

PROPOSAL  
for  
Designating Geothermal Resource Subzones  
by the  
Board of Land and Natural Resources



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

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Honolulu, Hawaii  
July 1984



GEORGