaii where existing exploration for geothermal resources has been underway since early 1981.

Conclusions

The assessment of Hawaii's geothermal resources involved the analysis of available scientific information. To initiate this activity the Department enlisted the help of a technical committee comprised of scientists in fields of geophysics, geochemistry, geology, engineering and hydrology. This committee conducted a county-by-county assessment of Hawaii's potential geothermal areas based on currently available geotechnical information. Twenty separate areas were identified and studied. Of these, seven areas were identified and mapped as having high temperature geothermal resources of 125 degree celsius or 257 degree fahrenheit at depths less than 3 kilometers or 9840 feet. Five areas are located on the island of Hawaii and two on Maui. Five other areas in the State were identified as having low temperature geothermal resources of less than 125 degree celsius. These areas are located on the islands of Hawaii, Maui and Oahu.

Examination of the seven areas relative to social, economic, environmental, geologic hazards, and compatibility with land uses reveal several impacts that may result from the exploration, development and production of geothermal resources for electrical power generation. Weighting of the assessment criteria was based upon an acceptable balance between the factors set forth in Act 296, SLH 1983.

Considered also in the evaluation of impacts was the provisions of Chapter 226, the Hawaii State Planning Act. The statutory objective, "increased energy self-sufficiency" and statutory policies "accelerate research development and use of new energy sources" and "promote the use of new energy sources" were considered. Additionally, the State Energy Plan developed as one of the Hawaii State Planning Act's twelve Functional Plans specifies the need to develop alternate energy resources, including direct solar energy; indirect solar energy such as wind, hydropower potentials, biomass, and ocean thermal differences; and geothermal energy.

After evaluating the seven potential geothermal resource areas on the basis of resource availability, prospects for utilization and examining the social, environmental, economic, geologic hazards, compatibility with land use, in addition to the statutory State energy objectives and policies, the following sites were determined as deserving consideration for designation as geothermal resource subzones by the Board of Land and Natural Resources:

Kilauea Lower East Rift, Hawaii
Kilauea Upper East Rift, Hawaii
Haleakala Southwest Rift, Maui

The above areas have the following common desirable elements for the exploration, development, and production of geothermal resource energy:

* potential for developing geothermal resources.
* interest in exploration, development and production of geothermal resource energy.
* commitment towards geothermal resource energy as a viable alternate energy source for Hawaii.
* advanced technology in geothermal resource development, such as emission control systems, noise control systems, well and power plant designs, and safety provisions from lava flows, reduces the concerns for public health and safety.
* potential degradation to the environment has been fully investigated and mitigation measures considered.

Recommendation

That the Board of Land and Natural Resources designate the Kilauea Lower East Rift, Island of Hawaii, Kilauea Upper East Rift, Island of Hawaii, and the Haleakala Southwest Rift, Island of Maui as geothermal resource subzones.

A description of the areas follows:

Kilauea Lower East Rift, Island of Hawaii

The area shown in Figures 1 and 2 identifies two separate sites--the Kapoho section and the Kamaili section. The probability of locating high temperature geothermal resources is estimated to be greater than 90 percent and the prospect for development and production of electrical energy is good. Relatively recent volcanic flows in the 1950's and 1960's indicate the availability of geothermal resources in the area. Active exploration and development currently underway also attest to the availability of geothermal resources.

The Kapoho Section, approximately 5939 acres lies adjacent to two subzones established by the Legislature in Act 151, SLH 1984. The extreme eastern end of the proposed Kapoho section is zoned as conservation due to relatively recent lava flows with the rest of the area zoned as agriculture. The northern boundary is buffered by a 2000-foot area where sensitive forest areas are located. The western end abuts Leilani Estates, a sparsely populated subdivision. The southern boundary generally follows the 90 percent resource probability line.

The area includes 279 acres of an existing Geothermal Resource Mining Lease R-4 issued to Puna Geothermal Venture.

The existing subzones are identified by Geothermal Resource Mining Lease R-2 issued by the Department of Land and Natural Resources for approximately 816 acres to Kapoho Land Partnership, subleased to Puna Geothermal Venture (Thermal Power Company, Dillingham, Inc. and Amfac) and Geothermal Resource Mining Lease R-3 issued to Barnwell Geothermal Corporation by the Department of Land and Natural Resources for approximately 769 acres. The two subzones are zoned agriculture by the State Land Use Commission.

The Kamaili Section comprised of 5519 acres, is entirely located in agricultural zoned lands. A Natural Area Reserve System (NARS) is located west of the area and Leilani Estates lie to the east. The 90 percent probability line is to the south. A 2000-foot buffer area has been provided to separate the NARS area from the proposed Kamaili Section. Also, the conservation district lands lying to the southeast having high quality native forest serve to buffer a portion of the proposed Kamaili area from Leilani Estates.

Kilauea Upper East Rift, Island of Hawaii

This area of approximately 5300 acres shown in Figure 3 has a 90 percent or greater probability of locating high temperature geothermal resources and the prospect of utilizing the resource is good.

Impacts expected to be encountered include the proximity to the Kilauea Volcanoes National Park to the west and the Natural Area Reserve System designation to the east. Additionally, the endangered bird O'u has been identified to habitat the area and high quality native forest are located north of the rift zone. Other impacts include scenic and aesthetic values, air quality, employment and housing needs.

Since early 1983, intermittent volcanic activity centered at Puu O has been taking place in the proposed subzone area. The location of geothermal wells and power plants should be carefully sited on older or recently cooled lava flows. When the current eruption activity has ceased, drilling and construction can take place at the risk of the developers.

The area includes the Board of Land and Natural Resources authorization for a Conservation District Use Application to the Estate of James Campbell for the exploration of geothermal resources.

In consideration of mitigating the significant impacts expected to be encountered, the proposed area provides for a 2000-foot buffer zone to both the Volcanoes National Park and the Wao Kele O Puna Natural Area Reserve. The proposed subzone area includes only a small portion of the natural forest and encroachment has been minimized to concentrate development activities towards the rift or volcanic flow areas. By limiting the range of the northern boundary, 75% of the potential resource area remains protected and maintained as high-quality native forest.

Other potential impacts may be mitigated by subsequent State and County permitting processes on a case-by-case basis.

Haleakala Southwest Rift, Island of Maui

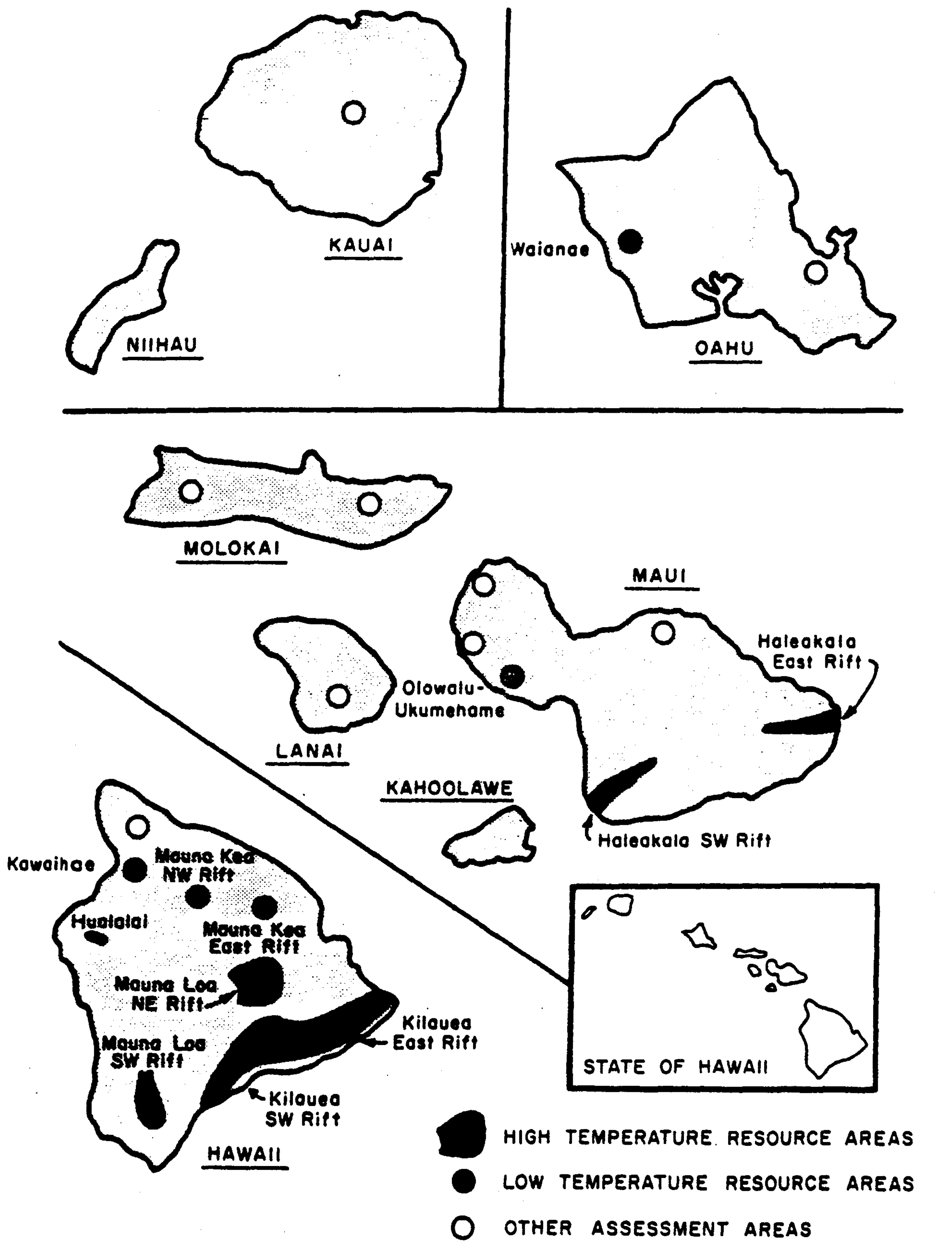
The area covering 4154 acres shown in Figure 4 has a 25 percent probability of locating geothermal resources. It appears to offer the best site on Maui and the prospect for utilizing the resources is good.

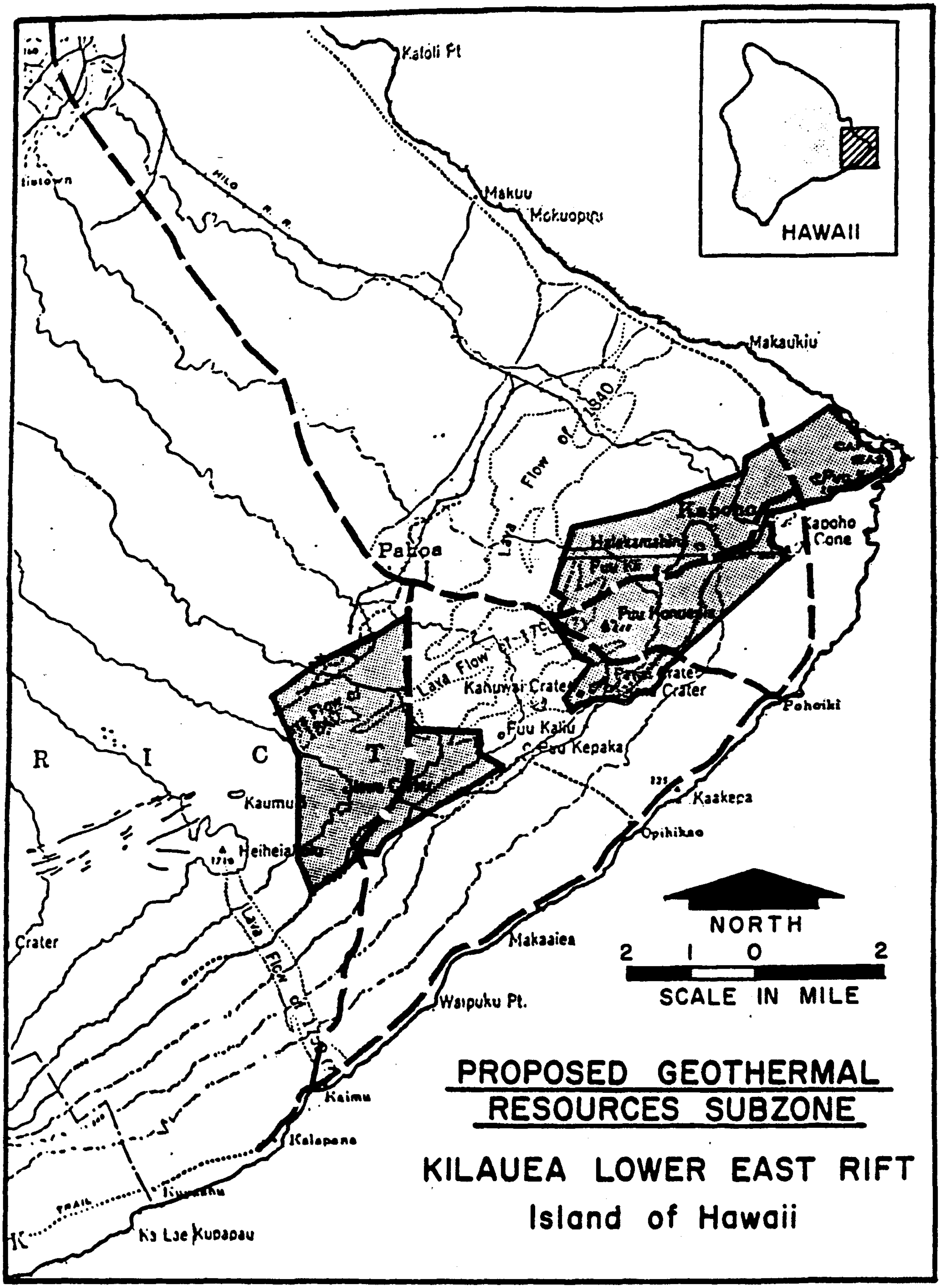
Impacts expected are to scenic and aesthetic values; including noise, lifestyle, culture and community setting, air quality, employment and housing needs.

These impacts may be mitigated through subsequent State and County permitting processes on a case-by-case basis.

Figure 1.

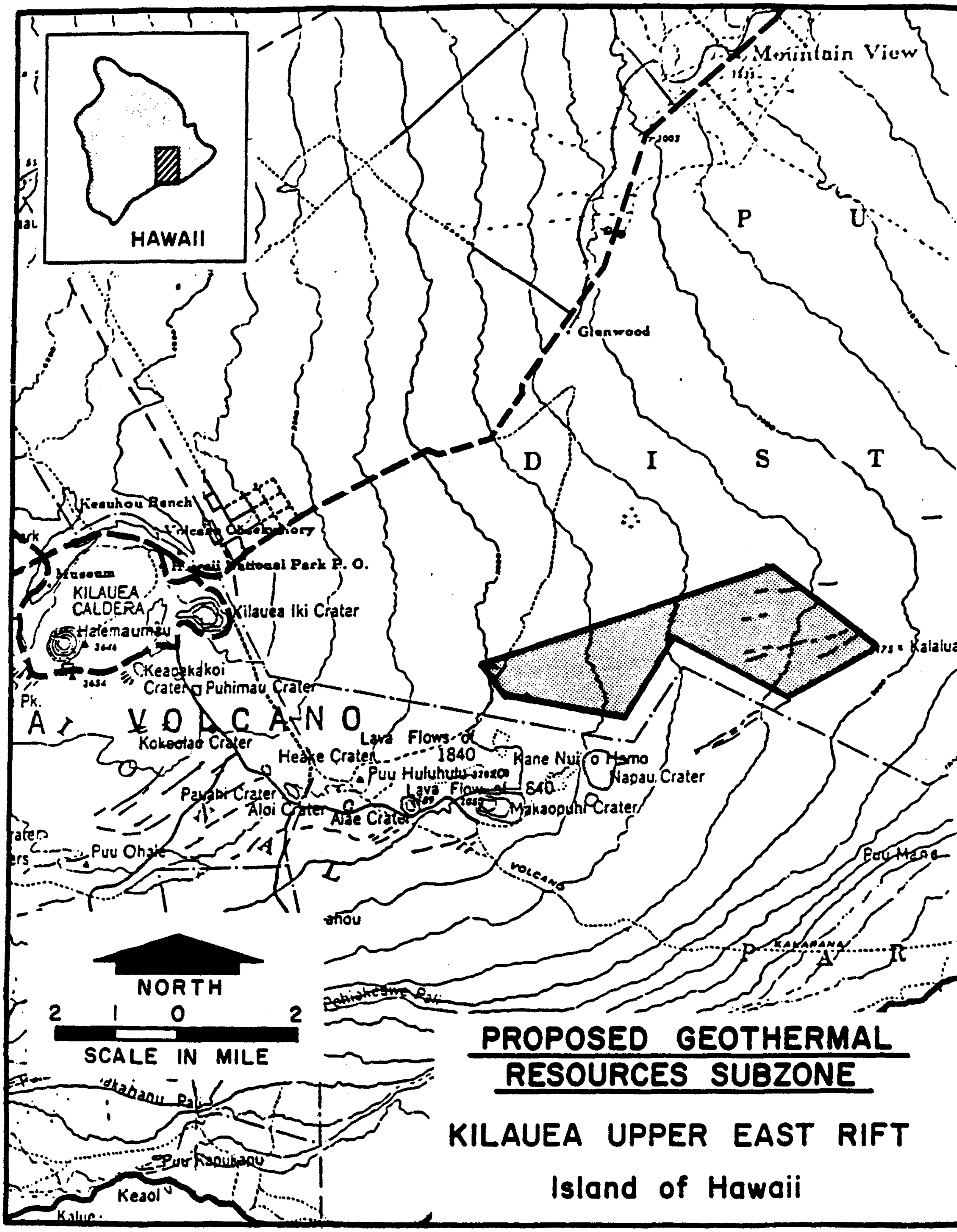
STATEWIDE ASSESSMENT OF GEOTHERMAL RESOURCES





HAWAII
NORTH
2 1 0 2
SCALE IN MILE
PROPOSED GEOTHERMAL RESOURCES SUBZONE
KILAUEA LOWER EAST RIFT
Island of Hawaii
Kaloli Pt
Makuu
Makaukiu
Kapoho Cone
Pahoa
Pohoiki
Fuu Kaliu
Kaakepa
Opihikao
Makaaiea
Waipuku Pt.
Kaimu
Kalapana
Crater
Kaumu

Figure 2.


HAWAII
Mountain View
Glenwood
P
U
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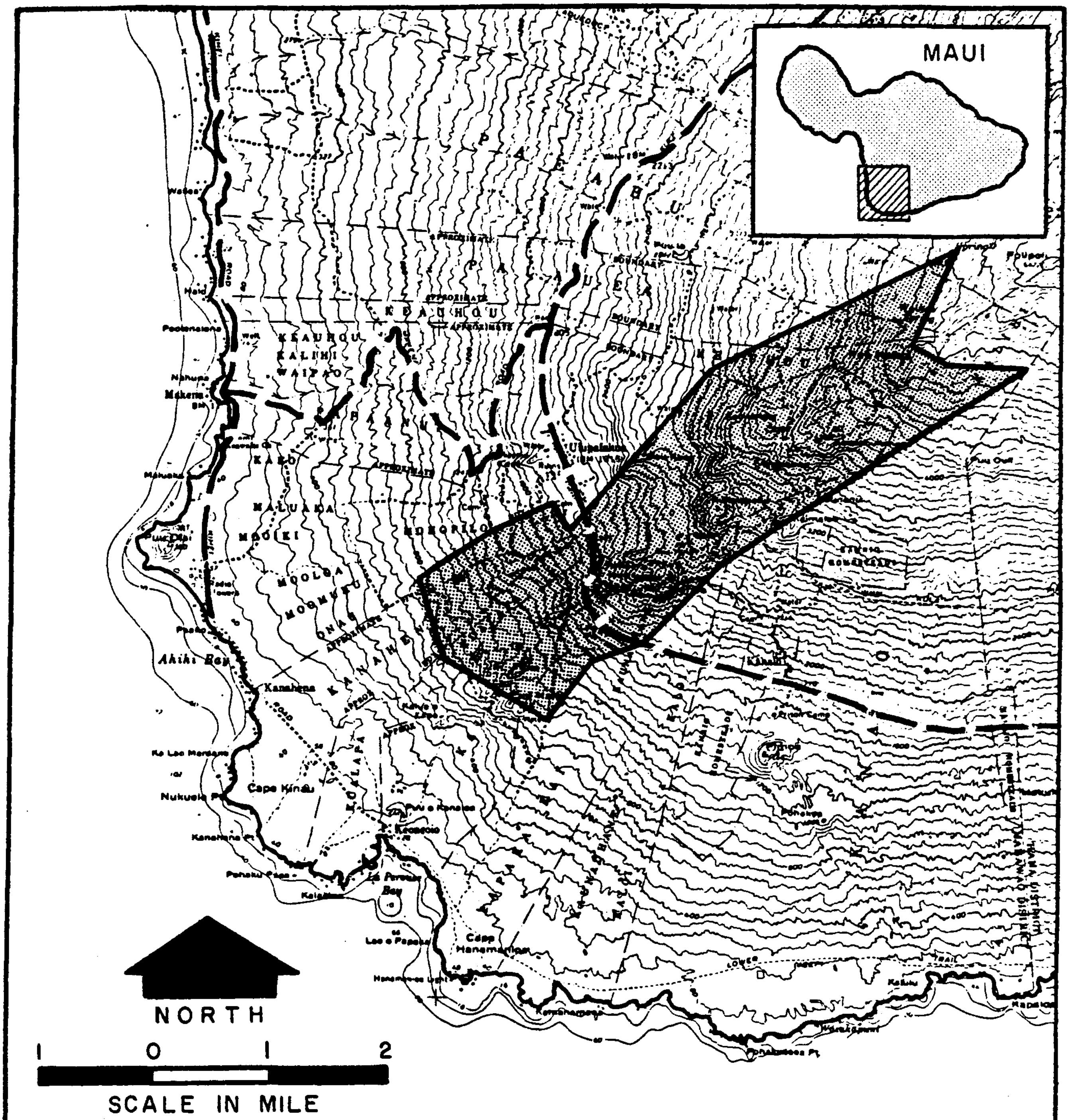
T
Keauhou Ranch
Volcano Observatory
Hawaii National Park P. O.
Museum
KILAUEA
CALDERA
Halemaumau
Kilauea Iki Crater
Keanakakoi
Crater
Puhimau Crater
VOLCANO
Kokoolao Crater
Lava Flows of
1840
Heake Crater
Puu Huluhulu
Kane Nui o Hamo
Napau Crater
Lava Flow of
840
Pauahi Crater
Aloi Crater
Alae Crater
Makaopuhi Crater
Puu Ohale
Kalalua
Puu Mane
NORTH
2 1 0 2
SCALE IN MILE
Puu Kapukapu
Keaol
PROPOSED GEOTHERMAL
RESOURCES SUBZONE
KILAUEA UPPER EAST RIFT
Island of Hawaii

Figure 3.



PROPOSED GEOTHERMAL RESOURCES SUBZONE

HALEAKALA SOUTHWEST RIFT

Island of Maui

Figure 4.

INTRODUCTION

Act 296, SLH 1983, relating to geothermal energy was signed into law on June 14, 1983 by Governor George R. Ariyoshi. The legislature found that the development and exploration of Hawaii's geothermal resources is of statewide concern, and that this interest must be balanced with interests in preserving Hawaii's unique social and natural environment. The purpose of this Act is to provide a policy that will assist in the location of geothermal resources development in areas of the lowest potential environmental impact.

The Board of Land and Natural Resources is charged with the responsibility of designating geothermal resource subzones in the State. Once the subzones are established, all geothermal development activities may be conducted only in these designated subzones. Pursuant to the provisions of HRS Chapter 205-5.2(a)-(c), this report was prepared to assess currently available information relating to the existence and the impacts of geothermal resources in Hawaii.

This report presents a county-by-county assessment of potential geothermal resource areas. The report is divided into the following sections: legal authority, statewide assessment of geothermal resources, geothermal technology, assessment factors, community concerns, evaluation of impacts on potential geothermal resource areas, conclusions on potential geothermal resource areas, and recommended subzones.

LEGAL AUTHORITY

Introduction

Act 296, SLH 1983, relating to geothermal energy, is the basis for this effort. This Act charges that the Board of Land and Natural Resources designate geothermal subzones. Section 3 of this Act requires the Board to "adopt, amend, or repeal rules related to its authority to designate and regulate the use of geothermal resource subzones in the manner provided under chapter 91." This mandate is provided for under Title 13, Chapter 184, "Designation and Regulation of Geothermal Resource Subzones" of the Department of Land and Natural Resources' Rules and Regulations. Finally, Act 151, SLH 1984, clarified various aspects of existing geothermal development activities within the State and the roles of State and County governments.

Act 296, Session Laws of Hawaii 1983

Act 296, SLH 1983, relating to geothermal energy was signed into law on June 14, 1983 by Governor George R. Ariyoshi.

The Board of Land and Natural Resources is charged with the responsibility of designating geothermal resource subzones in the State of Hawaii. Once subzones are established, all geothermal activities including the exploration, development, and production of electrical energy may be conducted only in the designated geothermal resource subzones.

Some of the highlights of Act 296, SLH 1983 include:

* Provides for the designation of Geothermal Resource Subzones in each of the four State land use districts--conservation, agriculture, urban, and rural.

* The Board of Land and Natural Resources is charged with the responsibility of designating geothermal resource subzones.

* The Board of Land and Natural Resources shall adopt administrative rules to designate geothermal resource subzones.

* The administration of the use of subzones for exploration, development, production and/or distribution of electrical energy shall be governed as follows:

    * BLNR for conservation districts.

    * Existing State and County laws for agriculture, urban, and rural districts.

* No Land Use Commission approval is necessary for the use of subzones.

* Provides for contested case hearing. Upon request, the hearing shall be conducted by the BLNR or County agency prior to the issuance of a geothermal resource permit.

* Any property owner may petition the BLNR to have an area designated as a geothermal resource subzone.

* An EIS is not required for the assessment of areas.

* The BLNR beginning in 1983 shall conduct a county-by-county assessment of potential geothermal resource development areas. The assessment shall be revised or updated at the discretion of the BLNR once every 5 years beginning in 1988.

Pursuant to the provisions of Act 296, SLH 1983, a county-by-county assessment of areas with geothermal potential for the purpose of designating geothermal subzones was made. This report addresses the various factors as given below:

1. The area's potential for the production of geothermal energy;

2. The prospects for the utilization of geothermal energy in the area;

3. The geologic hazards that potential geothermal projects would encounter;

4. Social and environmental impacts;

5. The compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;

6. The potential economic benefits to be derived from geothermal development and potential related industries; and

7. The compatibility of geothermal development and potential related industries with the uses permitted under sections 183-41 and 205-2, where the area falls within a conservation district.

In addition, the board shall consider, if applicable, objectives, policies and guidelines set forth in part I of chapter 205A, and the provisions of chapter 226.

<u>Title 13, Chapter 184</u>

In accordance with Chapters 91 and 205, Hawaii Revised Statutes, and Act 296, SLH 1983, public hearings on the "Proposed Rules for the Designation and Regulation of Geothermal Resource Subzones" were held on May 22, 1984, on all islands by the State Department of Land and Natural Resources.

These proposed rules, formally adopted on July 13, 1984, describe the procedure for initiating the designation of subzones, establishing criteria, providing for the modification and withdrawal of existing subzones, and providing for the regulation of geothermal resource subzones.

Act 151, Session Laws of Hawaii 1984

On May 25, 1984, Act 151, SLH 1984, was signed into law by Governor George R. Ariyoshi. This Act clarifies the rights of existing lessees holding geothermal mining leases issued by the State or geothermal developers holding exploratory and/or development permits from either the State or County governments. Act 151, SLH 1984, also clarifies the respective roles of the State and County governments in connection with the control of geothermal development within geothermal resource subzones.

Some of the highlights of Act 151, SLH 1984, include:

* Permits geothermal development activities within urban, rural, agricultural, and conservation land use districts.

* Defines geothermal development as "the exploration, development or production of electrical energy from geothermal resources."

* Existing leases within an agricultural district which were issued a special use permit by the County for geothermal development activities, is declared a geothermal resource subzone for the duration of the lease.

* Clarifies the governing jurisdiction of the State and County governments in the geothermal development approval process, and also exempts the permit process from special use permit procedures under section 205-6.

* Clarifies the issuing County agency by defining "appropriate county authority" as the "county planning commission unless some other agency or body is designated by ordinance of the county council."

* Further clarifies the roles of the State and County governments in connection with land use designations, as well as conduct of a permit approval process.

* Mandates that the county authority, in the absence of a mutually agreed upon extension, must provide a decision on a complete and properly filed application within 6 months.

STATEWIDE ASSESSMENT OF GEOTHERMAL RESOURCES

Basis of Assessment

A Geothermal Resource Technical Committee, selected by the Department of Land and Natural Resources on the basis of their specific expertise, examined each area's potential for the production of geothermal energy and the prospects for the utilization of geothermal energy in the area. Due to the complexity of Hawaii's geologic structure and the variable nature of ground-water hydrology and geochemistry, the committee did not rely on just one set of data or a single set of rules. The assessment of potential for each island was based on a qualitative interpretation of several regional surveys conducted in Hawaii during the last 15 to 20 years. It was further noted that the use of probability ranges was more appropriate in assessing geothermal resource, in that probabilities, would be more precise than other subjective wording. A map of the locations examined is provided at the end of this section.

The committee's assessment was based on the following types of geological, geophysical and geochemical data:

1. Groundwater temperature data. Near surface water having temperatures significantly above ambient, indicative of a possible nearby geothermal reservoir.

2. Geologic age. Recent eruptive activity and the evidence of surface features such as rift zones, calderas, vents and active fumaroles.

3. Geochemistry. Groundwater having geochemical anomalies related to the interaction between high temperature rock and water. Some of the indicators of thermally altered ground water are anomalously high silica(SiO_2), chloride(Cl), and magnesium(Mg) concentrations. In addition, the evidence

of above normal concentrations of trace and volatile elements such as mercury(Hg) and radon(Rn) may indicate leakage of geothermal fluids into nearby rock structures.

4. Resistivity. The electrical resistivity of the subsurface rock formation is affected by the salt content and temperature of ground water. Therefore, rocks saturated with warm saline ground water have lower resistivities than rocks saturated with colder ground water.

5. Infrared surveys. Infrared studies of land surface and coastal ocean water can identify thermal spring discharges and above ambient ground temperatures.

6. Seismic. Seismic monitoring of the frequency and clustering of earthquakes can identify earthquake concentrations that may be related to geothermal systems.

7. Magnetics. Aeromagnetic surveys have identified magnetic anomalies associated with buried rift zones and calderas. Also, rocks at high temperature or those that have been thermally altered have substantially lower magnetism than normal rock strata.

8. Gravity. Gravity surveys can provide information on the location of subsurface structural features such as dense intrusive bodies and dike zones.

9. Exploratory drilling. Data acquired from deep exploratory wells can confirm the existence of high temperatures and determine if there is adequate permeability necessary for development.

10. Self potential. Self potential anomalies (natural voltages at the earth's surface) have been found to be highly correlated with subsurface thermal anomalies along the Kilauea east rift.

Hawaii County

Upon evaluation of currently available geotechnical data, the Geothermal Resource Technical Committee identified nine locations on the Island of Hawaii and assigned a percent probability of finding low temperature (less than 125°C) resources and high temperature (greater than 125°C) resources at depths less than 3 kilometers. These locations and summary findings are as follows:

Location	Low Temperature	High Temperature
1. Kawaihae	45% or less	less than 10%
2. Hualalai	70% or less	35% or less
3. Mauna Loa Southwest Rift	60% or less	35% or less
4. Mauna Loa Northeast Rift	60% or less	35% or less
5. Kohala	less than 10%	less than 5%
6. Mauna Kea Northwest Rift	less than 50%	less than 20%
7. Mauna Kea East Rift	less than 30%	less than 10%
8. Kilauea Southwest Rift	greater than 90%	greater than 90%
9. Kilauea East Rift	greater than 90%	greater than 90%

Maui County

Within the County of Maui, six locations on the Island of Maui were identified, as well as the Islands of Molokai and Lanai. The Island of Maui has three potential geothermal resource areas. A summary of the locations within the County and the estimated percent probability of finding a low and high temperature resource is given below:

Location	Low Temperature	High Temperature
1. Olowalu-Ukumehame Canyon	75% or less	less than 15%
2. Lahaina-Kaanapali	less than 5%	less than 5%
3. Honolua	less than 5%	less than 5%
4. Haleakala Southwest Rift	35% or less	25% or less
5. Haleakala Northwest Rift	less than 10%	less than 5%
6. Haleakala East Rift	35% or less	25% or less
7. Molokai	less than 5%	less than 5%
8. Lanai	less than 5%	less than 5%

City and County of Honolulu

The Island of Oahu is made up of two major volcanic edifices: the Waianae shield and the Koolau shield. Both locations were determined to have a low probability of finding either a low or high temperature geothermal resource. The summary findings are provided as follows:

Location	Low Temperature	High Temperature
1. Waianae Volcano	15% or less	less than 5%
2. Koolau Volcano	less than 10%	less than 5%

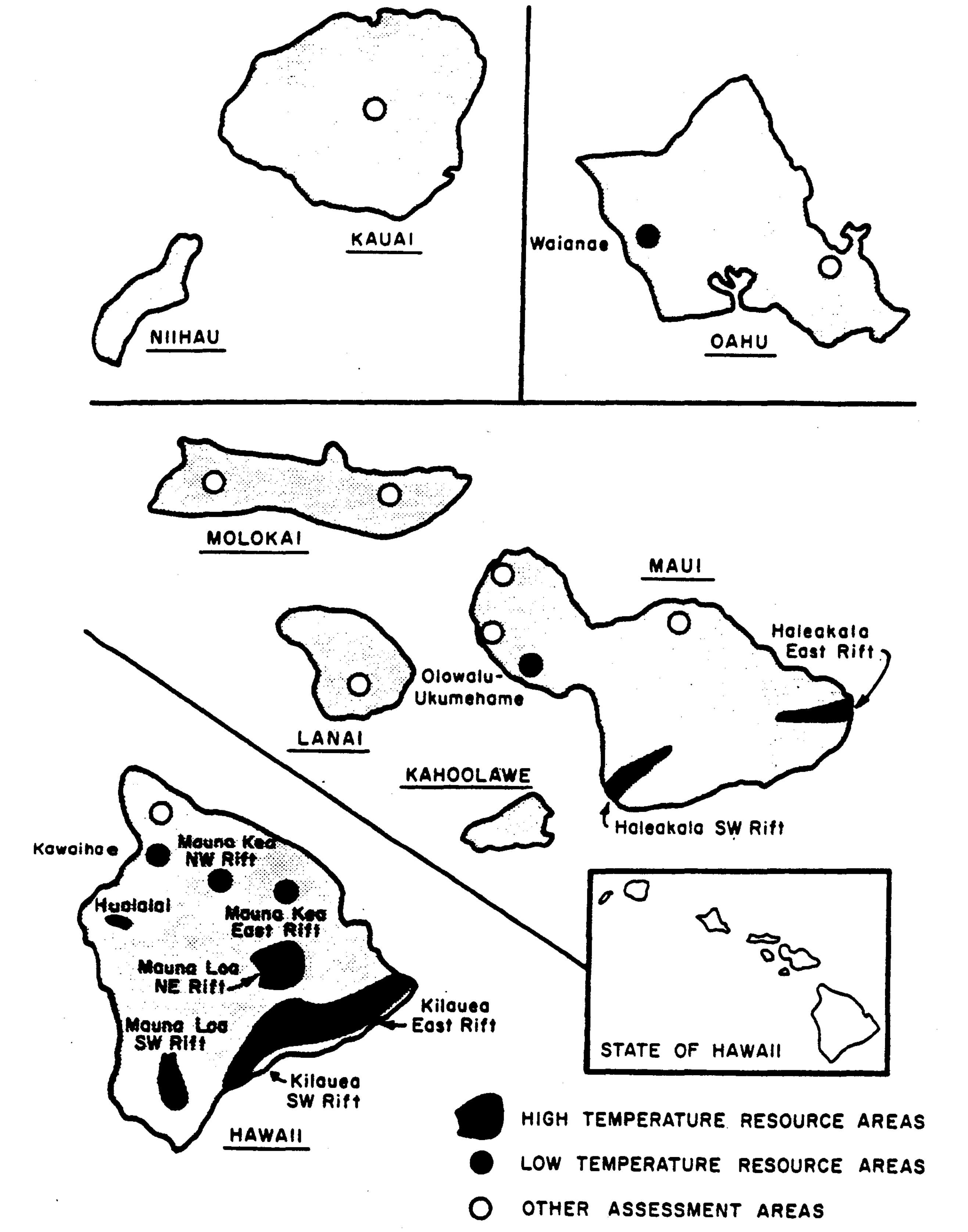
Kauai County

On the basis of currently available information, the geologically old age of Kauai's volcanic activity and the absence of any significant geothermal related anomalies, the probabilities for a geothermal resource are as follows:

Location	Low Temperature	High Temperature
Island of Kauai	less than 5%	less than 5%

Figure 5.

STATEWIDE ASSESSMENT OF GEOTHERMAL RESOURCES



GEOTHERMAL TECHNOLOGY

Geothermal Wells

Drilling Depth. In Hawaii, geothermal reservoirs are expected to occur 4,000-8,000 feet below sea level. The rotary drilling rigs likely to be used in Hawaii are rated for drilling to a maximum depth of about 16,000 feet. Some mainland oil-rigs can drill to 22,000 feet but are not considered economical when applied to geothermal development in Hawaii.

Directional Drilling. A geothermal rig can drill a hole perpendicular to the ground surface or directional holes to almost any desired angle from ground surface. A moderate curve in the drill route can also be achieved. Directional drilling can reduce both environmental and economic costs by allowing multiple holes to be drilled from one drill site. However the most economic and shortest route for a drill hole is usually straight and perpendicular to the surface.

Drill Hole Casing. The typical drilled hole has a 26 inch diameter for the first 250 feet, tapering to an eight inch diameter bottom hole in the production zone. The usual casing program includes a conductor pipe (surface to 250 feet), surface casing (surface to 2500 feet), intermediate casing hung from the end of the surface casing (2500 to 4000-6000 feet), and possibly a production liner hung from the end of the intermediate casing to the bottom. All joints should be cemented and joined to ensure casing integrity into the production zone. Available well control techniques and blow-out prevention equipment can substantially reduce the risk of well blow-outs.

Drill Site Surface Area. A 2/1 ratio of good to bad wells is expected in a proven resource area. Once a successful well is drilled, six closely spaced wells (four expected successful) may be drilled within a radius of 2000 feet of the drill site. Two acres of land would be cleared for an exploratory hole. Approximately five acres of land would be cleared on a proven drill site. Four successful wells (three and spare) may be needed for a 12.5 megawatt (MW) plant. Generation capacity can vary from three to ten MW per well depending on the output rate and type (water or vapor dominated) of geothermal resource. The HGP-A test well is producing about three MW; however commercial wells are expected to have a larger capacity. Unsuccessful or expended wells would be abandoned unless used for injection of geothermal effluent.

Drilling Emissions and Effluents. Depending on geologic structure and capability of drilling equipment, either "drilling mud" or air will be used to remove cuttings and lubricate the drill bit. Drilling activities may use 2000 barrels of water per day per well. The mud and cuttings are disposed of at a drill site sump but can be removed to an approved disposal site if required. In the production zones, air drilling (instead of mud) may be used to avoid reduction of permeability in the production zone. While in the production zone, the return-air will contain cuttings and geothermal gases (most significant being H_2S). A caustic soda (NaOH) injection system and cyclone muffler can be used to abate hydrogen sulfide (H_2S), particulates, and noise during drilling. After completing the well, four to eight hours of unabated venting may be required to clear the hole of rock debris. Completed wells will be subjected to flow testing to determine reservoir characteristics. Emissions must meet Department of Health (DOH) standards. If the well is water dominated, a flash separator may be used at the well site to return brine to either a nearby percolation pond or re-injection well.

Injection Wells. One injection well may be needed for the three active wells which may be required to fuel a 12.5 MW plant. The number of injection wells will vary depending on the permeability of the injection well and the quantity of brine flowing from the production wells. The initial injection wells (specifically drilled for injection) are likely to be close to the power plant to limit brine piping distance. Non-producing or expended production holes may also be used for injection. Geothermal effluents will be injected into a geothermal aquifer having similar characteristics. Drill casing intergrity through overlying fresh water aquifers is essential if usable water supplies are to be protected. Injection wells are subject to standards and regulations of the State Department of Land and Natural Resources and Department of Health.

Steam Piping

The steam piping from well-head to plant is likely to be 16 to 22 inch diameter carbon-steel pipes. Piping may be placed four to six feet above ground-level on "saddles" which may be fortified to accomodate pahoehoe lava flows. Alternatively, piping may be buried for safety and aesthetics. The piping will have expansion joints which will allow for thermal expansion and some ground movement. Surface area needed for a pipeline corridor is discussed in the section titled "Roads".

Geothermal Power Plants

Operation. Before a plant becomes operational the Department of Health must issue permits regarding the quality of the air and fluids discharged from the plant. Components of this system are described below.

The characteristics of the geothermal fluid may vary from site to site. It may be liquid or vapor dominated. A vapor dominated system provides more steam for power generation per hole while reducing the amount of brine which must be injected back into the ground. HGP-A is a water dominated system. Kapoho wells #1 and #2 have been reported to be vapor dominated.

As the geothermal fluid enters the power plant the steam and brine components are separated in the "separator". Various heavy metal concentrations such as arsenic, lead, and mercury are very low (based on HGP-A data) and should remain in the brine that is eventually re-injected. The steam phase leaving the seperator consists of primarily water vapor and noncondensable gases. The two most significant noncondensable gases at HGP-A are H_2S and Radon 222.

As described below, the level of H_2S can be almost completely abated. Outdoor concentration levels of emitted radon, if properly abated by dilution in the cooling tower, are lower than most indoor levels; since cement emits some radon in most buildings. Again, the composition of fluids and gases are likely to vary within each reservoir.

The steam phase from the separator enters the turbine, turns the rotors, and exhausts into the condenser. Electricity is produced as the turbine spins the generator. The steam flow and resultant turbine-rotor turning is enhanced by the vacuum created in the condenser as the steam is condensed into liquid. This liquid (condensate) returns with the warm condenser cooling water to the cooling tower where it is cooled by evaporation. The size of the steam plume will vary with the size and efficiency of the plant and the ambient weather characteristics.

Emission Abatement. The gas phase which exits the condenser consists primarily of the same noncondensable components which left the seperator, most notably H_2S. An abatement system is utilized at this point to reduce the H_2S content to an acceptable level. A report recently prepared for the U.S. Environmental Protection Agency, Evaluation of BACT for and Air Quality Impact of Potential Geothermal Development in Hawaii, analyzes most available H_2S abatement systems. These include the iron catalyst primary system; the iron catalyst secondary system; the hydrogen peroxide, caustic, iron catalyst (HPCC) primary system; burner-scrubber system; and the Stretford system. The report recommends the Stretford system as the primary on-line abatement system. This system can remove over 99% of the H_2S contained in the noncondensable gases. By-products of the Stretford system include marketable elemental sulfur and sludge which requires disposal.

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 or emergency. If maintenance is required on either the turbine or generator, the geothermal steam can be routed directly into the condenser utilizing the primary abatement systems. Since the turbine does not dissipate any heat or energy in the bypass mode, the cooling system must be over-designed to accomodate the extra heat during "turbine bypass". If the primary abatement system is not operational, a secondary abatement system such as NaOH (caustic soda) scubbing can be used in combination with a rock muffler to achieve 92-95% H_2S removal. In emergencies, well throtting may be accomplished by manual valve turndown or automatic valve control. Throtting must be slow (at least 15 minutes) and can reduce flow to a fraction of the well's maximum flow rate. The degree of throtting possible will depend upon the characteristics of each well. However, there is a danger that the additional stress with increased pressure could damage the well-bore, casing, or well-head equipment. If a geothermal developement has more than one power plant, the wells could be moderately throtted and diverted to an operating plant. If all the above contingency abatement options are not available, a geothermal well may have to be free vented through a silencer without H_2S abatement until such time as the well can be shut-in completely.

The abated gases, condensate, and warm water are circulated through the cooling tower. Cooled water from the cooling tower is recirculated through the condenser; any excess water (blowdown) is piped to an injection well. It is expected that a wet, mechanical draft, cooling tower will be applied to geothermal development. Warm water enters the tower near the top, while a fan forces air through slats designed to maximize the surface area of the falling warm water. Use of drift eliminators significantly reduces the chance that any water droplets will exit with the steam plume. This falling water also scrubs any particulates from the gas exiting the abatement system. At "The Geysers" geothermal development in California, small amounts of boron from the condensate has been emitted with cooling tower drift (small water droplets entrained in the the steam plume) having some adverse effects on nearby vegetation. Based on the characteristics of the HGP-A reservoir fluids and the emission abatement which will be required by the DOH, cooling tower emissions from Hawaii's geothermal resources should not be toxic to flora and fauna in the vicinity of the geothermal power plant. Data available from the HGP-A indicates that the plume from the cooling tower should consist entirely of water vapor. The proposed DOH regulations require 98% H_2S abatement and a concentration of no greater than 25 parts per billion H_2S at the property line of a development.

In addition to cooling tower blowdown, brine leaving the seperator will be piped into the injection well. If the rate of silica deposition in the brine is high, a silica-dropout system will be utilized between the steam-brine seperator and the injection well. Otherwise, silica deposition within the injection well might cause it to become plugged. The silica deposits will be removed periodically and disposed of in an acceptable manner.

Plant Site Surface Area. The surface area required for a power plant varies with its megawatt output. By using 12.5 or 55 MW power plant units in tandem, a 25 MW or 110 MW facility can be constructed without increasing the land area of the plant site significantly. Generally, a 12.5 or 25 MW plant will have structure dimensions of 90 feet x 40 feet x 54 feet high (per 12.5 MW unit) sited on a surface area of about 7 acres. A 55 or 110 MW plant will have structure dimensions of 350 feet x 80 feet x 75 feet high (per 55 MW unit) sited on a surface area of about 15 acres.

Roads

Roads must be constructed to accomodate geothermal exploration, development, and production activities. Their placement should avoid volcanic hazards as much as possible. The extent of road building activities at a particular location will be influenced by the existing road infrastructure. Road designs must be submitted to the counties for construction permit approval. Approximate road dimensions are given below:

	Width (ft.)	Height (ft.)	Description
Initial access	20	--	One lane with shoulders.
Main access with transmission lines	78	76*	Two lanes, shoulders, & transmission lines on both sides
Well field road	30	4-6**	One lane, shoulders, dual pipeline corridor on one side

*Electric transmission line poles.
**Steam piping height.

Electric Transmission Lines

Construction of a new transmission line corridor is required to connect the geothermal power plant to the existing power grid. Considering the existing power grid on the island of Hawaii, it appears that the need for new power line corridors will be minimal. However existing lines may need to be upgraded. A 69 kilovolt power line is about 70 feet high and requires a cleared corridor about 70 feet wide. A 138 kilovolt power line is about 80 feet high which requires a corridor of about 80 feet. Dual lines will be used to assure reliability.

Noise Levels and Abatement

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. High noise levels are produced during well drilling, production testing, and bleeding before connection to the generator. 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. While most operations can be effectively muffled by acoustical baffling and rock mufflers, some emit unavoidable noise. The above noise levels apply to the immediate vicinity within 100 feet of the source.

The County of Hawaii geothermal noise level guidelines state that a general noise level of 55 decibels during the daytime and 45 decibels at night may not be exceeded at existing residential receptors which might be impacted.

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. Construction of a rock muffler at the facility has reduced noise levels to about 44 decibels at the fence line of the project. Noise will vary with weather conditions and topography. Technology exists which should abate noise to acceptable levels.

Hazard Mitigation Plans.

Various methods which could be used to mitigate dangers from geologic hazards are listed below. No attempt is made to prioritize methods since priorities may differ with the risks at each specific site. A survey should be conducted at each development site to closely examine topography and structural integrity of the surface and sub-surface areas.

- o Keep the power plant as far outside the rift zone as is possible since volcanic activity is concentrated there, e.g. lava flows, lava tubes, cracking, subsidence, pit craters, grabens, swelling. The piping distance from the well field to the power plant is limited due to increased thermal losses with distance, for example, the Kahauale'a site development map shows a maximum distance of about 2½ miles from its farthest well to a power plant.
- o Power plants and wells should be constructed on the highest ground available. Even a very small hill or ridge could offer considerable protection from lava flows. Channels and valleys should be avoided, even if upslope, as lava flows tend to be channeled into and be deepest in these relatively low areas.

- If a sufficiently large hill is not available, a plant or well could be protected by constructing an earth-and-rock platform several meters high. Depending on the perceived risk from flow hazard, wells or plants can be sufficiently fortified to withstand almost any lava flow. A cost/risk analysis would have to be made.
- Another well-protection alternative is to enclose the well-head in a concrete cellar allowing the lava to flow above rather than around the well-head. Recovering a well covered with a thick flow could be quite arduous and time consuming. The precise effect the lava's heat would have on the well-head mechanisms is not known.
- To complement the platform, a berm or wall could be constructed to divert lava flows. The embankment should be several meters high around the upslope and cross-slope sides of the structure.
- Available information indicates that the northern flank of Kilauea's rift zones are safer than the southern. For example, ground movements are more frequent on the Kilauea east rift zone's southern flank. The vast majority of erupted lava on Kilauea's rift zones has flowed over the southern slopes.
- A geologic survey may identify near-surface lava tubes which could collapse under construction.
- Power plants should be modular and somewhat portable so that, if all fortifications fail, units might be salvaged and reused. This tends to encourage use of smaller decentralized plants.
- Steam transmission piping may be protected from a thin, fluid pahoehoe flow by installing downslope support structures. Thick aa flows would probably disrupt surface piping. Underground piping may offer more protection but installation and maintenance would be quite costly.
- Comprehensive evacuation plans should be designed to assure worker safety. Warning time prior to inundation can be as little as one hour. Procedures should be established to protect equipment. Multiple access roads should be provided in the event one gets covered by a flow.
- The development should coordinate contingency planning with government field geologists (e.g. Hawaiian Volcano Observatory)

and local civil defense authorities to ascertain when an eruption appears imminent and what subsequent action should be taken. Escape and abandonment procedures may be flexible but should be predetermined and clear. The developers have been giving this area much consideration.

- o If a lava flow is impending during well drilling, the well can be fitted with a pressure and temperature resistant "bridge plug" to safely isolate and protect the lower, resource-bearing portion of the well. These plugs can be installed in one hour.
- o Trip wires, placed in the expected path of a lava flow, can alert development personnel as to the distance and speed of the oncoming flow. The crew can then take appropriate action in accord with their preexisting evacuation plan.
- o Protecting structures or machinery against damage by pyroclastic fallout might be achieved by enclosing those parts vulnerable to abrasion or contamination. Building roofs should be strong, having a sufficient pitch so that pyroclastic fallout does not accumulate. Access to roofs should be easy so that, if necessary, they can be manually kept cleared of pyroclastic material.
- o Plant generators can be specifically designed to be adjustable to some ground surface tilting or subsidence.
- o Steam transmission piping can be made with expansion joints to accommodate appreciable subsidence and ground movements.
- o Plants should be constructed to withstand an earthquake of 7.5 magnitude.
- o Power plants should not be constructed in coastal regions, if risk from tsunami is to be avoided.
- o In extraordinary situations, bombing a lava channel may cut the feed to a flow-front and prevent or slow further advance of the lava flow.
- o If warranted by volcanic risk, adequate spacing between developments should be maintained so that one eruption would not likely endanger more than one development. It is a common utility practice to maintain reserves sufficient to prevent a major blackout. Reserve requirements and associated costs may be limited by using small decentralized power plants rather than one large plant.

- If geothermal development investors assume all of the economic risk of loss resulting from geologic hazards, then developers would have a clear economic incentive to utilize appropriate mitigation measures and to select sites which offer the optimum balance of safety and productivity.
- It is generally assumed that the resource developers will bear the risks of loss associated with their activities. However, if the utility owns the power plant, there may be some question as to whether the investors or the rate-payers will bear the risks of loss. This assumption of risk would be reflected in the cost of electricity from geothermal plants. It may be better that this cost be apparent "up front" rather than be delayed and possibly deferred to rate-payers in the event of a catastrophe. In the past, there have been some instances where hazard losses were recovered by the utility from rate revenues (e.g. Hilo tsunami of 1960). Policy regarding assigning and clarifying risks of loss may be implemented by imposing conditions to be met by development investors prior to the granting of a CDUA permit by the State (conservation district) or geothermal resource permit by the County (urban, rural, or agriculture districts).

ASSESSMENT FACTORS

Pursuant to Act 296, SLH 1983, and Act 151, SLH 1984, each of the potential geothermal subzones was examined to determine whether any significant impacts would occur if geothermal development activity would take place. The factors examined included social impacts, economic impacts, environmental impacts, geologic hazards, and compatibility of development with land uses. In addition, the objectives and policies of the Hawaii State Planning Act, Chapter 226, HRS, relating to energy generally and geothermal resources specifically were also examined. This assessment was based on currently available information. This chapter describes the various assessment factors, which were considered in evaluating its significance for designating geothermal resource subzones.

Hawaii State Planning Act

Act 296 specifies that the Board of Land and Natural Resources shall consider the provisions of Chapter 226, the Hawaii State Planning Act. Several provisions of Chapter 226 applies to energy, generally, and with geothermal resources in particular. Excerpts from the Act are presented to serve as a guide for implemention of legislative overall theme, goals, objectives, and policies.

> "Overall theme. Hawaii's people, as both individuals and groups, generally accept and live by a number of principles or values which are an integral part of society. This concept is the unifying theme of the state plan. The following principles or values are established as the overall theme of the Hawaii state plan:
>
> (1) Individual and family self-sufficiency refers to the rights of people to maintain as much self-reliance as possible. It is an expression of the value of independence, in other words, being able to freely pursue personal interests and goals. Self-sufficiency means that individuals and families can express and maintain their own self-interest so long as that self-interest does not adversely affect the general welfare. Individual freedom and individual achievement are possible only by reason of other people in society, the institutions, arrangements and customs that they maintain, and the rights and responsibilities that they sanction.
>
> (2) Social and economic mobility refers to the right of individuals to choose and to have the opportunities for choice available to them. It is a corollary to self-sufficiency. Social and economic mobility means that opportunities and incentives are available for people to seek out their own levels of social and economic fulfillment.
>
> (3) Community or social well-being is a value that encompasses many things. In essence, it refers to healthy social, economic, and physical environments that benefit the community as a whole. A sense of social responsibility, of caring for others and for the well-being of our community and of participating in social and political life, are important aspects of this

concept. It further implies the aloha spirit--attitudes of tolerance, respect, cooperation and unselfish giving, within which Hawaii's society can progress.

"One of the basic functions of our society is to enhance the ability of individuals and groups to pursue their goals freely, to satisfy basic needs and to secure desired socio-economic levels. The elements of choice and mobility within society's legal framework are fundamental rights. Society's role is to encourage conditions within which individuals and groups can approach their desired levels of self-reliance and self-determination. This enables people to gain confidence and self-esteem; citizens contribute more when they possess such qualities in a free and open society.

"Government promotes citizen freedom, self-reliance, self-determination, social and civic responsibility and goals achievement by keeping order, by increasing cooperation among many diverse individuals and groups, and by fostering social and civic responsibilities that affect the general welfare. The greater the number and activities of individuals and groups, the more complex government's role becomes. The function of government, however, is to assist citizens in attaining their goals. Government provides for meaningful participation by the people in decision-making and for effective access to authority as well as an equitable sharing of benefits. Citizens have a responsibility to work with their government to contribute to society's improvement. They must also conduct their activities within an agreed-upon legal system that protects human rights.

"State goals. In order to guarantee those elements of choice and mobility that insure that individuals and groups may approach their desired levels of self-reliance and self-determination, it shall be the goal of the State to achieve:

(1) A strong, viable economy, characterized by stability, diversity, and growth, that enables the fulfillment of the needs and expectations of Hawaii's present and future generations.

(2) A desired physical environment, characterized by beauty, cleanliness, quiet, stable natural systems, and uniqueness, that enhances the mental and physical well-being of the people.

(3) Physical, social, and economic well-being, for individuals and families in Hawaii, that nourishes a sense of community responsibility, of caring and of participation in community life.

"Objectives and policies for facility systems--energy/utilities.

(a) Planning for the State's facility systems with regard to energy/utilities shall be directed towards the achievement of the following objectives:

(1) Dependable, efficient, and economical statewide energy and communication systems capable of supporting the needs of the people.

(2) Increased energy self-sufficiency.

(b) To achieve the energy/utilities objectives, it shall be the policy of this State to:

(1) Accelerate research development and use of new energy sources.

(2) Provide adequate, reasonably priced, and dependable power and communication services to accommodate demand.

(3) Ensure a sufficient supply of energy to enable power systems to support the demands of growth.

(4) Promote prudent use of power and fuel supplies through education, conservation, and energy-efficient practices.

(5) Ensure that the development or expansion of power systems and sources adequately consider environmental, public health, and safety concerns, and resource limitations.

(6) Promote the use of new energy sources.

(7) Facilitate the development and use of improved communications technology."

Chapter 226 also establishes an overall priority direction and implementing actions to address areas of statewide concern. Priority actions for energy use and development specified include:

(1) Encourage the development of alternate energy sources.

(2) Encourage development of a program to promote conservation of energy use in the State.

(3) Encourage future urbanization into easily serviceable, more compact, concentrated developments in existing

urban areas wherever feasible to maximize energy conservation.

(4) Encourage consumer education programs to reduce energy waste and to increase awareness for the need to conserve energy.

(5) Encourage the use of energy conserving technology and appliances in homes and other buildings.

(6) Explore possible incentives to encourage the use of alternate energy sources in homes and other buildings.

(7) Encourage the development and use of energy and cost-effieint transportation systems.

The Hawaii State Planning Act also provides for the formulation of Functional Plans in twelve functional areas of services provided by the State government. One such area specified is in the functional area of energy. The State Department of Planning and Economic Development was identified to prepare the Energy Functional Plan. The Act provides that the functional plan shall contain objectives to be achieved and policies to be pursued in the primary field of activity and such policies shall address major programs and the location of major facilities, and shall also contain implementation priorities and actions which may include, but not be limited to, programs, maps, regulatory measures, standards, and interagency coordination provisions.

The following implementing actions relating to geothermal energy are excerpted from the State Energy Functional Plan.

ALTERNATE ENERGY RESOURCE DEVELOPMENT

"B. OBJECTIVE: Accelerate the Transition to an Indigenous Renewable Energy Economy by Facilitating Private Sector Activities to Explore Supply Options and Achieve Local Commercialization and Application of Appropriate Alternate Energy Technologies.

"Hawaii's near-total dependence on imported petroleum, spiraling oil prices, the net outflow of dollars for oil payments, and the political unrest of major oil-producing nations threaten local economic stability and the ability to serve energy needs over time. Support and assistance for private sector activities to develop local energy resources will reduce dependence on the world oil market, improve the State's balance of payments, and thus promote economic development, and increase the number and diversity of employment opportunities.

B(1). POLICY: Investigate and alleviate non-technical (legal/institutional/economic/financial) barriers to alternate energy resource development.

B(1)(g). IMPLEMENTING ACTION: GEOTHERMAL ENERGY - Support continued implementation of the State Geothermal Commercialization Program to address and mitigate legal and institutional concerns.

Lead Organization(s): DPED
Assisting Organization(s): DLNR; Hawaii County Planning Dept.
Time Frame: Ongoing
Comments: This program was previously Federally-funded. State support will be needed for program continuation. See action E(1)(a) for additional program components. Recommended near-term activities include: (1) legal clarification of the ownership of geothermal resources; (2) assessment of the desirability of establishing a State of Hawaii geothermal resource area (GRA) in Puna to identify the most probable and acceptable area for future geothermal development; and (3) coordination with appropriate State and County agencies to investigate regulatory and land use permit streamlining for geothermal development.

B(2). POLICY: Facilitate research, development and demonstration activities designed to resolve remaining technical barriers to alternate energy technologies in order to expedite local commercialization.

B(2)(a). IMPLEMENTING ACTION: Continue statewide alternate energy resource assessment studies as appropriate to supplement private sector investigations.

Lead Organization(s): UH: C&C DPW: Hawaii R&D; Kauai OED; Maui Mayor's Office
Assisting Organization(s): DPED; HNEI
Time Frame: On going
Comments: High priority is given to the completion of resource assessments for geothermal energy on Hawaii and Maui; and for wind and insolation throughout the State to develop a data

base for small-scale, dispersed installations. Further assessment of ocean thermal energy resources along Leeward Oahu may also be necessary.

B(2)(g). IMPLEMENTING ACTION: GEOTHERMAL ENERGY - Continue geothermal research activities as appropriate to support commercialization efforts.

Lead Organization(s): UH
Assisting Organization(s): HGP-A Development Group
Time Frame: Ongoing
Comments: Continued funding is recommended for the following activities: (1) Kapoho reservoir synthesis; (2) electric and seismic properties of rock systems; (3) corrosion studies; and (4) non-electric applications research."

Social Impacts

Health Aspects. The health aspects of geothermal resource development involve primarily the effects of chemical, particulate, and trace element emissions on the physical environment and on residents in the vicinity. Hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) are the major gaseous compounds concerned, but the naturally existing or ambient air of the volcanic regions also contains these compounds. This section deals with the concerns, perceptions and attitudes of the residents regarding the health aspects of geothermal emissions.

Two community-wide survey studies produced information relating to perceptions and concerns about the effects of geothermal development on elements of physical environment such as air quality. The first was done by a community association in Puna, the Puna Hui Ohana. In this survey, 351 Hawaiian residents in the Puna area were interviewed. The results were prepared in a report, Assessment of Geothermal Development Impact on Aboriginal Hawaiians, published in February, 1982. In response to the question of "What kind of change would geothermal development bring about on the physical environment (noise, air quality, visual environment) of Puna?" Out of the 253 responses, 56 said it was "slightly bad" and 114 said it was "very bad".

The second survey study was conducted for the State Department of Planning and Economic Development and the Hawaii County Department of Planning, by SMS Survey, Inc. The Puna Community Survey, completed in April, 1982, interviewed 778 residents in the Puna area. The study reported only one-fifth of the total survey respondents as mentioning that they felt that they had been affected by the geothermal wells in Puna. Of those indicating they were affected, the negative effects mentioned were "health problems" and "smell".

In addition to these two major survey studies, other inputs made by community associations and other organizations and individuals regarding the HGP-A well and the Kahauale'a Conservation District Use Application are available.

A study is presently being conducted by the Hawaii State Department of Health, on the health status of the Puna population exposed to low levels of hydrogen sulfide and other geothermal effluents. This study surveyed some 135 households in the Leilani Estates representing 350 people and a "control" group of 179 households in the Hawaiian Beaches Estates, representing 604 people, the control population being similar in demographic characteristics to but not having the exposure to geothermal emissions as the Leilani Estates population. A series of close to thirty questions were asked concerning health backgrounds and conditions and problems. Survey data are being processed and analysed and the results are expected by late 1984.

Noise Aspects. 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 to be controlled and monitored. In terms of people's perceptions of and concerns with the noise factor, the SMS Puna Community Survey reported that of the 18% who responded "yes" to the question of whether they or their households had been affected by the wells in Puna in any way, 22% mentioned they were affected by "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 and state-wide, based on lower existing ambient noise levels for the Island of Hawaii.

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 concern in terms of the effects of any introduced changes, especially when the changes may be in the direction of industrial development in a relatively rural setting. The Puna area has the most information and the input to-date on these aspects in relation to geothermal development may for the time being be applicable to an extent to other localities. 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.

Much about the cultural background, beliefs, practices, and lifestyles of the Hawaiian residents in Puna were reported and discussed in the survey by the Puna Hui Ohana's, Assessment of Geothermal Development Impact on Aboriginal Hawaiians. On attitudes towards the effects of geothermal development, the survey reported "A large number of impacts were perceived as negative by the respondents; and only one, economic impact, was reported to be clearly positive. Yet the question asking about the 'overall' impact of geothermal development in Puna produced responses averaging in the "neither good nor bad" middle ground. There seems to be a balancing of the potential economic benefits of geothermal development with the environmental and social costs of development".

In the SMS study, The Puna Community Survey, respondents asked to name the best things about life in Puna today cited a great variety of factors, with 49% of the factors or items mentioned being in the category of lack of population and development, e.g. country atmosphere, rural area, uncrowded, etc., and 40% of the factors cited in the category of physical environment, and 33% of the elements cited being in the social/lifestyle factors group.

The survey also reported that the greatest divergence among attitudinal responses was between the Keaau and Kapoho-Kalapana planning areas, Keaau residents being the most concerned with economic development and jobs while Kapoho-Kalapana respondents were "suspicious of it". This was analysed in the report to be a function of the uncertainties and anxieties among Keaau residents concerning the closing down of Puna Sugar Plantation, whereas Kapoho-Kalapana's current rural character would be more affected by geothermal-related activities.

Aesthetic Aspects. Although 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--consideration of aesthetic aspects should include careful siting, tasteful design, and effective landscaping.

The SMS study mentioned before, The Puna Community Survey, reported that of the negative impacts perceived relating to the geothermal well, 5% felt that it "looks bad". The area respondents with the greatest percentage of citing of the aesthetic aspect were Keaau residents, with 25% of the factors mentioned being under the category of negative appearance.

Techniques of preserving aesthetic aspects of the landscape and natural vistas include attractive design, painting of structures and towers and plants with colors to blend in with the natural setting. A 20MW to 30MW plant complex might be given attention and care as a design model for any future expansion that may be considered desirable.

Economic Impacts

As with any economic activity, the injection of dollars into the economy will result in direct impacts through the purchases of various goods and services from the other industries. In the case of a 20 to 30 megawatt geothermal plant, the dollars injected into the economy may be the result of the inflow of investment capital or the dollars prevented from being "exported" from the State or the County in the substitution or displacement of approximately 390 thousand barrels of petroleum each year that would have otherwise been imported into this State for conversion into electricity. The additional purchases made will, in turn, cause these industries to purchase more goods and services from other industries. The result is a chain-reaction of purchases, or a "multiplier" effect produced by the original increase in purchases.

The simpliest way to understand the basics of the multiplier effect is to consider what would happen if one were given a "brand new dollar". It is likely that the person would spend part of it and save the rest. Let's say you spent 80¢ of that dollar. For simplicity, assume that individuals and businesses were equal entities in their economic behavior. If the ratio of .8 was assumed to remain constant, then of the 80¢, 64¢ would be spent and the balance saved. If this process were to continue indefinitely until all the money was either spent or saved in this proportion, the "injection" of this "brand new dollar" would ultimately yield $5.00 in output for our simple economy.

The State's 1977 input-output model's income, output and employment multipliers were used. This model summarized the economic activities of the State at a given moment or period in time, providing information on the inter-relationships between all sectors within the economy. The analysis concentrated on the economic impacts that may result due to the operation of a geothermal plant. It disregarded the impacts which may occur during the construction phases.

The full measure of these impacts may be offset by the degree to which monies used to finance the operations originated locally or outside of Hawaii. Additionally, County conditions may not provide the opportunities that can be found on Oahu, and as such, the full impact of the output generated may not occur. Furthermore, one of the major characteristics of the input-output model used to generate these multipliers is that it implicitly assumes that the structure of Hawaii's economy in terms of the state of technology in 1977 has not changed significantly.

These impacts, especially the total impacts are long run in nature. That is, the subsequent indirect and induced activities do not take place instantaneously, but requires fairly lengthy periods of time for such events to take place, all other things held constant.

The overall assessment is that a 20 to 30 megawatt geothermal power plant will have some economic impact on a State-wide and County-wide basis, but the impact would probably not be significant. Based upon the data available, the direct wages to the 25 direct project employees will be about $560,000 per year. This direct income will stimulate a multiplier effect totalling an estimated $1.3 million. Additionally, an estimated 57 additional jobs will be created.

Public Revenue and Community Resource Analysis. Any economic activity results in certain gains and losses to the economy. In particular, an economic activity provides the public sector with additional sources of revenues and also increases the burden on the available public resources. In order to assess the impact of this project, an estimate of the incremental revenues and costs needs to be made. For the purposes of this analysis, only those major financial impacts likely to occur as a result of this project was considered. Order-of-magnitude estimates of the variables in this section were made where data was available and considered applicable to the assumed 20 to 30 megawatt geothermal plant case study. The estimation of a revenue-cost ratio was omitted at this preliminary stage of analysis.

For simplicity of analysis, it was assumed that all the employees will be brought in from outside the County. This will provide the "worst case" situation. Furthermore, it was assumed that a one-to-one relationship between employee and household exists. Thus, a total of 25 households will become the basis of the analysis. Lastly, it was assumed that all households will reside within the same district as the geothermal site.

Public Sector Revenue. At the County level, three major sources of revenue was addressed in relation to the existence of a geothermal plant. The first is property taxes, followed by fuel taxes and sewer charges.

At the State level, there are four major sources of public revenue that deserves treatment. The first is the general excise tax.

Next, is income taxes, both the corporate and the personal. Finally, the royalty income on the geothermal mineral rights.

Community Resource Analysis. Although the on-site facility will draw upon the community's resources, this section addressed only the probable impacts that may take place due to the increase in population within the immediate community or to the County. The principal resources that will be analyzed includes: housing, lower education, police and fire.

Based upon the scenerio that all 25 workers are from outside the County, the selected sources of revenues to both the County and to the State will not be a significant amount, in relative terms as well as in absolute ones, due to the size of the plant. However, a more precise delineation of the type of plant, in terms of legal organization and activities, will be required to determine a more accurate public revenue estimate.

Overall, the impact of the 25 additional households to the community will be primarily in the housing market, if all 25 workers are from outside the County. The likelihood of this "worst case" assumption seems to be fairly small. Thus, it is probable that a part of the needed workforce will come from the County and therefore the housing impact will not be as great. Other community resources will not be affected in a significant manner under the current scenerio.

Environmental Impacts

Meteorology. The winds in the Hawaiian Islands are very important in geothermal operation because of their effect on emissions and noise. The most common winds over the Hawaiian Islands are the trade winds from the northeast which account for about 70% of the winds in the Islands. These trades prevail over 90% of the time in June through August and only 40 to 60% of the time in January through March. During the winter, the trade winds are sometimes absent almost an entire month.

The analysis of wind direction was based on the few wind summaries available along the rift zone and interpolation drawn from existing data collected in other parts of the island. Due to the limited amount of available data, earlier written articles were also utilized in the study of the wind patterns over the rift zones.

Testimony at the public information meetings indicated that localized wind patterns from Kahaualea which normally blow into the National Park during the day, sometimes reverses direction at night blowing toward residential communities.

Flora and Fauna. One of most serious potential impacts of geothermal energy development in Hawaii is the disruption of native forests. Air pollution and ground water impacts of geothermal development may be substantially avoided by requiring full control technologies and impacts on native forest ecosystems can be mitigated through careful siting. Siting to avoid damage to biologically valuable forest can prevent both degradation of the forest due to invasion of weed species and disturbance of native bird species due to human activity and noise.

Native forests are particularly vulnerable to invasion by exotic species along roadways or other cleared areas. Once such an invasion begins, native forest is gradually altered, and non-native species, which initally invaded along relatively narrow corridors, spread and multiply. Major geothermal development, with an attendant network of roads and construction corridors, may be expected to dissect and possibly degrade undisturbed native forest by opening it to invasion by weedy species.

Geothermal development may also have potential negative impact on native birds, including many of which are endangered. Construction noise and human activity are factors which favor urban nuisance species over native forest species. It is therefore important to consider the habitat of native bird species, particularly those which are endangered, in assessing the impact of geothermal energy development. Any development within the habitat of native birds which have potential environmental impact should be fully investigated and mitigation measures implemented.

In selecting areas in which geothermal development will have the least environmental impact, it is therefore useful to assess both forest quality and native bird habitat. Those areas with mature native forest and significant native bird habitat will tend to be the most environmentally important, while those without native bird habitat and less intact forest will be substantially less impacted. For this study, indicators were used to distinguish, on a broad scale, areas of high and low potential environmental impact. For the present assessment, two indicators have been chosen, one of native habitat importance and one of forest quality.

The indicator chosen to depict the value of an area to native fauna is the presence of endangered species. While under some circumstances a simple survey for endangered species is an unacceptably superficial form of environmental assessment, in the present situation the presence of endangered species correlates quite well with the value of the area to native fauna in general. Relative value of native forest has been assessed using a categorization system developed by the University of Hawaii Environmental Center based on forest type mapping done by the United States Fish and Wildlife Services. This system indicates areas in which geothermal development would have the greatest environmental impact, areas in which geothermal development would have little or no impact on valuable native forest, and areas in which the impact of geothermal development on native forest is uncertain.

For the present assessment, endangered species habitat was considered present wherever essential habitat outlined in an approved Endangered Species Recovery Plan existed. Endangered Species Recovery Plans are plans of action for restoring the population of a species pursuant to its listing as endangered by the Secretary of the Interior. Recovery plans are drafted by teams of wildlife experts from both State and Federal agencies, and represent estimates of the range and life requirements of endangered species by the foremost experts in the field. Essential habitat outlined in an Endangered Species Recovery Plan is therefore almost without exception the most authoritative estimate of the actual habitat for a particular endangered species. Where no essential habitat has been designated, distribution was determined from population surveys condected by the U.S. Fish and Wildlife Services or other available information. Essential habitats have been defined for all endangered forest birds and the Hawaiian Crow (Alala) on the Island of Hawaii and for the Nene on both Maui and the Big Island. Essential habitat has not been determined for the endangered Maui forest birds, and therefore U.S. Fish and Wildlife Service population counts were used to determine habitat boundaries for these species.

The potential for environmental impact on the flora of the resource areas was assessed using a forest categorization system based on U.S. Fish and Wildlife Service vegetation type mapping. The U.S. Fish and Wildlife Service system incorporates information on extent of canopy cover, height of canopy, understory composition, and vegetation association by type. Vegetation information has been assembled and mapped by U.S. Fish and Wildlife Service using this system for large portions of four of the five main Hawaiian Islands, including Maui and Hawaii. Information in this form was available to the present study for all or portions of each of the resource areas. Areas not covered were lower Hana, lower Makena, Kilauea S.W. Rift, and lower Puna. In these areas aerial photo interpretation was used to estimate vegetation type, and in high resource potential areas this aerial interpretation was verified on the ground from readily accessible roadways wherever possible. Lack of access routes made ground verification for the Kilauea S.W. Rift site impractical. The boundaries delineated on the aerial photographs were transferred to orthophoto quadrangles and assigned a vegetation type code following the U.S. Fish and Wildlife Service system. Vegetation type data was then ranked according to potential impacts from geothermal development.

Surface Water. Geothermal development activities should not directly affect existing land uses since there are no surface streams located in the recommended areas. While drilling and construction phases of geothermal development may be a cause of concern, little or no environmental impacts are expected. However, if surface water becomes available, accidental pollution of streams should be prevented, and adequate and safe disposal methods of geothermal brine are available.

Almost all geothermal fluids have a total dissolved solids content greater than 1,000 parts per million, and their indiscriminate discharge into streams, ponds, and watersheds should not be allowed. The normal disposal practice is expected to be by reinjection into the geothermal reservoir. In some cases it is possible that byproduct fluids may be of satisfactory quality to be disposed of without treatment. Surface disposal, in these cases, could be allowed under controlled conditions. Environmental impacts on surface waters resulting from the development of geothermal resources in the prospective geothermal subzones are expected to be minimal.

Ground Water. Ground water in the various geothermal areas may occur as (1) perched water, (2) dike water, and (3) basal water.

Perched water, the least common, is water that is ponded on ash beds, soil formed on weathered lava, and on dense lava flows. Most perched water bodies are thin and show little lateral extent. The presence of perched water may be indicated by perched springs, usually found at higher elevations.

Dike water is water impounded in compartments between dikes in the rift zones of the volcanoes. The numerous dikes form nearly vertical walls that are less permeable than the masses of ordinary lava flows between them. In some of the dike complexes, water is held between the dikes to a height of more than 2,000 feet above sea level.

Basal water occurs most commonly in the islands. The basal ground water body is the fresh water resting on salt water within the permeable rocks that make up most of the base of the islands. In the areas considered, ground water will not be adversely affected because geothermal wells are drilled past the ground water aquifer. In addition, surface casing will be set and cemented through a competent subsurface formation below the basal lens. The drilling, casing installation, maintenance and abandonment of all geothermal wells, including re-injection wells will be regulated and monitored to protect the groundwater aquifer. Subsurface disposal of geothermal fluids by re-injection would be allowed only under controlled conditions, and alternate safe disposal methods should be developed.

Air Quality. The assessment of air quality impacts resulting from geothermal development requires examination of ambient air quality along active rift zones, emissions from geothermal wells and power plants and the current level of geothermal emission abatement technology.

Geothermal developments in Hawaii will be required to have abatement systems that meet the proposed State Department of Health air quality standards. At present, the recommended H_2S abatement system, the Stretford System, is capable of removing over 99% of the H_2S contained in the non-condensable gases. Use of this system would enable facilities to comply with the proposed air quality standards that require 98% of the H_2S present to be removed.

It should be noted that due to the sulfur content of fuel oil, oil-fired power plants may emit at least ten times more sulfur dioxide per megawatt-hour than would a geothermal power plant. Therefore, replacement of oil-fired power plants with geothermal power plants may reduce the overall impact to the environment and air quality.

Two major sources of recent information that help answer the questions and concerns are: Environmental Baseline Survey, Kilauea East Rift, Puna and Ka'u Districts, County of Hawaii (Final Report, 1984), prepared for the Hawaii State Department of Planning and Economic Development by NEA, Inc., in which definitive additional information on ambient air composition was obtained; and Evaluation of BACT for and Air Quality Impact of Potential Geothermal Development in Hawaii, January, 1984, prepared for the U.S. Environmental Protection Agency by Dames & Moore.

In its conclusions on the air quality impact of potential geothermal development in Hawaii, the Dames and Moore study reports the following, based on the Best Available Control Technology (BACT) for emission abatement:

> "H_2S, particulate and trace element emission rates were all developed from data gathered at HGP-A and assuming the emission controls described above. EPA-developed air dispersion models were then used to estimate the impact of these pollutant emissions on ambient air quality. Based on

these calculations, potential H_2S emissions during normal power plant operations for the development scenarios [25MW and 50MW] described in this report are well below the proposed Hawaii ambient air quality standard (HAAQS) for H_2S. However, H_2S emissions during well bleeding operations have the potential to exceed the proposed HAAQS. This potential can be eliminated by developing (and implementing) H_2S emissions control measures for use during well bleeding or by altering the assumed emission release characteristics of well bleeding activities.

"Calculations of potential particulate and trace element impacts on ambient air quality were also conducted as part of this study. These data indicate that the proposed project does not have the potential to exceed applicable ambient air quality guidelines for these compounds."

Cultural and Archaeological Values. Cultural values refer to the range of historical activities carried out by early Hawaiian residents. Archaeological values refer to all structures and artifacts that provide evidence of early habitation.

The Hawaiian land use concept of the ahupuaa is most useful in understanding the range of activities likely to occur within a subzone area, as well as the potential for archaeological sites within a subzone. For example, early coastal fishing villages often had inland agricultural fields. In addition to fishing and farming, various forest products were harvested from mauka or upland areas (koa for canoes, pulu for stuffing, ohia logs, birds for feathers) and early trail systems connected remote villages.

Evidence of these activities found in remaining archaeological sites is critical to reconstructing Hawaiian history and pre-history.

Geothermal development may potentially degrade such remaining evidence by site clearing and facility construction.

Estimates of the likely impacts of geothermal development can be accomplished by (1) completing an archaeological literature search for each geothermal resource subzone for evidence of early human activity, (2) by plotting the location of known archaeological sites within or nearby proposed subzones, and (3) by on-site archaeological reconnaissance surveys.

Two literature searches were prepared for the Kahaualea EIS. A similar search accompanied by maps showing known sites could be prepared for each subzone area.

Scenic and Aesthetic Values. Scenic and aesthetic values, in general, refer to landscape qualities likely to be impacted by geothermal development. Since most sites with geothermal potential are located in remote wilderness areas and are often heavily forested, development of geothermal facilities represents a visual intrusion.

The potential sources of visual intrusion include: clearing forested areas for construction, the temporary presence of drilling rigs, night lighting of drilling rigs, permanent presence of power plant structures with cooling towers (50 to 65 feet in height), geothermal fluid transmission lines, electrical transmission lines (70+ feet in height), and a periodic presence of steam plumes above well heads and power plant cooling towers (under certain climatic conditions, steam plumes may rise to 150 to 200 feet above the site).

Estimates of visual impact are accomplished by preparing an area-wide terrain analysis to determine locations outside the project area from which drilling rigs, powerlines, power plant facilities, etc. can be seen. In preparing a terrain analysis of visual impacts, various observer location points are selected and view lines calculated at each site. The observer is assumed to have an eye level 10 feet above ground surface and power plant height is assumed to be 80 feet above ground level. Profiles or visual perspectives are constructed to show the view lines from each observer location to a proposed power plant location. From such a profile, it is possible to determine the extent to which a site is visible from each observer location.

Geologic Hazards

General. The same volcanic activity which provides the source of geothermal heat may also create a hazard to people and property. Volcanic hazards include lava flows, pyroclastic fallout, ground deformation, cracking, and subsidence. With proper evacuation planning, lava flows should not be a great danger to people because of their usually slow speed and somewhat predictable paths, however, substantial property damage is a possibility. The table below summarizes past eruptive activity.

Historic Eruptions Within Geothermal Resource Areas

Location	Number of Eruptions Since 1750	Average Area (km^2)
Kilauea Upper East Rift*	21	6
Kilauea Lower East Rift*	5	11
Kilauea Southwest Rift	5	7
Mauna Loa Northeast Rift	7	37
Mauna Loa Southwest Rift	7	34
Hualalai	1	46
Haleakala Southwest Rift	1	6
Haleakala East Rift	0	--

*An imaginary line extending approximately north of Kalapana distinguishes the lower and upper east rift zone. Caldera eruptions were not considered.

A significant phenomenon is unique to Kilauea: the southern flanks of its rift zones are much more prone to be covered by lava flows than are the north flanks due to topography.

Several mitigation methods are available which may reduce the risk from geologic hazards. These methods include strategic siting, special construction designs and fortifications, evacuation planning, decentralization of power plants, and giving development investors a clear economic incentive to utilize mitigation methods by having them assume all the associated risks of loss.

In the past, several attempts have been made to restrict the flow of lava in Hawaii, Italy, and Iceland. These examples illustrate the effectiveness of the technology used and the costs involved. In those situations, governmental authorities spent large amounts of money, sometimes millions of dollars, in efforts to protect communities threatened by lava flows.

The past history and nature of geologic hazards can provide a valid guide to the probable course of future activity, although it is not possible to detail the specific time and location of such activity.

Lava Flows. Lava flows generated during volcanic eruptions and can cover extensive areas extending out to more than 10 kilometers from the source, be it a vent or long linear fissure or crack. Lava tends to flow freely and the course taken by the flow is fairly predictable since it is determined by ground slope. However, ridges built by cooling lava on the sides of a flow may create channels and alter the lava flow direction. Flows from earlier phases of an eruption can quickly change the topography and expected course of the flow. In a somewhat similar manner, other natural and man-made obstacles can divert lava flows.

Lava flows vary in their flow behavior. Thick distal aa flows tend to bulldoze, crush, bury, and burn any surface structures in their path. The more fluid, newly erupted, proximal (near-vent) lava tends to flow around obstacles. A fluid flow could enter buildings and may not cause much structural damage beyond igniting flammable materials and softening and distorting some of the metalwork. In principle, fluid pahoehoe lava can subsequently be removed and the building reoccupied. In principle this would also apply to flows covering protective well cellars and thin pahoehoe flows surrounding transmission piping. However, recovery from a deep or long duration flow could take many months.

Pyroclastic Fallout. Explosive high-output eruption fountains may eject rock fragments of many types and sizes. The fallout range can be appreciable as far as 500 or 1000 meters away from an eruptive vent or fissure. Large fragments tend to fall close to the vent building cones and may be tens or hundreds of feet thick. Smaller particles can form a long, narrow, blanket many feet thick downwind of the vent.

The probability of an eruption being potentially explosive (with resultant increased debris) increases as the coast is approached and is near 100% for a vent within about 1 kilometer of the coast. Steam from the near-surface water table promotes such explosiveness.

Other dangers from fallout include lung irrigation, poor visibility, anxiety or panic, blockage of escape routes, and severe cleanup problems.

Ground Cracks. Cracks which may open as much as several feet, can be the surface expression of dikes that fail to reach the surface. These cracks can produce a surface graben in which the ground subsides between two parallel cracks. This type of cracking related to magma movement is concentrated in volcanic rift zones which are narrow and clearly defined. Cracks could possibly open outside a rift zone; however, not enough information is available to assess the probability, which is considered to be low.

Ground cracking can also be associated with tectonic earthquakes. Their formation is often accompanied by a relative vertical or lateral displacement of the ground on either side. Tectonic ground cracking is usually localized in definable zones.

Ground cracking across a geothermal plant could cause a suspension of operation, depending on the extent and location of damages.

Pipes carrying steam between the wells and plant are unlikely to be damaged by minor ground cracking, since they are designed with expansion joints at regular intervals.

Ground cracking close to a well bore might open up an alternate path for the steam and cause its loss from the well. This is unlikely due to the vertical pitch of most cracks. However, in the event a crack does intercept a well bore several things might happen. If the crack is below the local water table, water could rush into the bore and seal the release of steam by hydrostatic pressure. If the crack is above the water table, steam could escape into the surrounding rock strata. If the crack is close to surface, steam could escape and vent its way to the surface. In the latter event, a cement plug poured from an intercepting directional drill hole may seal the leak.

Ground Subsidence. Subsidence from geothermal fluid withdrawal is not likely to be problem; since the islands are generally comprised of dense, permeable, self-supporting basaltic rock, especially in geothermal production zones. Of more concern is the volcanic or tectonic subsidence which usually occurs on or about active rift zones, e.g. Kilauea.

Small to large grabens may result from the subsidence of rock blocks (usually rectangular) which are downthrown along or between cracks.

Subsidence and cracking may also be associated with tectonic earthquakes, e.g. subsiding slump blocks along the Hilina fault system near Kilauea.

Collapsing pit craters and lava tubes can result in very severe localized subidence. Pit craters usually occur within a summit or rift zone of a volcano. Fragile, near-surface lava tubes (usually found in pahoehoe flows) are subject to collapse from heavy surface activity. A geologic site-survey could identify these hazards.

Aside from the immediate effects subsidence may have on the foundation and contents of a power plant, subsidence also increases the hazards from lava flows since flows usually seek lower areas.

Earthquakes. Most earthquakes in Hawaii are volcanic in nature, resulting from the vibration of near surface magma movements. They usually cause little direct damage. Larger earthquakes tend to be tectonic, generally resulting from the movement of large rock bodies.

Major earthquake shaking can potentially damage poorly constructed buildings. Indirect damage may also be caused by smaller, more common volcanic earthquakes. Experts have recommended that development facilities be constructed to withstand shaking from a 7.5 magnitude earthquake. The largest earthquake in the State occurred on the island of Hawaii in 1868, having a magnitude of 7.5.

Tsunami. Tsunamis are large sea waves usually generated by movement of large submarine rock masses or volcanic eruptions. These waves can travel great distances at speeds of almost 500 miles per hour and move on shore turbulently or merely rise quietly.

The tsunami hazard is probably localized to a zone of land approximately 2 kilometers wide along the coast, and at elevations not much higher than 75 feet. This is not expected to pose a significant danger to geothermal developments which are likely to be situated at higher elevations.

Compatibility with Land Uses

State Land Use Classification. 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 shall be placed: (1) urban, (2) rural, (3) agricultural, and (4) conservation.

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

Rural districts shall 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 shall 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 parts and open area recreational facilities.

Conservation districts shall 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 use of an area for the exploration, development and production of electrical energy from geothermal sources within a geothermal resource subzone shall be governed by the Board of Land and Natural Resources within the conservation district and by existing State and County statutues, ordinances, and rules within the agricultural, rural, and urban districts, except that no Land Use Commission approval shall be required for the use of subzones.

In addressing the compatibility of geothermal activity within a conservation district, we must first recognize the various land use districts. There are four major land use districts in which all lands in the State of Hawaii are placed: urban, rural, agricultural, and conservation. The lands designated as conservation have also been labeled conservation under the respective county general and community plans. The conservation area is further divided into five subzones: protective (P), limited (L), resource (R), general (G), and special (SS).

The protective subzone has as its objective the protection of valuable resources in such designated areas as restricted watersheds; marine, plant, and wildlife sanctuaries, significant historic, archaeological, geological, and volcanological features and sites; and other designated unique areas. The limited subzones are designated areas where natural conditions suggest constraints on human activities. The objective of the resource subzone is to develop, with proper management, areas to ensure sustained use of the natural resources of those areas. General subzones are open space where specific conservation uses may not be defined, but where urban use would be premature. Special subzones are specifically designated areas which possess unique developmental qualities which complement the natural resources of the area.

Conservation districts constitute a large percentage of the potential resource areas. Each area within the conservation district has permitted uses. In each of the areas mentioned; protective, limited, resource and general; the use of the area for "monitoring, observing, and measuring natural resources" is permitted. In this respect exploration of geothermal resources can be allowed in a conservation district. The development of these resources within a conservation district which, allows "governmental use not enumerated herein where public benefit outweights any impact on the conservation district" is therefore permitted and can eventually lead to greater Statewide benefit. In managing the uses of conservation lands, careful analysis of the proposed use is required. Thus, only when the benefits of the proposed use is determined to be greater than any repercussions on the land will the use be permitted.

The compatability of geothermal development with the proposed land uses outlined in each respective county's general plan can be determined with respect to the various land use categories. One of the general objectives set forth in the County General Plans is to "protect and encourage the utilization of the County's limited prime agricultural lands" and promote "uses of land meeting the social and economic needs of the people". Thus, careful management of geothermal development in urban, rural and agricultural districts can insure compatability with the broad objectives and policies for long range development of the County.

COMMUNITY CONCERNS

Various channels and methods of community input are involved in the preliminary and future processes of geothermal resource development evaluation and actualization. The community surveys by the Puna Hui Ohana and by SMS Research, Inc. involved resident response and assistance in conducting these surveys.

In a study prepared by Dr. Penelope A. Canan, Assistant Professor of Sociology and Urban and Regional Planning at the University of Hawaii, The Social and Economic Impacts of Geothermal Development in Hawaii, theoretical social impact assessment and management models were suggested and discussed, along with the use of multi-disciplinary groups, "objective" and "subjective" social indicators, the inclusion of the planning process in community process models, and the prerequisite of site specification in social impacts assessment.

Public informational meetings held by the State Department of Land and Natural Resources during the month of May and July, 1984 on the Islands of Hawaii and Maui, encouraged public participation, so that the planning process may include, in the preliminary stage as well as later on in the process, as much input as possible from the public.

Other sources and channels of community input include 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 and its input processes, as well as policies brought forth by representatives of people and communities in the State Legislature.

During the course of the assessment, several public information and participation meetings were held and conducted by the staff of the Division of Water and Land Development. Following are the dates and places of community meetings held:

May 8, 1984	- Hilo, Hawaii
May 9, 1984	- Kahului, Maui
May 29, 1984	- Hilo, Hawaii
May 30, 1984	- Kahului, Maui
July 10, 1984	- Puna Community Council
July 11, 1984	- Volcano Community Association
July 27, 1984	- Ulupalakua, Kanaio, Maui

Island of Hawaii, Generally

Support for geothermal resource exploration, development, and production on the island of Hawaii has been voiced by the Mayor, County Council, Chamber of Commerce, and several communities in the Puna area.

Opposition has been expressed in specific phases of the overall development, such as emissions and noise emanating from geothermal resource activities, but not necessarily with development of geothermal resource energy as an alternate energy source for Hawaii.

Puna Community

Comments recieved at public information meetings in Hilo and at Puna indicate that geothermal resource activities, if done with due regard to local concerns, would not be detrimental to the area.

Volcano Community

Vocal opposition to geothermal resource development were generally expressed at all of the public information meetings. Adverse effects to forests, bird habitats, proximity to the Volcanoes National Park and the lowering of property values were highlighted. The current volcanic flows were cited as a potential hazard to development activities indirectly affecting the safety of nearby communities.

Island of Maui, Generally

Support was also expressed by the Mayor, County Council, Chamber of Commerce and the Maui Electric Company. Opposition was voiced by some residents living in the Ulupalakua and Kanaio areas.

Ulupalakua-Kanaio Residents

Residents of the Ulupalakua and Kanaio areas voiced their concerns at the public information meetings, citing adverse effects on the health of residents and disturbance to rural lifestyle. An arboretum located on the Vockrodt property in Ulupalakua was visited by the staff on invitation by the owners.

EVALUATION OF IMPACTS ON POTENTIAL GEOTHERMAL RESOURCE AREAS

Kilauea Lower East Rift, Hawaii

Potentials for Production. Commercially feasible quantities of steam have been confirmed by deep exploratory drilling on the lower rift zone. On the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, there is a greater than 90% chance of finding a high temperature, i.e., greater than 125°C or 257°F, resource at depths less than 3 kilometers or approximately 9840 feet..

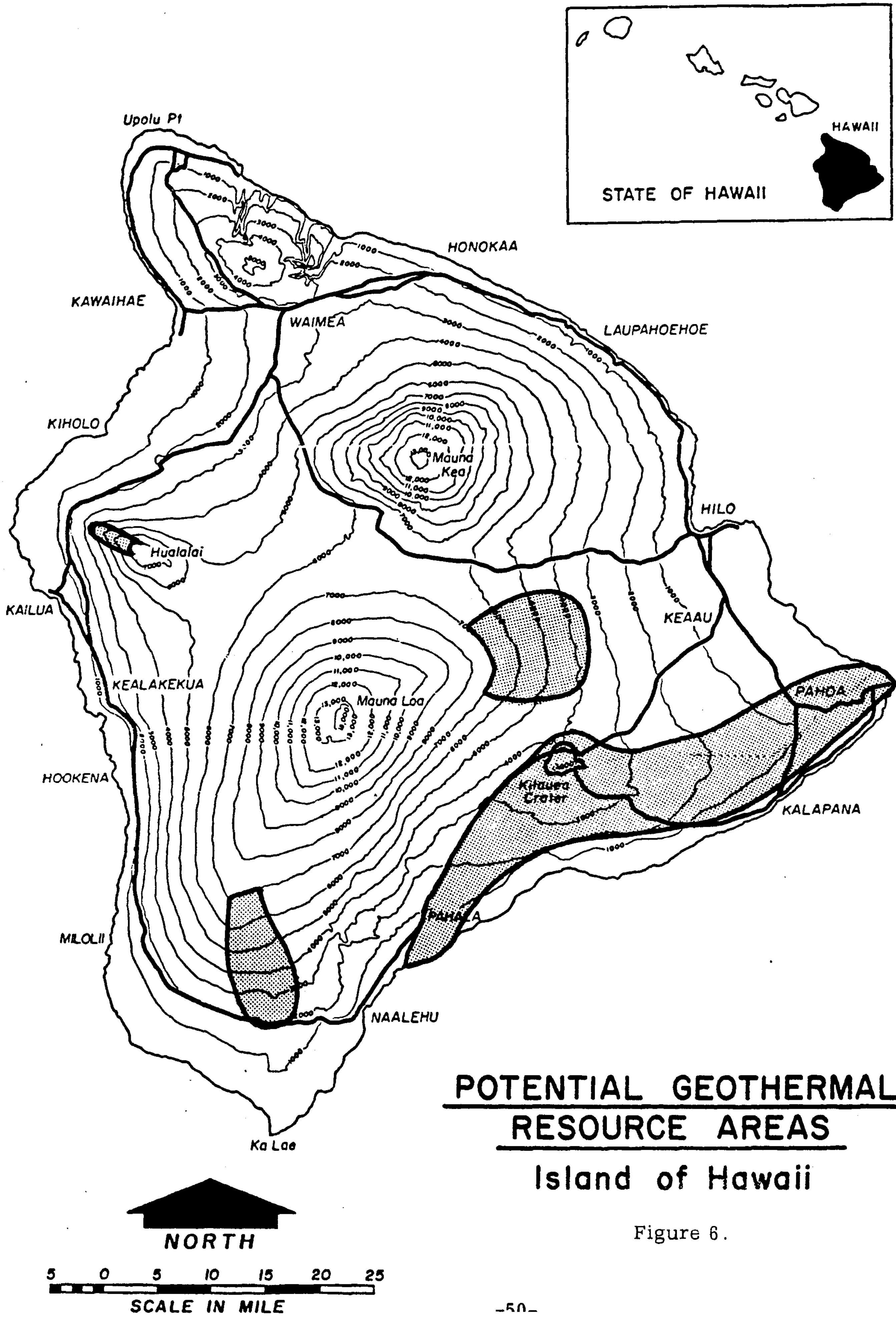
Prospects for Utilization. Based upon prior permit applications and developer activity, the prospects for utilization of both subzones being proposed is considered good.

Geologic Hazards. Historic lava flows have occurred in Kilauea's lower east rift zone in 1750, 1790, 1840, 1955, and 1960. Eruptions (and associated hazards of ash fallout, ground deformation, cracking, etc.) are expected to occur within this area in the future but the precise time and place is unpredictable. There may be some danger from tsunami and ground subsidence in coastal areas.

Risk of loss resulting from geologic hazards is expected to be assumed by geothermal developers. Utilization of appropriate mitigation measures and careful site selection (outlined in "Hazard Mitigation Plans") should result in an optimum balance of safety and productivity.

Social Impact. The principal social factors affected by geothermal development would be in terms of lifestyle, culture, and community setting as they are experienced in Puna. The impact is expected to be moderate and adverse conditions can be mitigated. Also important is the preservation of natural beauty and aesthetics, which could be achieved by well-planned siting, landscaping, and well-designed plant architecture.

Environmental Impacts. The general impact of geothermal development to the environment will be in the areas of noise and air quality. These conditions are to be minimized and adverse impacts



POTENTIAL GEOTHERMAL RESOURCE AREAS

Island of Hawaii

Figure 6.

mitigated by utilizing current technological equipment to muffle and filter.

Compatibility of Development. A portion of the proposed Kapoho subzone includes two current Geothermal Resource Mining Leases, R-2 and R-3, which were declared subzones through Act 151, SLH 1984.

The proposed Kapoho subzone rests within agricultural and conservation districts. Geologic hazards as outlined in Chapter 4 can be mitigated and adverse environmental conditions minimized.

The existing HGP-A facility demonstrates that with careful planning geothermal development can be compatible with existing uses in this area.

Economic Impact. Geothermal development within the proposed subzone will provide a measure of energy self-sufficiency and reduce the State's dependency on imported oil for electrical production. In addition, development of geothermal resources will generate added income and initiate additional jobs in the area. The construction industry may benefit should additional housing be needed to accommodate new workers.

Kilauea Upper East Rift, Hawaii

Potentials for Production. Currently available studies indicate that a geothermal resource is present along the entire length of the Kilauea East Rift Zone. On the basis of positive geochemical and geophysical data and the recent eruptive and intrusive activity along the Kilauea East Rift Zone, there is a greater than 90% chance of finding a high temperature, i.e., greater than 125°C or 257°F, resource at depths less than 3 kilometers or approximately 9840 feet.

Prospects for Utilization. Based upon prior permit applications and developer interest, the prospects for utilization of the proposed subzone is considered good.

Geologic Hazards. The proposed Kilauea Upper East Rift Zone subzone is in an area generally north of the rift zone axis. About 75% of this proposed subzone area has not been affected by historic lava flows. Every historic flow has flowed to the south with the exception of the present Puu 'O' flows. Eruptions (and associated hazards of ash fallout, ground deformation, cracking, etc.) are expected to occur within this area in the future but the precise time and place is unpredictable. Volcanic activity which creates a hazard is also the source of geothermal heat required for power generation. The largest recent earthquake (magnitude 7.2) occurred in 1975 about 5 km southwest of Kalapana. It resulted in cracking, subsidence, and tsunami.

Geothermal development activities may occur once present volcanic activity ceases. Those areas that have been covered by recent flows are likely to be used for well sites, while safer northern areas are likely to be used for power generation facilities. Risk of loss resulting from geologic hazards is expected to be assumed by geothermal developers. Utilization of appropriate mitigation measures and careful site selection (outlined in "Hazard Mitigation Plans") should result in an optimum balance of safety an productivity.

Social Impact. Social impacts related to geothermal development can be minimized with careful planning. In the volcano area, the principal social factors that may be affected by development activities are in terms of lifestyle, culture and community setting.

The location of the proposed geothermal resource subzone is set back away from the Volcano community, Hawaii Volcanoes National Park boundaries, and the Wao Kele O Puna Natural Area Reserve. The preservation of natural beauty and aesthetics can be achieved by well-planned siting, landscaping, well-designed plant architecture, and proper mitigation measures.

Environmental Impacts. The development of geothermal resources along the Kilauea Upper East Rift Zone will be limited to the proposed subzone area. The general environmental impact from development activities will be in the area of noise and air quality. These impacts are expected to be minimized and adverse conditions mitigated by utilizing current technological equipment to muffle and filter. Air quality within surrounding areas should not be impacted, since given the current level of abatement technology, developers will be required to comply with State Department of Health Air Quality Standards.

While a major portion of this proposed subzone area is situated in high quality native forest and bounded by an endangered species habitat, only 25% of the total flora and fauna habitat in the Kahaualea area has been proposed for subzone designation.

Site development may impact the endangered O'u habitat and native forest, but with careful planning and minimal removal of vegetation and trees, development activities should not significantly threaten existing flora and fauna.

Compatibility with Land Uses. The proposed subzone area is situated within LUC classified "conservation, limited" land. While geothermal development is considered to have a significant impact, each area within the conservation district has permitted uses. In each of these subzones, Protective, Limited, Resource, and General; the use of the area for "monitoring, observing and measuring natural resources" is allowed. In addition, the use of lands within a conservation district in which "governmental use not enumerated herein where public benefit outweighs any impact on the conservation district" is permitted. In this respect, geothermal related activities can be allowed in a conservation district and the development of these resources lead to widespread public benefit.

Utilizing buffer zones, the Hawaii Volcanoes National Park and the Natural Area Reserve has been excluded from the proposed subzone. In addition, mitigation measures will be required in the conservation district before geothermal development is permitted.

Economic Impact. Geothermal development within the proposed subzone will generate added income and create additional jobs. The need for additional housing to accommodate new workers should benefit the local construction industry.

Most importantly, geothermal development activities will promote energy self-sufficiency and reduce the State's dependency on imported oil.

Kilauea Southwest Rift, Hawaii

Potentials for Production. On the basis of positive geophysical data, recent volcanic activity, and consideration given to the absence of any significant groundwater chemical anomalies, it was estimated that there was a greater than 90% chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization. Based upon available information, it is uncertain as to whether developers would drill within the Pahala resource area.

Geologic Hazards. Historic lava flows have occurred in Kilauea's southwest rift zone in 1823, 1868, 1919, 1971, and 1974. Eruptions (and associated hazards of ash fallout, ground deformation, cracking, etc.) are expected to occur within this area in the future but the precise time and place is unpredictable. There may be some danger from tsunami and ground subsidence in coastal areas. Recent earthquakes with magnitudes above 6 have occurred in the saddle area between Mauna Loa an Kilauea, the largest being of magnitude 6.7 in November 1983.

Social Impacts. Preservation of the natural setting can be achieved through careful planning and mitigation measures. Geothermal development should have little impact on aesthetics in the potential resource area.

Environmental Impacts. The impact of geothermal development to the environment will be in the area of air quality. This impact is expected to be minimized by current abatement technology.

Compatibility with Land Uses. The assessed resource area is currently classified as "conservation, resource" and "agriculture" by the State Land Use Commission. Potential impacts that may occur from geothermal development can be mitigated by careful planning and siting.

Economic Impacts. Geothermal development in the resource area will provide a measure of self sufficiency, reduce oil imports and bring added income and new jobs.

Mauna Loa Northeast Rift, Hawaii

Potentials for Production. Based on available data it was estimated that there was a 35% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization. It is uncertain as to whether geothermal development activities will take place in the resource area.

Geologic Hazards. Historic lava flows have occurred in Mauna Loa's northeast rift zone in 1852, 1855, 1880, 1899, 1935, 1942, and 1984. Eruptions (and associated hazards of ash fallout, ground deformation, cracking etc.) are expected to occur within this area in the future but the precise time and place is unpredictable. Recent earthquakes with magnitudes above 6 have occurred in the saddle area between Mauna Loa and Kilauea, the largest being of magnitude 6.7 in November 1983.

Social Impacts. Geothermal development should have little impact on aesthetics in the resource area. In addition, preservation of the natural setting can be achieved by proper planning and mitigation measures.

Environmental Impacts. There would be a potential impact upon the environment in the areas of air quality and noise. These conditions are expected to be mitigated by utilizing current technological equipment to muffle and filter.

Any development in the resource area may have an impact on the existing flora and fauna. Some 60% of the assessed resource area consists of Category 1 forests, "exceptional native forest; closed canopy, with over 90% native cover". The forest area also provides habitat for various endangered bird species: Hawaiian Creeper, Akepa, Akiapola'au, 'O'u, and the Nene. This impact is expected to be minimized by proper planning and current abatement technology.

Compatibility with Land Use. Some 75% of the assessed resource area is presently classified as "conservation, protective" lands under the State Land Use District Classification. Geothermal development is expected to have some potential impact that can be mitigated by careful planning and proper siting.

Economic Impact. Geothermal development activity in the potential resource area should enhance employment. Additional housing may be needed to accommodate new workers.

Mauna Loa Southwest Rift, Hawaii

Potentials for Production. On the basis of historic volcanic eruptions, seismic activity and taking into consideration the absence of any other significant geophysical or geochemical anomalies, it was estimated that there was a 35% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization. It is uncertain as to whether geothermal development activities will take place in this resource area.

Geologic Hazards. Historic lava flows have occurred in Mauna Loa's soutwest rift zone in 1868, 1887, 1907, 1916, 1919, 1926, and 1950. Eruptions (and associated hazards of ash fallout, ground deformation, cracking, etc.) are espected to occur within this area in the future but the precise time and place is unpredictable. Recent earthquakes with magnitudes above 6 have occurred in the saddle area between Mauna Loa and Kilauea, the largest being of magnitude 6.7 in November 1983.

Social Impacts. Geothermal development within the assessed resource area is expected to cause potential changes in the aesthetics, lifestlye, culture and community setting. The impact of development activities should be minimized by proper planning and mitigation measures.

Environmental Impacts. There would be a potential impact on the air quality from geothermal resource development. In addition, impacts may occur on the fauna in this area. Approximately 50% of the resource area encompasses endangered bird species (Akepa, Akiapola'au and the Hawaiian Creeper) and mitigation measures must be implemented before development can occur.

Compatibility with Land Use. The assessed resource area is currently classified by the State Land Use Commission as "conservation limited" and "agriculture". Development activity may have potential impacts that can be mitigated by careful planning and proper siting.

Economic Impact. Employment should increase if geothermal development takes place within the area. The construction industry may benefit should additional housing be needed to accommodate new workers.

Hualalai Northwest Rift, Hawaii

Potentials for Production. Based on positive geothermal indications from geophysical data (resistivity, magnetics, and self potential) and the geologic age of vents along the upper rift and summit, there is an estimated 35% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization. It is uncertain as to whether geothermal development activities will take place in this resource area.

Geologic Hazards. The only historic eruption of Hualalai occurred in 1801. It produced two large flows covering 46 km^2 east and north towards the ocean. Several thousand earthquakes, from a source beneath Hualalai, shook the island in 1929. Eruptions and earthquakes (and associated cracking, fallout, subsidence, etc.) may occur here in the future but it is not possible to predict the precise time and place of future activity.

Social Impact. The impact on aesthetics in the resource area is expected to be mitigated by careful planning and siting.

Environmental Impacts. Approximately 10% of the resource area consists of Category 1 forest, "exceptional native forest with over 90% native canopy cover". The endangered fauna which inhabit the forest include the Alala, Hawaiian Creeper, Akepa and the Nene. Development in this area may have an impact on the flora and fauna. In addition, potential impacts may occur in the areas of air quality and noise. These impacts should be mitigated in order to minimize any adverse effects.

Compatibility with Land Use. The assessed resource area is currently classified as "conservation, protective & resource" under the State Land Use District Classification. Geothermal development in this resource area may have potential impacts that can be mitigated by proper siting and careful planning.

Economic Impact. Development activity in the geothermal resource area would create an increase in employment and additional housing may be required.

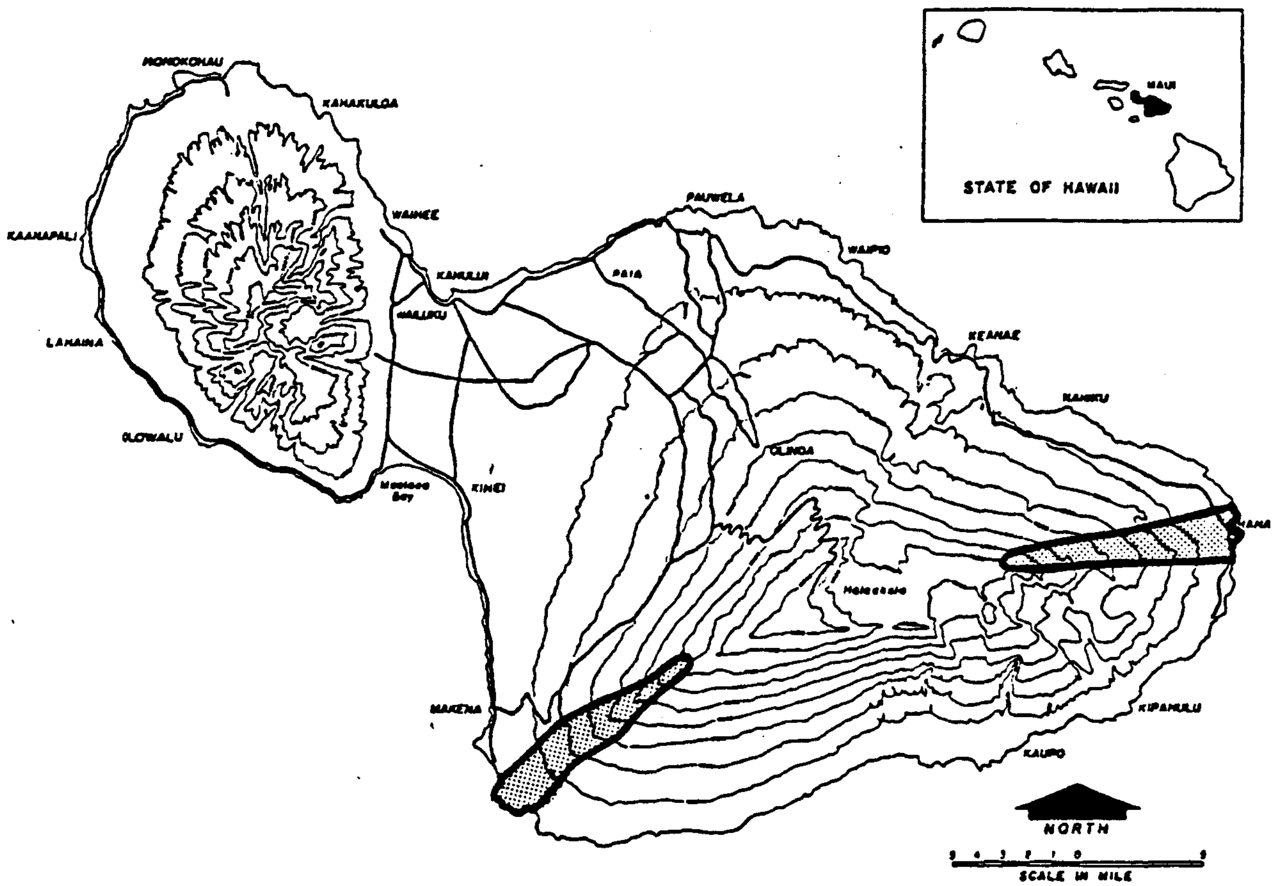
Haleakala Southwest Rift, Maui

Potentials for Production. Based on the historic 1790 eruption and results of deep resistivity soundings, it was estimated that there is a 25% or less chance of finding high a temperature (greater than 125°C) resource at depths less than 3 kilometers.

Prospects for Utilization. Based upon developer interest and activity, the prospects for utilization of the proposed subzone area is good.

Geologic Hazards. Flows range from 200 to 20,000 years old. Six flows have erupted in this area within the last 1000 years. Based on past activity, the average rate of eruption is one per 150-200 years. The last flow occurred in 1790 by the coast; it was the largest (6 km^2) of the more recent flows. The risk from volcanic hazards includes dangers from lava flows and other attendant phenomenon such as pyroclastic fallout, cracking, subsidence, and swelling. There may be some danger from tsunami in coastal areas. The most recent earthquake near Maui occurred in 1938, 40 miles off the northern coast of East Maui. Haleakala's eruptive history suggests that an eruption could occur on Haleakala within the next hundred years. However, there is no way to predict a specific time or place of the next eruption.

Risk of loss resulting from geologic hazards is expected to be assumed by geothermal developers. Utilization of appropriate mitigation measures and careful site selection (outlined in "Hazard Mitigation Plans") should result in an optimum balance of safety and productivity.



POTENTIAL GEOTHERMAL RESOURCE AREAS

Island of Maui

Figure 7.

Social Impacts. Geothermal development activities will have an effect on the lifestyle, culture and way of life for those residents living near Ulupalakua and Kanaio. The aesthetic impact of geothermal facilities within the proposed subzone must be minimized by careful siting, landscaping and architectural design. Mitigation measures will be required to protect the natural beauty and aesthetics of this area before geothermal development is permitted.

Environmental Impacts. Geothermal development in this area will be required to utilize abatement systems that meet the proposed State Department of Health air quality standards. Air quality within surrounding areas should not be impacted and little or no effects are expected on the existing flora and fauna habitats.

While air quality and noise will have an impact on the environment, these conditions are expected to be minimized and adverse conditions mitigated by using current technological equipment to muffle and filter.

Compatibility with Land Use. The assessed resource area is classified by the State Land Use Commission as "agriculture" and as "conservation, protective, general & resource". Any potential impact from geothermal development can be minimized by careful planning and mitigation measures.

Economic Impacts. Geothermal development within the proposed subzone area will provide a measure of energy self-sufficiency, reduce oil imports, bring about added income and provide additional jobs. In addition, the need for additional housing to accommodate new workers may benefit the local construction industry.

Haleakala East Rift, Maui

Potentials for Production. Based on the geologic age of the Hana Series lava flows, there is an estimated 25% or less chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometers within the Haleakala East Rift Zone.

Prospects for Utilization. It is uncertain as to whether developers would drill for geothermal resources in this assessed area.

Geologic Hazards. The most recent flow on the east side of Haleakala is just north of the geothermal resource area between Olopawa and Puu Puou; it is about 500 years old. Based on past activity, the average rate of eruption is one per 10,000 years. The risk from volcanic hazards includes dangers from lava flows and other attendant phenomenon such as pyroclastic fallout, cracking, subsidence, and swelling. The most recent earthquake near Maui occurred in 1938, 40 miles off the northern coast of East Maui. There may be some danger from tsunami in coastal areas.

Social Impacts. The potential effects on lifestyle, culture, and the community due to geothermal development activities, as well as the impact on aesthetics is expected to be minimized. The visual impact of geothermal development can be mitigated by proper citing and planning.

Environmental Impacts. Air quality and noise may have an impact upon the environment. However, the effects on flora and fauna within the resource area will be minimized by utilizing mitigation measures. Approximately 50% of the area is Category 1 forest, "exceptional native forest, closed canopy with over 90% native cover". The forested areas provide habitat for three endangered forest birds: Maui Parrot bill, Crested Honeycreeper, and the Akepa.

Compatibility with Land Use. The assessed resource area is presently classified as "conservation, protective" under the State Land Use District Classification. Geothermal development in this area may have potential impacts that can be mitigated.

Economic Impacts. Development within the geothermal resource area will provide additional jobs for the community. Additional housing may be required to accommodate new workers.

Figure 8. EVALUATION OF IMPACTS ON POTENTIAL GEOTHERMAL RESOURCE SUBZONE AREAS

Basis for Evaluation	Island of Hawaii						Island of Maui	
	Kilauea East Lower	Kilauea East Upper	Kilauea Southwest	Mauna Loa Southwest	Mauna Loa Northeast	Hualalai Northwest	Haleakala East	Haleakala Southwest
Potentials for Production	+90%	+90%	+90%	35%	35%	35%	25%	25%
Prospects for Utilization	good	good	uncertain	uncertain	uncertain	uncertain	uncertain	good
Geologic Hazards Impacts								
Lava Flows	x	x						
Pyroclastic Fallout								
Ground Cracks		x						
Ground Subsidence		x						
Earthquakes								
Tsunami								
Social Impacts								
Health								
Noise							x	x
Lifestyle, Culture, Community Setting				x			x	x
Aesthetics	x	x		x	x	x	xx	xx
Environmental Impacts								
Meteorology								
Surface Water								
Ground Water								
Air Quality	x	x	x	x	x	x	x	x
Flora and Fauna		xx		xx	xx	xx	xx	
Water Quality								
Culture and Archaeological Values								
Scenic and Aesthetic Values	x	x		x	x	x	x	xx
Recreational Values								
Compatibility of Development								
State Land Use Districts		xx			xx	xx	xx	
County Zoning								
Surrounding Areas								
Present Land Uses								
Economic Impacts								
Public Revenue Sources								
Public Service Costs								
Employment	x	x	x	x	x	x	x	x
Housing	x	x		x			x	x

Key:
+90%=greater than 90% 35%=35% or less 25%=25% or less x=moderate impact expected xx=significant impact expected

CONCLUSIONS ON POTENTIAL GEOTHERMAL RESOURCE AREAS

The assessment of Hawaii's geothermal resources involved the analysis of available scientific information. To initiate this activity the Department enlisted the help of a technical committee comprised of scientists in fields of geophysics, geochemistry, geology, engineering and hydrology. This committee conducted a county-by-county assessment of Hawaii's potential geothermal areas based on currently available geotechnical information. Twenty separate areas were identified and studied. Of these, seven areas were identified and mapped as having high temperature geothermal resources of 125 degree celsius or 257 degree fahrenheit at depths less than 3 kilometers or 9840 feet. Five areas are located on the island of Hawaii and two on Maui. Five other areas in the State were identified as having low temperature geothermal resources of less than 125 degree celsius. These areas are located on the islands of Hawaii, Maui and Oahu.

Examination of the seven areas relative to social, economic, environmental, geologic hazards, and compatibility with land uses reveal several impacts that may result from the exploration, development and production of geothermal resources for electrical power generation. Weighting of the assessment factors was based upon a balance rather than a sequential priority as specified in Act 296, SLH 1983.

Considered also in the evaluation of impacts was the provisions of Chapter 226, the Hawaii State Planning Act. The statutory objective, "increased energy self-sufficiency" and statutory policies "accelerate research development and use of new energy sources" and "promote the use of new energy sources" were considered. Additionally, the State Energy Plan developed as one of the Hawaii State Planning Act's twelve Functional Plans specifies the need to develop alternate energy resources, including direct solar energy; indirect solar energy such as wind, hydropower potentials, biomass, and ocean thermal differences; and geothermal energy.

After evaluating the seven potential geothermal resource areas on the basis of resource availability, prospects for utilization, geologic hazards and examining the social, environmental, compatibility, economic concerns, and considering the statutory State energy objectives and policies; the following sites were determined as deserving consideration for designation as geothermal resource subzones by the Board of Land and Natural Resources:

Kilauea Lower East Rift, Hawaii
Kilauea Upper East Rift, Hawaii
Haleakala Southwest Rift, Maui

The above areas have the following common desirable elements for the exploration, development, and production of geothermal resource energy:

* potential for developing geothermal resources.
* interest in exploration, development and production of geothermal resource energy.
* commitment towards geothermal resource energy as a viable alternate energy source for Hawaii.
* advanced technology in geothermal resource development, such as emission control system, noise control systems, well and power plant designs, and safety provisions from lava flows, reduces the concerns for public health and safety.
* potential degradation to the environment has been fully investigated and mitigation measures considered.

RECOMMENDED SUBZONES

Based upon the assessment of geothermal poential in the State of Hawaii, the evaluation of social impacts, economic impacts, environmental impacts, geologic hazards and the compability with land uses, including community concerns and the state of technology in geothermal resource developments, it is recommended that the Board of Land and Natural Resources designate the Kilauea Lower East Rift, Island of Hawaii, Kilauea Upper East Rift, Island of Hawaii, and the Haleakala Southwest Rift, Island of Maui as geothermal resource subzones.

A description of the areas follows:

Kilauea Lower East Rift, Island of Hawaii

The area shown in Figures 1 and 2 identifies two separate sites--the Kapoho section and the Kamaili section. The probability of locating high temperature geothermal resources is estimated to be greater than 90 percent and the prospect for development and production of electrical energy is good. Relatively recent volcanic flows in the 1960's and 1970's indicate the availability of geothermal resources in the area. Active exploration and development currently underway also attest to the availability of geothermal resources.

The Kapoho Section, approximately 5939 acres lies adjacent to two subzones established by the Legislature in Act 151, SLH 1984. The extreme eastern end of the proposed Kapoho section is zoned in conservation due to relatively recent lava flows with the rest of the area zoned in agriculture. The northern boundary is buffered by a 2000-foot area where sensitive forest areas are located. The western end abuts Leilani Estates, a sparsely populated subdivision. The southern boundary generally follows the 90 percent resource probability line.

The area includes 279 acres of an existing Geothermal Resource Mining Lease R-4 issued to Puna Geothermal Venture.

The existing subzones are identified by Geothermal Resource Mining Lease R-2 issued by the Department of Land and Natural Resources for approximately 816 acres to Kapoho Land Partnership, subleased to Puna Geothermal Venture (Thermal Power Company, Dillingham, Inc. and Amfac) and Geothermal Resource Mining Lease R-3 issued to Barnwell Geothermal Corporation by the Department of Land and Natural Resources for approximately 769 acres. The two subzones are zoned agriculture by the State Land Use Commission.

The Kamaili Section comprised of 5519 acres, is entirely located in agricultural zoned lands. A Natural Area Reserve System (NARS) area is located west of the area and Leilani Estates lie to the east. The 90 percent probability line is to the south. A 2000-foot buffer area has been provided to separate the NARS area to the proposed Kamaili

Section and the conservation district lands lying to the southeast having high quality native forest serve to buffer a portion of the proposed Kamaili area from Leilani Estates.

Kilauea Upper East Rift, Island of Hawaii

This area of approximately 5300 acres shown in Figure 3 has a 90 percent or greater probability of locating high temperature geothermal resources and the prospect of utilizing the resource is good.

Impacts expected to be encountered include the proximity to the Kilauea Volcanoes National Park to the west and the Natural Area Reserve System designation to the east. Additionally, the endangered bird O'u has been identified to habitat the area and high quality native forest are located north of the rift zone. Other impacts include scenic and aesthetic values, air quality, employment and housing needs.

Since early 1983, intermittent volcanic activity centered at Puu O has been taking place in the proposed subzone area. The location of geothermal wells and power plants will be carefully sited on cooled or latent lava flows. When the current eruption activity has ceased, drilling and construction can take place at the risk of the developers. The area includes the Board of Land and Natural Resources authorization for a Conservation District Use Application to the Estate of James Campbell for the exploration of geothermal resources.

In consideration of mitigating the significant impacts expected to be encountered, the proposed area provides for a 2000-foot buffer zone to both the Volcanoes National Park and the Wao Kele O Puna Natural Area Reserve. The proposed subzone area includes only a small portion of the natural forest and encroachment has been minimized to concentrate development activities towards the rift or volcanic flow areas. By limiting the range of the northern boundary, 75% of the potential resource area remains protected and maintained as high-quality native forest.

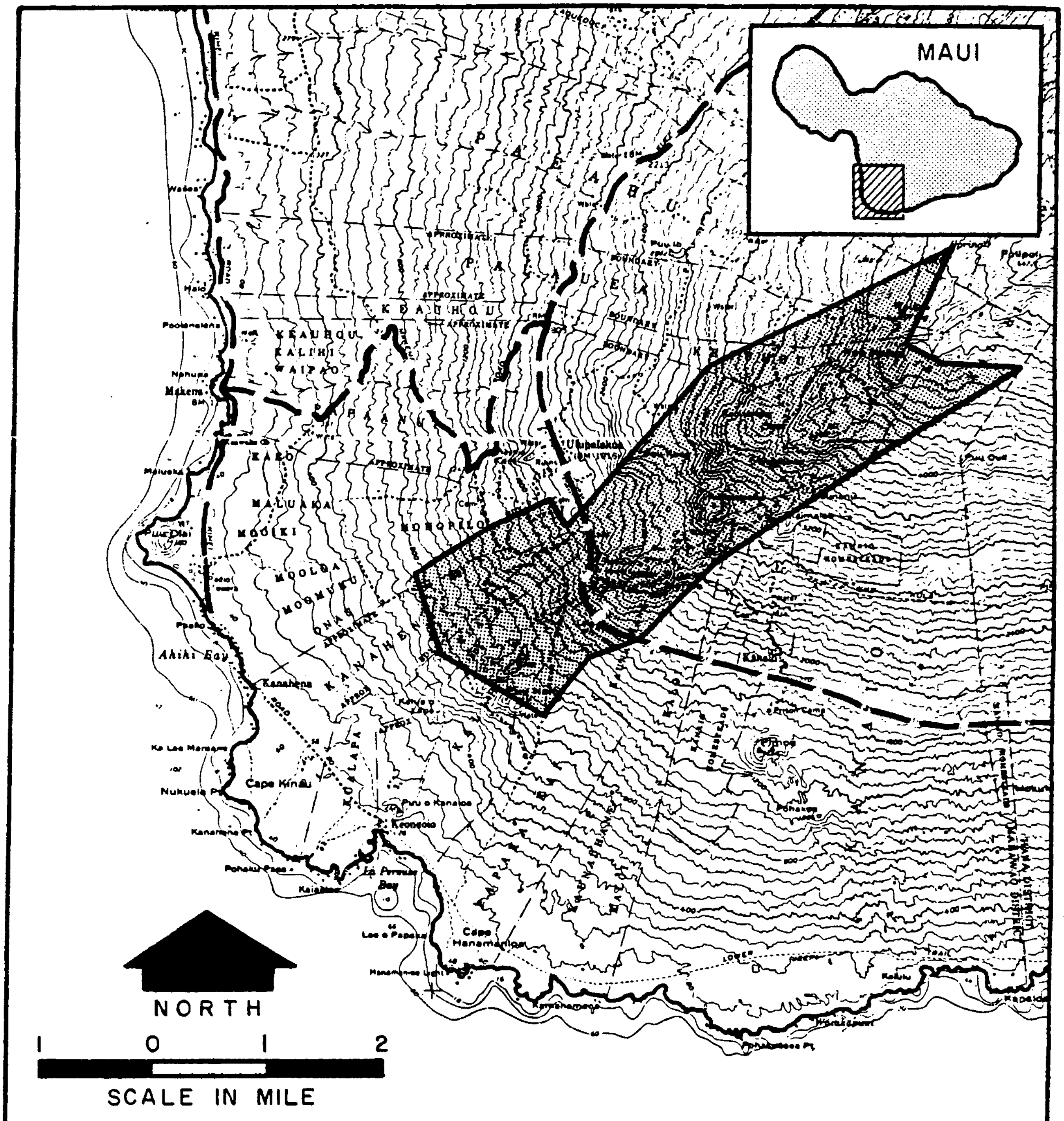
Other potential impacts may be mitigated by subsequent State and County permitting processes on a case-by-case basis.

Haleakala Southwest Rift, Island of Maui

The area covering 4154 acres shown in Figure 4 has a 25 percent probability of locating geothermal resources. It appears to offer the best site on Maui and the prospect for utilizing the resources is good.

Impacts expected are to scenic and aesthetic values. Impacts include noise, lifestyle, culture and community setting, air quality, employment and housing needs.

These impacts may be mitigated through subsequent State and County permitting processes on a case-by-case basis.



PROPOSED GEOTHERMAL RESOURCES SUBZONE

HALEAKALA SOUTHWEST RIFT

Island of Maui

Figure 9.

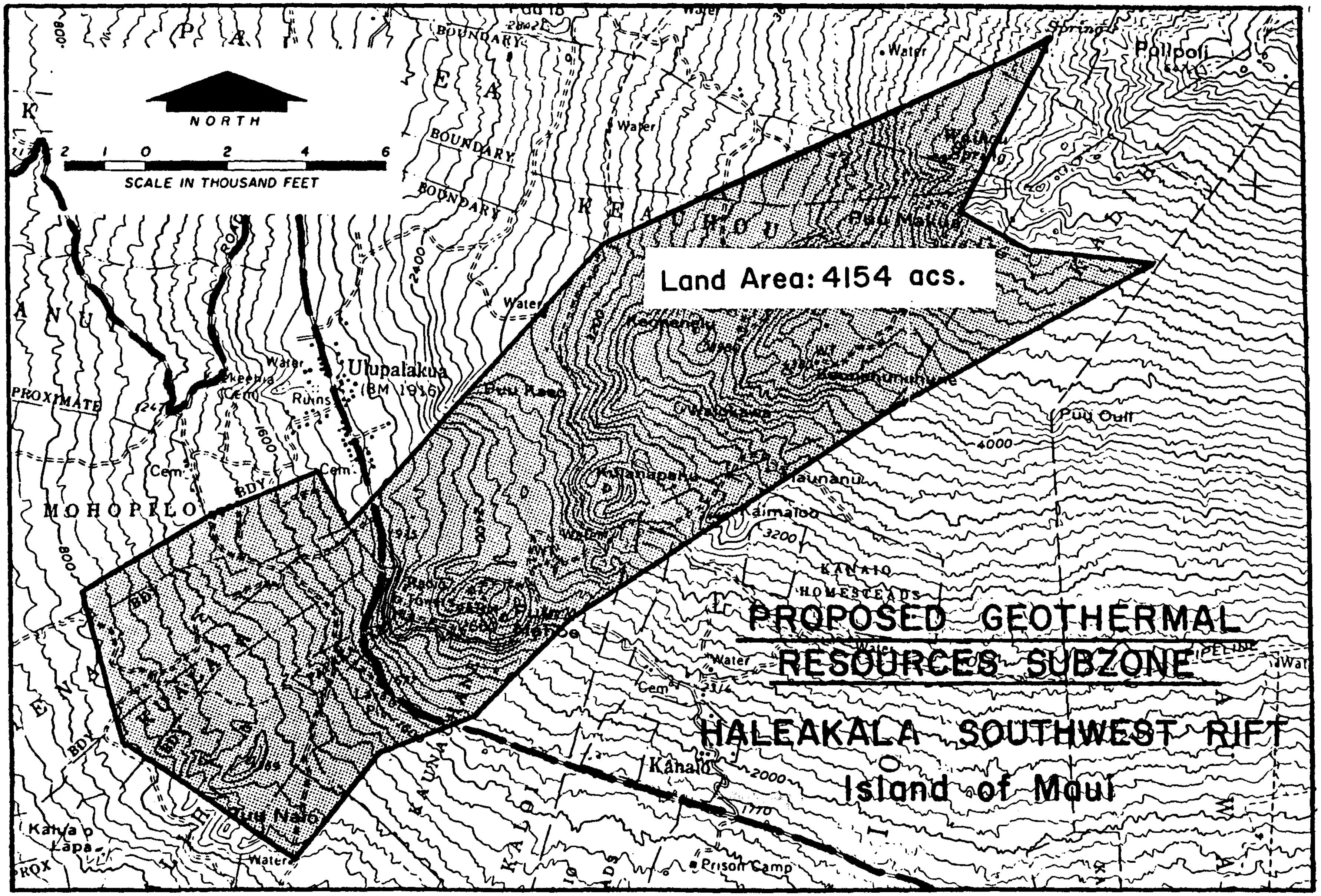
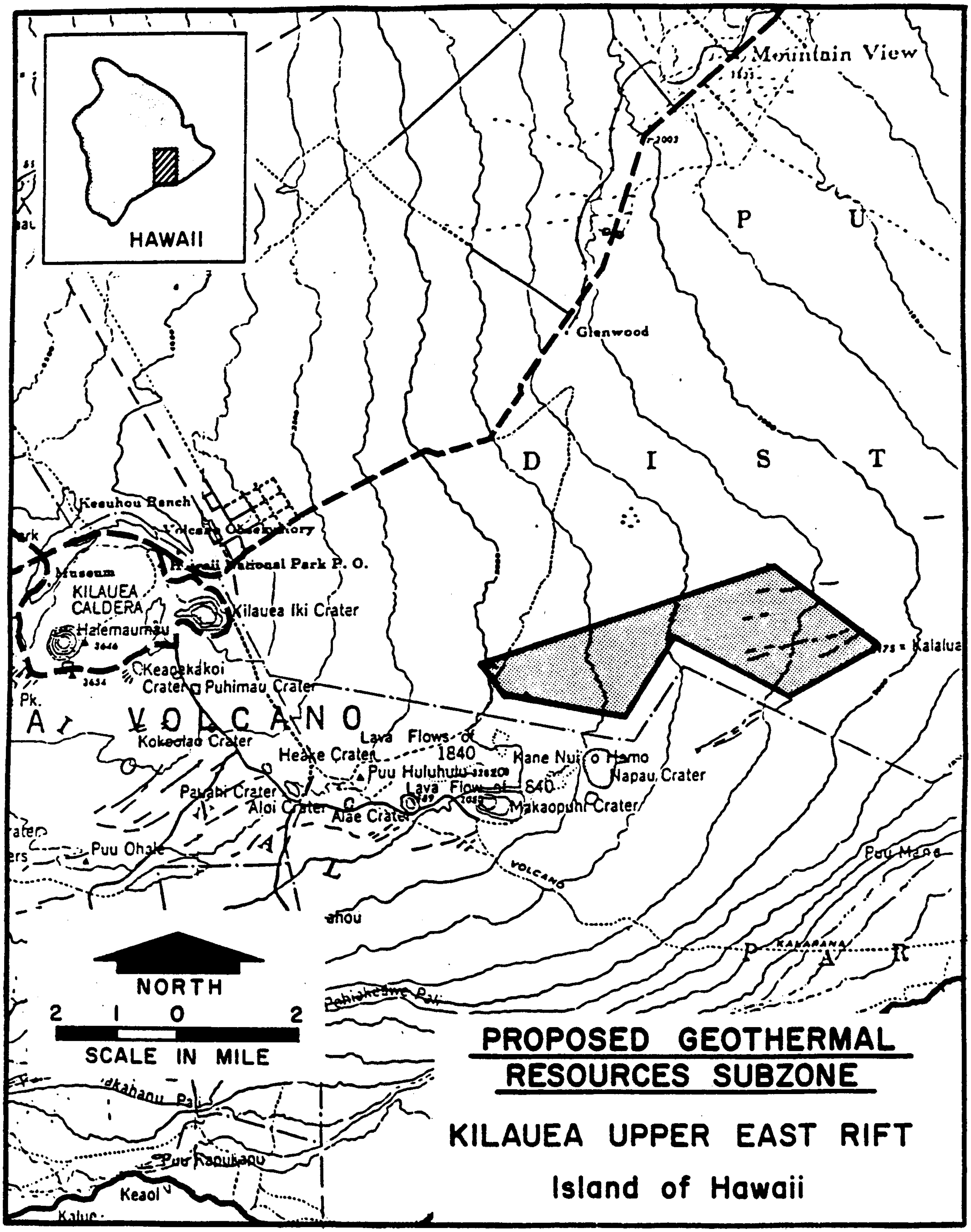

NORTH
2 1 0 2 4 6
SCALE IN THOUSAND FEET
Land Area: 4154 acs.
PROPOSED GEOTHERMAL
RESOURCES SUBZONE
HALEAKALA SOUTHWEST RIFT
Island of Maui
Ulupalakua
(BM 1916)
Puu Nalo
Kahalo
Prison Camp
KANAIO
HOMESTEADS
MOHOPILO
Puu Ouli
Kaimaloo
Kauhanu
Polipoli
Puu Makua
Puu Kaeo
Water
Ruins
Cem.
BOUNDARY
4000
3200
2000
2400
1770

Figure 10.



HAWAII
Mountain View
Glenwood
P U
D I S T
Keauhou Ranch
Hawaii National Park P. O.
Museum
KILAUEA CALDERA
Halemaumau
Kilauea Iki Crater
Keanakakoi Crater
Puhimau Crater
VOLCANO
Kokoolau Crater
Lava Flows of 1840
Heake Crater
Puu Huluhulu
Kane Nui o Hamo
Napau Crater
Pauahi Crater
Aloi Crater
Alae Crater
Lava Flow of 1840
Makaopuhi Crater
Kalalua
Puu Ohale
NORTH
2 1 0 2
SCALE IN MILE
Keaoi
PROPOSED GEOTHERMAL RESOURCES SUBZONE
KILAUEA UPPER EAST RIFT
Island of Hawaii

Figure 11.

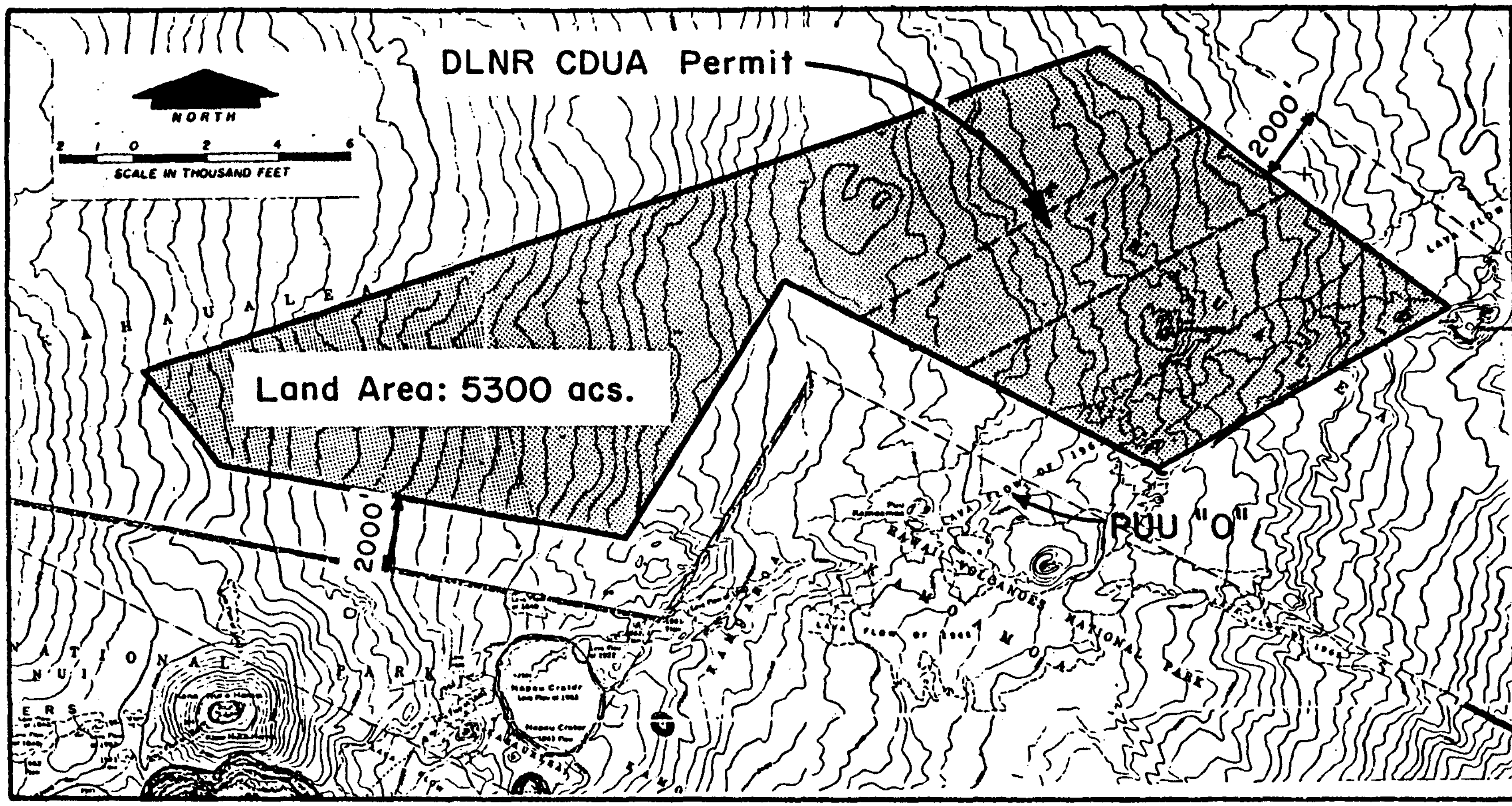


Figure 12.

PROPOSED GEOTHERMAL RESOURCES SUBZONE

KILAUEA UPPER EAST RIFT

Island of Hawaii

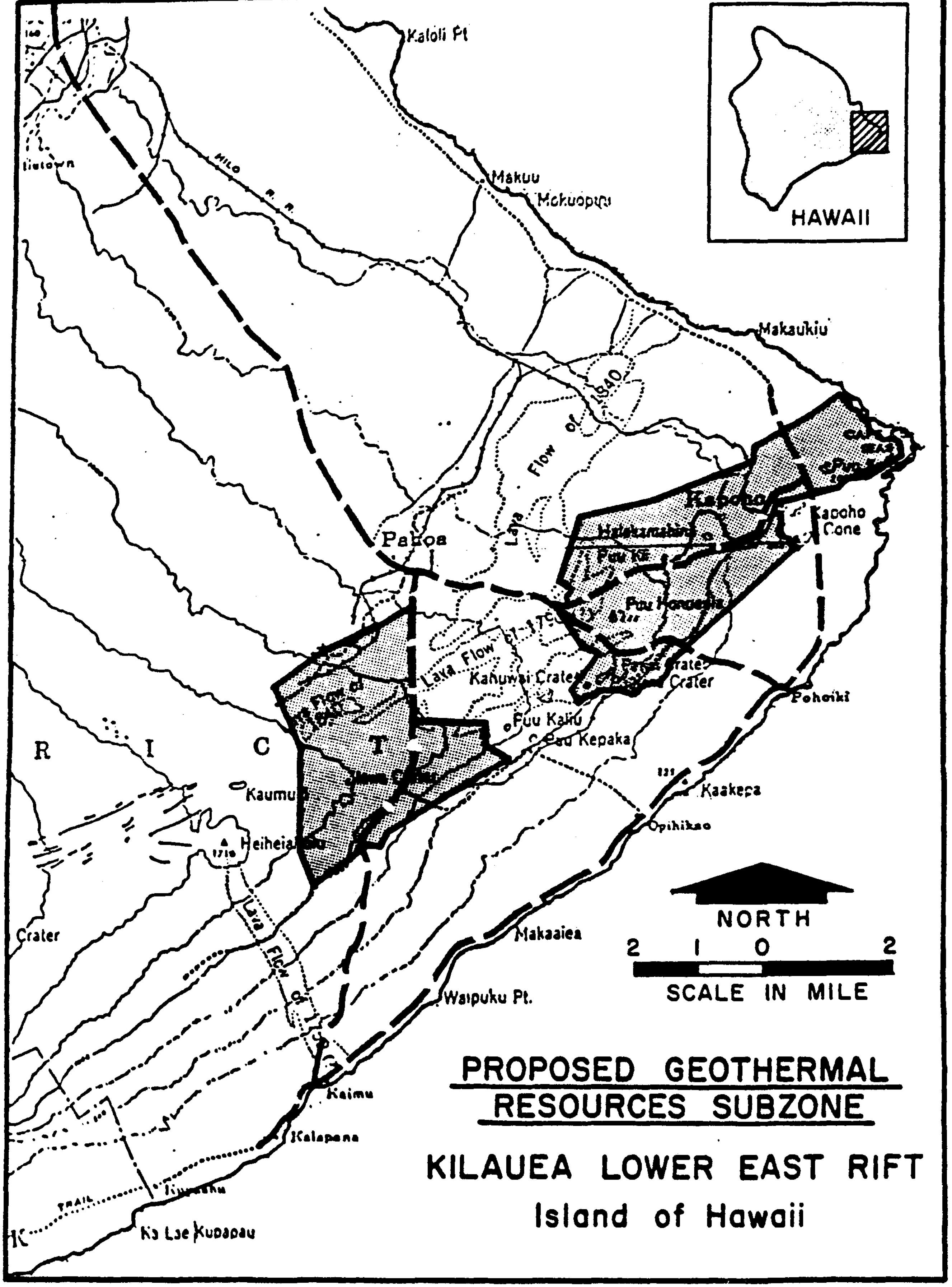

HAWAII
Kaloli Pt
Makuu
Makakiu
Pahoa
Lava Flow of 1840
Kapoho
Kapoho Cone
Puu Kii
Lava Flow
Kahuwai Crater
Crater
Puu Kaliu
Puu Kepaka
Pohoiki
Kaakepa
Opihikao
R I C T
Kaumu
Heiheiahulu
Crater
Makaaiea
Waipuku Pt.
Kaimu
Kalapana
Ka Lae Kupapau
TRAIL
NORTH
2 1 0 2
SCALE IN MILE
PROPOSED GEOTHERMAL
RESOURCES SUBZONE
KILAUEA LOWER EAST RIFT
Island of Hawaii

Figure 13.

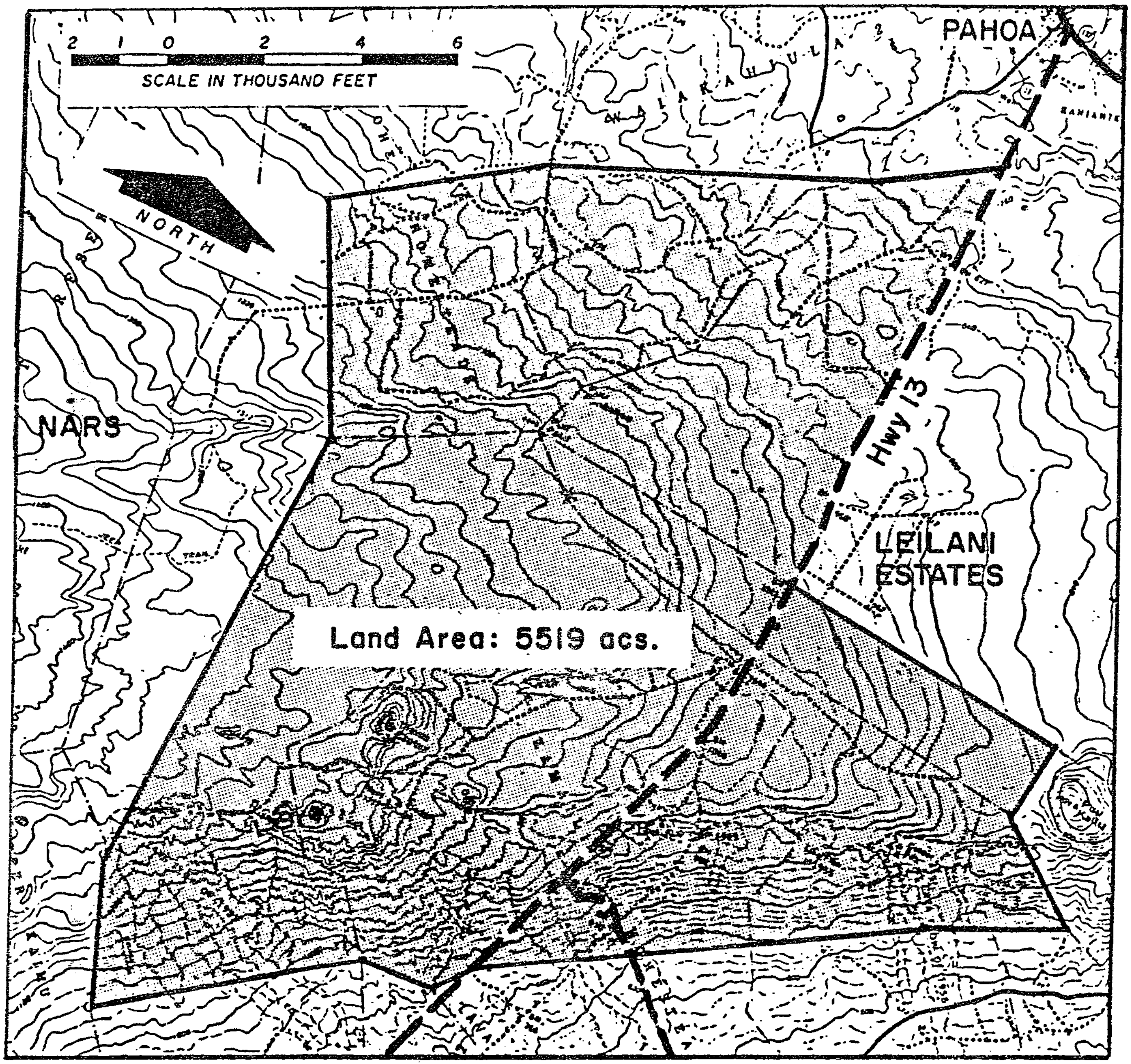
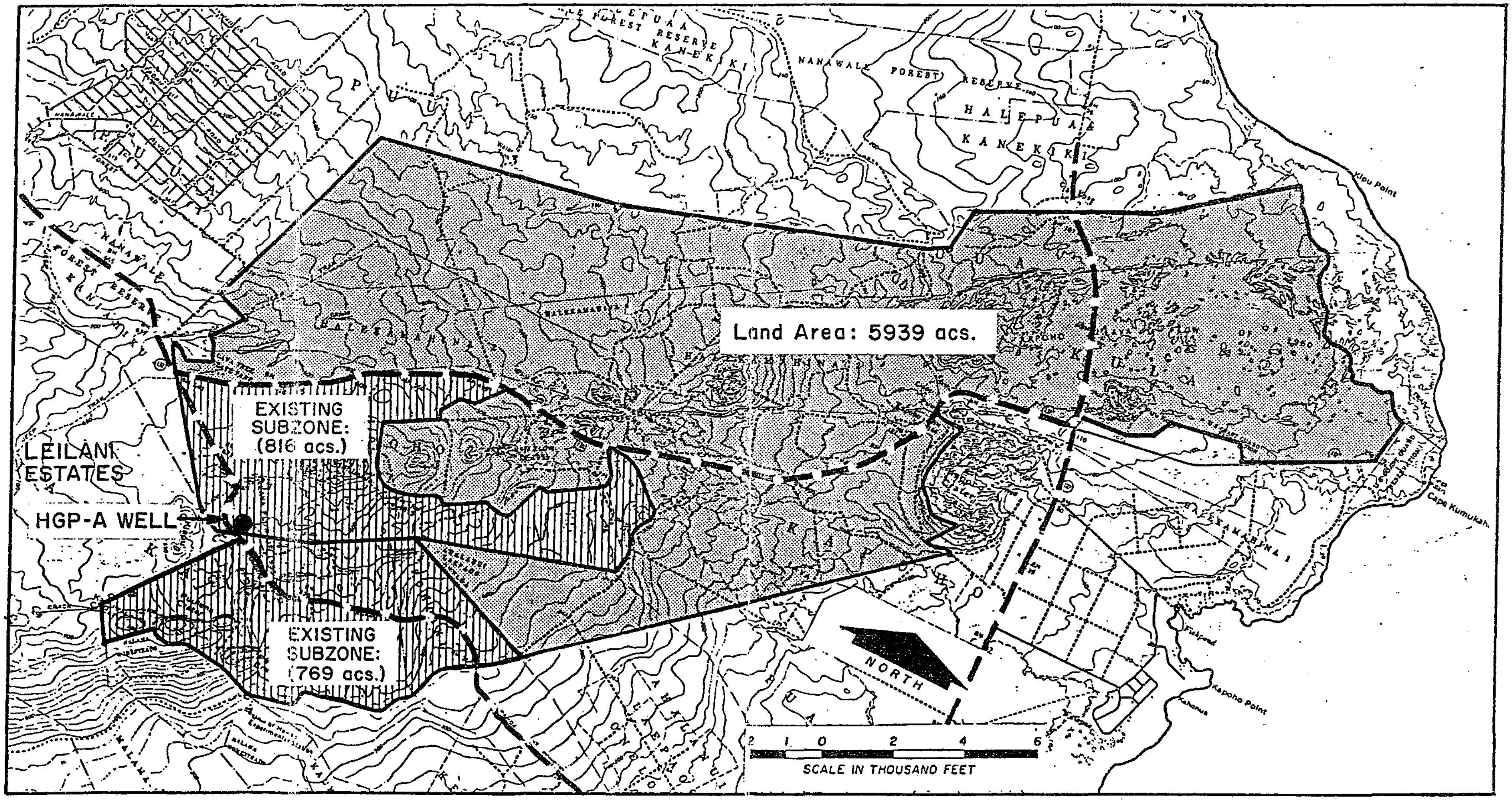


Figure 14.

PROPOSED GEOTHERMAL RESOURCES SUBZONE

KILAUEA LOWER EAST RIFT (KAMAILI SECTION)

Island of Hawaii



PROPOSED GEOTHERMAL RESOURCES SUBZONE

KILAUEA LOWER EAST RIFT (KAPOHO SECTION)

Island of Hawaii

APPENDIX A - ACT 296, SLH 1983

(To be made one and seven copies)
THE SENATE
TWELFTH LEGISLATURE, 19 83
STATE OF HAWAII

ACT 296

S.B. NO. 903 S.D. 1 H.D. 2 C.D. 1

A BILL FOR AN ACT

RELATING TO GEOTHERMAL ENERGY.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. The legislature finds that the development and exploration of Hawaii's geothermal resources is of statewide concern, and that this interest must be balanced with interests in preserving Hawaii's unique social and natural environment. The purpose of this Act is to provide a policy that will assist in the location of geothermal resources development in areas of the lowest potential environmental impact.

SECTION 2. Section 182-4, Hawaii Revised Statutes, is amended to read as follows:

"§182-4 Mining leases on state lands. (a) If any mineral is discovered or known to exist on state lands, any interested person may notify the board of land and natural resources of his desire to apply for a mining lease. The notice shall be accompanied by a fee of $100 together with a description of the land desired to be leased and the

minerals involved and such information and maps as the board by regulation may prescribe. As soon as practicable thereafter, the board shall cause a notice to be published in a newspaper of general circulation in the county where the lands are located, at least once in each of three successive weeks, setting forth the description of the land, and the minerals desired to be leased. The board may hold the public auction of the mining lease within six months from the date of the first publication of notice or such further time as may be reasonably necessary. Whether or not the state land sought to be auctioned is then being utilized or put to some productive use, the board, after due notice of public hearing to all parties in interest, within six weeks from the date of the first publication of notice or such further time as may be reasonably necessary, shall determine whether the proposed mining operation or the existing or reasonably foreseeable future use of the land would be of greater benefit to the State. If the board determines that the existing or reasonably foreseeable future use would be of greater benefit to the State than the proposed mining use of the land, it shall disapprove the application for a mining lease of the land without putting the land to auction.

The board shall determine the area to be offered for lease and, after due notice of public hearing to all parties in interest, may modify the boundaries of the land areas. At least thirty days prior to the holding of any public auction, the board shall cause a notice to be published in a newspaper of general circulation in the State at least once in each of three successive weeks, setting forth the description of the land, the minerals to be leased, and the time and place of the auction. Bidders at the public auction may be required to bid on the amount of annual rental to be paid for the term of the mining lease based on an upset price fixed by the board, a royalty based on the gross proceeds or net profits, cash bonus, or any combination or other basis and under such terms and conditions as may be set by the board.

(b) Any provisions to the contrary notwithstanding, if the person who discovers the mineral discovers it as a result of exploration permitted under section 182-6, and if that person bids at the public auction on the mining lease for the right to mine the discovered mineral and is unsuccessful in obtaining such lease, that person shall be reimbursed by the person submitting the highest bid at public auction for the direct or indirect costs incurred in

the exploration of the land, excluding salaries, attorney fee's and legal expenses. The department shall have the authority to review and approve all expenses and costs that may be reimbursed."

SECTION 3. Chapter 205, Hawaii Revised Statutes, is amended by adding new sections to be appropriately designated and to read as follows:

"§205- Geothermal Resource Subzones. (a) Geothermal resource subzones may be designated within each of the land use districts established under section 205-2. Only those areas designated as geothermal resource subzones may be utilized for the exploration, development, production, and distribution of electrical energy from geothermal sources, in addition to those uses permitted in each land district under this chapter.

(b) The board of land and natural resources shall have the responsibility for designating areas as geothermal resource subzones as provided under section 205- . The designation of geothermal resource subzones shall be governed exclusively by this section and section 205- , except as provided therein. The board shall adopt, amend, or repeal rules related to its authority to designate and regulate the use of geothermal resource subzones in the manner provided under chapter 91.

The authority of the board to designate geothermal resource subzones shall be an exception to those provisions of this chapter and of section 46-4 authorizing the land use commission and the counties to establish and modify land use districts and to regulate uses therein.

(c) The use of an area for the exploration, development, production and/or distribution of electrical energy from geothermal sources within a geothermal resource subzone shall be governed by the board within the conservation district and by existing state and county statutes, ordinances, and rules within the agricultural, rural, and urban districts, except that no land use commission approval shall be required for the use of subzones. The board and/or appropriate county agency shall, upon request, conduct a contested case hearing pursuant to chapter 91 prior to the issuance of a geothermal resource permit relating to the exploration, development, production, and distribution of electrical energy from geothermal resources. The standard for determining the weight of the evidence in a contested case proceeding shall be by a

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preponderance of evidence. Chapters 183, 205A, 226, and 343 shall apply as appropriate.

§205- Designation of areas as Geothermal Resource Subzones. (a) Beginning in 1983, the board of land and natural resources shall conduct a county-by-county assessment of areas with geothermal potential for the purpose of designating geothermal resource subzones. This assessment shall be revised or updated at the discretion of the board, but at least once each five years beginning in 1988. Any property owner or person with an interest in real property wishing to have an area designated as a geothermal resource subzone may submit a petition for a geothermal resource subzone designation in the form and manner established by rules and regulations adopted by the board. An environmental impact statement as defined under chapter 343 shall not be required for the assessment of areas under this section.

(b) The board's assessment of each potential geothermal resource subzone area shall examine factors to include, but not be limited to:

(1) The area's potential for the production of geothermal energy;

(2) The prospects for the utilization of geothermal energy in the area;

(3) The geologic hazards that potential geothermal projects would encounter;

(4) Social and environmental impacts;

(5) The compatibility of geothermal development and potential related industries with present uses of surrounding land and those uses permitted under the general plan or land use policies of the county in which the area is located;

(6) The potential economic benefits to be derived from geothermal development and potential related industries; and

(7) The compatibility of geothermal development and potential related industries with the uses permitted under sections 183-41 and 205-2, where the area falls within a conservation district.

In addition, the board shall consider, if applicable, objectives, policies and guidelines set forth in part I of chapter 205A, and the provisions of chapter 226.

(c) Methods for assessing the factors in subsection (b) shall be left to the discretion of the board and may be based on currently available public information.

(d) After the board has completed a county-by-county assessment of all areas with geothermal potential or after

any subsequent update or review, the board shall compare all areas showing geothermal potential within each county, and shall propose areas for potential designation as geothermal resource subzones based upon a preliminary finding that the areas are those sites which best demonstrate an acceptable balance between the factors set forth in subsection (b). Once such a proposal is made, the board shall conduct public hearings pursuant to this subsection, notwithstanding any contrary provision related to public hearing procedures.

(1) Hearings shall be held at locations which are in close proximity to those areas proposed for designation. A public notice of hearing, including a description of the proposed areas, an invitation for public comment, and a statement of the date, time, and place where persons may be heard shall be published and mailed no less than twenty days before the hearing. The notice shall be published on three separate days in a newspaper of general circulation state-wide and in the county in which the hearing is to be held. Copies of the notice shall be mailed to the department of planning and economic development, and the

planning commission and planning department of the county in which the proposed areas are located.

(2) The hearing shall be held before the board, and the authority to conduct hearings shall not be delegated to any agent or representative of the board. All persons and agencies shall be afforded the opportunity to submit data, views, and arguments either orally or in writing. The department of planning and economic development and the county planning department shall be permitted to appear at every hearing and make recommendations concerning each proposal by the board.

(3) At the close of the hearing, the board may designate areas as geothermal resource subzones or announce the date on which it will render its decision. The board may designate areas as a geothermal resource subzones only upon finding that the areas are those sites which best demonstrate an acceptable balance between the factors set forth in subsection (b). Upon request, the board shall issue a concise statement

of its findings and the principal reasons for its decision to designate a particular area.

(e) The designation of any geothermal resource subzone may be withdrawn by the board of land and natural resources after proceedings conducted pursuant to the provisions of chapter 91. The board shall withdraw a designation only upon finding by a preponderence of the evidence that the area is no longer suited for designation, provided that the designation shall not be withdrawn for areas in which active exploration, development, production or distribution of electrical energy from geothermal sources is taking place.

(f) This Act shall not apply to any active exploration, development or production of electrical energy from geothermal sources taking place on the effective date of the Act, provided that any expansion of such activities shall be carried out in compliance with its provisions."

SECTION 4. Statutory material to be repealed is bracketed. New material is underscored.

SECTION 5. If any provision of this Act, or the application thereof to any person or circumstance is held invalid, the invalidity does not affect other provisions or applications of the Act which can be given effect without the invalid provision or application, and to this end the provisions of this Act are severable.

SECTION 6. This Act shall take effect upon its approval.

Approved by the Governor on JUN 14 1983

APPENDIX B - ADMINISTRATIVE RULES

Title 13, Department of Land and Natural Resources

Sub-Title 7. Water and Land Development

Chapter 184, Designation and Regulation of Geothermal Resource Subzones

Rules Amending Title 13, Administrative Rules

July 13, 1984

SUMMARY

Title 13, Administrative Rules, is amended by adding a new Chapter 184 entitled, "Designation and Regulation of Geothermal Resource Subzones".

TITLE 13

DEPARTMENT OF LAND AND NATURAL RESOURCES

SUB-TITLE 7. WATER AND LAND DEVELOPMENT

Chapter 184

Designation and Regulation of Geothermal Resource Subzones

Subchapter 1. General

Subchapter 2. Designation of Geothermal Resource Subzones

Subchapter 3. Regulation of Geothermal Resource Subzones

Subchapter 1

General

§13-184-1 Purpose. The purpose of this chapter is to establish guidelines and procedures for the designation and regulation of geothermal resource subzones for the exploration, discovery, development, and production of geothermal resources for electrical energy production and distribution within conservation, agricultural, rural, and urban districts. These guidelines and procedures are intended to assist in designating areas which have potential for geothermal resource development for electrical energy production and which have an acceptable balance of the relationships of geothermal development to uses allowed in the land use classifications, to present uses of surrounding lands, to potential benefits, and to impacts. [Eff. Aug. 16, 1984 (Auth: HRS §205-5.1) (Imp: HRS §205-5.1)

§13-184-2 Definitions. As used in this chapter:

"Board" means the board of land and natural resources.

"Chairperson" means the chairperson of the board of land and natural resources or a designated representative.

"Department" means the department of land and natural resources.

"Geothermal resource" means the natural heat of the earth, the energy, in whatever form, below the surface of the earth present in, resulting from, or created by, or which may be extracted from such natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, steam and associated gases, in whatever form, found below the surface of the earth.

"Geothermal resource subzone" means any area designated by the board as provided in this chapter for use of geothermal resource exploration, discovery, development, production, and distribution for useful purposes in addition to those uses permitted in each land district under chapter 205 of the Hawaii Revised Statutes.

"GRS" means geothermal resource subzone.

"Operator" means any person as defined herein engaged in drilling, maintaining, operating, producing or managing any geothermal well and appurtenances, geothermal research facility, and geothermal production or utilization facility including electric power plant. [Eff. AUG 16 1984] (Auth: HRS §205-5.1) (Imp: HRS §205-5.1)

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§13-184-3 Subzone objectives. The establishment and regulation of geothermal resource subzones is intended to facilitate the exploration, development, and use of geothermal resources in those areas of the State where such activities will serve, in overall perspective, the best interest of the State, premised upon the criteria set forth in section 13-184-6. The major objectives are:

(1) To allow the utilization of geothermal energy for beneficial purposes, particularly electrical power generation, which would help achieve the State's goal of energy self-sufficiency and broaden the State's economic base through development of a natural resource;

(2) To allow geothermal exploration, discovery, development, production and utilization activities to potential or known geothermal areas of the State where such activities would be of greater benefit to the state than the existing or reasonably foreseeable future use of such areas; and

(3) To allow geothermal exploration, discovery, development, production and utilization activities to potential or known geothermal areas of the State which best demonstrate an acceptable balance among the criteria set forth in §13-184-6. [Eff. AUG 16 1984] (Auth: HRS §205-5.1) (Imp: HRS §205-5.1)

Subchapter 2

Designation of Geothermal Resource Subzones

§13-184-4 Board initiated subzone designation. Beginning in 1983, and prior to the designation of any area as a geothermal resource subzone, the board shall first make or cause to be made a county-by-county assessment of those areas within the State which have potential for geothermal exploration, discovery, development or production. The methods to be used for making the assessments shall be left to the discretion of the board, provided that the board shall as a minimum consider the criteria set forth in section 13-184-6. The board may in its discretion base its methods for assessment on currently available public information. Where applicable, the board shall consider the objectives, policies and guidelines set forth in part I of chapter 205A, HRS and the provisions of chapter 226, HRS.

The initial county-by-county assessments of areas with geothermal potential shall be revised or updated by the board at least once every five years beginning in 1988, or at any lesser interval of years at the discretion of the board. [Eff. AUG 16 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-5 Landowner initiated subzone designation. In addition to designations initiated by the board, any property owner, geothermal mining lessee, or person with an interest in real property may initiate an application for designation of any area with geothermal potential as a geothermal resource subzone by specifying the area to the board. The application shall be accompanied by the following information:

(1) Names and addresses of the applicant, operator, owner of the geothermal mineral rights, landowner if not the same as the applicant, and the geothermal lease number, if applicable;
(2) Evidence and certification that the applicant is qualified to submit such a petition.
(3) An accurate description and map of the area desired to be designated as a geothermal resource subzone;
(4) A statement by applicant of the purpose, justification, and need for designation; and
(5) An assessment report based on the criteria set forth in section 13-184-6 and any other information to support the proposed designation.

Applications for geothermal resource subzones shall be submitted to the department for approval by the board. Each application shall be accompanied by a filing fee of $100.00. The chairperson shall review the application for completeness and may request additional information deemed necessary to process the application for board approval. The chairperson shall notify the applicant in writing of the acceptance of the completed application. Within 180 days of the written notification of acceptance of the application, the board shall publish notice of and hold public hearings and render a decision on designating any part or all of the area requested for designation as a geothermal resource subzone. If the request for geothermal resource subzone is denied, the board shall state its reason for its decision. If the board fails to hold a hearing and render a decision within 180 days after issuance of the notice of acceptance of the application, the application is deemed approved subject to the conditions of section 13-184-11. [Eff. AUG 16 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-6 Criteria for designation of subzones. The board, in designating an area as a geothermal resource subzone, shall be guided by the selection of those areas that can demonstrate an acceptable balance among the criteria set forth below:

(1) That the area has known or plausible potential for the exploration, discovery, or production of geothermal resource;

(2) That there is a known or likely prospect for the utilization of geothermal resources for electrical energy production and distribution.
(3) That any potential geologic hazards to geothermal production or use in the proposed area are examined.
(4) That any environmental or social impacts of the development of geothermal resources within the proposed area be considered;
(5) That the compatibility of development and utilization of geothermal resources within the proposed area is considered with other allowed uses within the area and within the surrounding lands;
(6) That the potential benefits to be derived from geothermal development and utilization in the proposed area be in the interest of the county or counties involved and the State as a whole. [Eff. AUG 16 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-7 Environmental impact statement not required. An environmental impact statement as defined under chapter 343, Hawaii Revised Statutes, shall not be required in assessing any area proposed for designation as a geothermal resource subzone. [Eff. AUG 16 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-8 Notice and public hearings. When the board or a landowner proposes an area for designation as a geothermal resource subzone, the board shall hold a public hearing in reasonably close proximity to the proposed area and publish a notice of the public hearing setting forth:

(1) A description of the proposed area;
(2) An invitation for public comment; and
(3) The date, time, and place of the public hearing where written or oral testimony may be submitted or heard.

Such notice shall be published on three separate days in a newspaper of general circulation statewide and in the county in which the public hearing is to be held. The first publication shall be not less than twenty nor more than thirty days before the date set for the hearing. Copies of the notice shall be mailed to the state department of planning and economic development and the planning commission and planning department of the county in which the proposed area is located.

Publication of the notice of public hearing shall be considered sufficient notice to all landowners and persons who might be affected by the proposed designation.

The public hearing shall be held before the board and the conduct of the public hearing shall not be delegated to any agent or representative of the board. All persons and agencies shall be afforded the opportunity to submit data, views, and arguments whether orally or in writing. The department of planning and economic development and the affected county planning department shall be permitted to appear at the public hearing and make recommendations concerning the proposal to designate an area. [Eff. AUG 1 6 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-9 Decision of the board. At the close of the public hearing, the board shall consider all the testimony and after deliberation make a decision to designate any portion, all or none of the proposed area or announce the date on which it will render its decision. The board may designate a proposed area as a geothermal resource subzone only if it finds the proposed area possesses an acceptable balance of the criteria set forth in section 13-184-6. If the board designates an area as a geothermal resource subzone it shall cause a notice of its decision to be published in a newspaper of general circulation statewide and in a newspaper of general circulation in the county in which the area is located and when so published its decision shall be final unless otherwise ruled invalid by a court of appropriate jurisdiction. Upon request, the board shall issue a concise statement of its findings and the principal reasons for its decision to designate a particular area. [Eff. AUG 1 6 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-10 Modification and withdrawal of existing subzones. Modification of the boundaries or the withdrawal of an existing designated geothermal resource subzone by the board may be initiated by the board or by application of the appropriate County, landowner or person having a geothermal mining interest in the land. The procedure for modifying the boundaries or withdrawal of an existing designated geothermal resource subzone shall be conducted pursuant to the provisions of chapter 91, HRS; provided, however, that within an existing subzone with active geothermal exploration, development, production or use, the area may not be modified or withdrawn. An environmental impact statement as defined under chapter 343, HRS, shall not be required in assessing any modification of the boundaries or withdrawal of subzones. [Eff. AUG 1 6 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

Subchapter 3

Regulation of Geothermal Resource Subzones

§13-184-11 Administration of subzones. Geothermal resource subzones designated by the board in any of the four land use districts; conservation, agricultural, rural, and urban shall be administered as follows:

(1) The board shall regulate the use of lands designated as geothermal resource subzones for geothermal resource activities that lie within conservation districts in accordance with chapter 205, Hawaii Revised Statutes and chapter 13-2, Administrative Rules of the department of land and natural resources.

(2) The appropriate county authority shall regulate the use of geothermal resource subzones that lie within urban, agricultural, or rural districts. [Eff. AUG 1 6 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-12 Contested case hearings. A contested case hearing shall, upon request, be conducted by the board or the appropriate county agency pursuant to chapter 91 of the Hawaii Revised Statutes. [Eff. AUG 1 6 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

§13-184-13 Effective date and applicability. This chapter shall not apply to any active exploration, development or production of electrical energy from geothermal sources taking place on June 14, 1983, the effective date of Act 296, SLH 1983; provided further that any expansion of activities shall be carried out in compliance with the provisions of this chapter. Active exploration, development or production of electrical energy from geothermal sources on the effective date of Act 296, SLH 1983 includes those activities relating to exploration, development or production of electrical energy from geothermal sources permitted and approved on or before June 14, 1983. [Eff. AUG 1 6 1984] (Auth: HRS §205-5.2) (Imp: HRS §205-5.2)

The amendment to Title 13, Administrative Rules, on the Summary Page dated July 13, 1984, was adopted on July 13, 1984, following public hearings held on Oahu, Hilo, Maui, and Kauai on May 22, 1984, after public notice was given in the Honolulu Star Bulletin on April 26, 1984; Hawaii Tribune Herald on April 26, 1984; Maui News on April 26, 1984; and The Garden Island on April 25, 1984.

These rules shall take effect ten days after filing with the Office of the Lieutenant Governor.

SUSUMU ONO, Chairperson
Board of Land & Natural Resources

Member
Board of Land & Natural Resources

GEORGE R. ARIYOSHI
GOVERNOR
STATE OF HAWAII

Dated: August 3, 1984

APPROVED AS TO FORM:

Deputy Attorney General

Filed

APPENDIX C - ACT 151, SHL 1984

THE SENATE
TWELFTH LEGISLATURE, 19 84
STATE OF HAWAII

S.B. NO. 2194-84
S.D. 1
H.D. 1
C.D. 1

A BILL FOR AN ACT

RELATING TO GEOTHERMAL ENERGY.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. The legislature finds that the rights of lessees holding geothermal mining leases issued by the state or geothermal developers holding exploratory and/or development permits from either the state or county government need to be clarified. The legislature finds that the respective roles of the state and county governments in connection with the control of geothermal development within geothermal resource subzones need to be clarified also. The purpose of this Act is to provide such further clarification.

SECTION 2. Section 205-5.1, Hawaii Revised Statutes, is amended to read as follows:

"[[]§205-5.1[]] Geothermal resource subzones. (a) Geothermal resource subzones may be designated within [each of] the urban, rural, agricultural and conservation land use districts established under section 205-2. Only those areas

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designated as geothermal resource subzones may be utilized for [the exploration, development, production, and distribution of electrical energy from geothermal sources,] geothermal development activities in addition to those uses permitted in each land use district under this chapter. Geothermal development activities may be permitted within urban, rural, agricultural, and conservation land use districts in accordance with this chapter. "Geothermal development activities" means the exploration, development or production of electrical energy from geothermal resources.

(b) The board of land and natural resources shall have the responsibility for designating areas as geothermal resource subzones as provided under section 205-5.2[.]; except that the total area within an agricultural district which is the subject of a geothermal mining lease approved by the board of land and natural resources, any part or all of which area is the subject of a special use permit issued by the county for geothermal development activities, on or before the effective date of this Act is hereby designated as a geothermal resource subzone for the duration of the lease. The designation of geothermal resource subzones shall be governed exclusively by this section and section 205-5.2, except as provided therein. The board shall adopt, amend, or repeal rules related to its authority to designate and regulate the use of geothermal resource subzones in the manner provided under chapter 91.

The authority of the board to designate geothermal resource subzones shall be an exception to those provisions of this chapter and of section 46-4 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.

(c) The use of an area for [the exploration,] geothermal development[, production and/or distribution of electrical energy from geothermal sources] activities within a geothermal resource subzone shall be governed by the board within the conservation district and, except as herein provided, by [existing] state and county statutes, ordinances, and rules not inconsistent herewith within [the] agricultural, rural, and urban districts, except that no land use commission approval or special use permit procedures under section 205-6 shall be required for the use of such subzones. [The board and/or appropriate county agency shall, upon request, conduct a contested case hearing

pursuant to chapter 91 prior to the issuance of a geothermal resource permit relating to the exploration, development, production, and distribution of electrical energy from geothermal resources. The standard for determining the weight of the evidence in a contested case proceeding shall be by a preponderance of evidence.] In the absence of provisions in the county general plan and zoning ordinances specifically relating to the use and location of geothermal development activities in an agricultural, rural, or urban district, the appropriate county authority may issue a geothermal resource permit to allow geothermal development activities. "Appropriate county authority" means the county planning commission unless some other agency or body is designated by ordinance of the county council. Such uses as are permitted by county general plan and zoning ordinances, by the appropriate county authority, shall be deemed to be reasonable and to promote the effectiveness and objectives of this chapter. Chapters 177, 178, 182, 183, 205A, 226, 342, and 343 shall apply as appropriate. If provisions in the county general plan and zoning ordinances specifically relate to the use and location of geothermal development activities in an agricultural, rural, or urban district, the provisions shall require the appropriate county authority to conduct a public hearing and, upon appropriate request, a contested case hearing pursuant to chapter 91, on any application for a geothermal resource permit to determine whether the use is in conformity with the criteria specified in section 205-5.1(e) for granting geothermal resource permits.

(d) 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.

(e) If geothermal development activities are proposed within agricultural, rural, or urban districts and such proposed activities are not permitted uses pursuant to county general plan and zoning ordinances, then after receipt of a properly filed and completed application, the appropriate county authority shall conduct a public hearing and, upon appropriate request, a contested case hearing pursuant to chapter 91 to determine whether a geothermal resource permit shall be granted to authorize the geothermal

development activities described in the application. The appropriate county authority shall grant a geothermal resource permit if it finds that applicant has demonstrated by a preponderance of the evidence that:

(1) The desired uses would not have unreasonable adverse health, environmental, or socio-economic effects on residents or surrounding property; and

(2) The desired uses would not unreasonably burden public agencies to provide roads and streets, sewers, water, drainage, school improvements, and police and fire protection; and

(3) That there are reasonable measures available to mitigate the unreasonable adverse effects or burdens referred to above.

Unless there is a mutual agreement to extend, a decision shall be made on the application by the appropriate county authority within six months of the date a complete application was filed; provided that if a contested case hearing is held, the final permit decision shall be made within nine months of the date a complete application was filed."

SECTION 3. Notwithstanding the provisions of section 205-5.2, Hawaii Revised Statutes, regarding county-by-county assessment of areas with geothermal potential, the board of land and natural resources shall separately conduct an assessment of the area described on maps attached to the board of land and natural resources decision and order, dated February 25, 1983, which was the subject of a conservation district use permit. The assessment shall be in accordance with all provisions of Act 296, Session Laws of Hawaii 1983, regarding the procedures and standards for designation of an area as a geothermal resource subzone. The board of land and natural resources shall make its determination regarding the designation of all or any portion of the abovementioned area, as a geothermal resource subzone, on or before December 31, 1984.

SECTION 4. If any provision of this Act or the application thereof to any person or circumstance is held invalid, the invalidity does not affect other provisions or applications of the Act which can be given effect without the invalid provision or application, and to this end the provisions of this Act are severable.

SECTION 5. Statutory material to be repealed is bracketed. New material is underscored.

SECTION 6. This Act shall take effect upon its approval.

Approved ... 25 1984

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APPENDIX D - GEOTHERMAL RESOURCE TECHNICAL COMMITTEE

The Geothermal Resource Technical Committee

MANABU TAGOMORI, P.E. (Chairman)
Engineer
Dept. of Land & Natural Resources
State of Hawaii

DONALD THOMAS, Ph. D.(Tech. Leader)
Geochemist
Hawaii Institute of Geophysics
University of Hawaii - Manoa

BILL CHEN, Ph. D.
Engineer
Dept. of Computer Sciences
University of Hawaii - Hilo

DANIEL LUM
Geologist
Dept. of Land & Natural Resources
State of Hawaii

DALLAS JACKSON
Geophysicist
Hawaiian Volcano Observatory
U.S. Geological Survey

RICHARD MOORE, Ph. D.
Geologist
Hawaiian Volcano Observatory
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JAMES KAUAHIKAUA, Ph. D.
Geophysicist
U.S. Geological Survey
Honolulu, Hawaii

JOHN SINTON, Ph. D.
Geologist
Hawaii Institute of Geophysics
University of Hawaii - Manoa

* * * * * * * * * * *

Staff
Division of Water and Land Development

DEAN NAKANO, Geologist

JOSEPH KUBACKI, Energy Specialist

APPENDIX E - REFERENCES

REFERENCES

State of Hawaii, Department of Land and Natural Resources, September 1983, Plan of Study for Designating Geothermal Resource Subzones, Circular C-97.

______, ______, January 1984, Assessment of Available Information Relating to Geothermal Resources in Hawaii, Circular C-98.

______, ______, March 1984, Public Participation and Information Program for Designation Geothermal Resource Subzones, Circular C-99.

______, ______, March 1984, Geothermal Resource Developments, Circular C-100.

______, ______, June 1981, Rules on Leasing and Drilling of Geothermal Resources, Chapter 183 of Title 13, Administrative Rules.

______, ______, July 1984, Statewide Geothermal Resource Assessment, Circular C-103.

______, ______, July 1984, Social Impact Analysis, Circular C-104.

______, ______, July 1984, Economic Impact Analysis, Circular C-105.

______, ______, August 1984, Environmental Impact Analysis, Circular C-106.

______, ______, July 1984, Geologic Hazards Impact Analysis of Potential Geothermal Resource Areas, Circular C-107.

______, ______, August 1984, Geothermal Technology, Circular C-108.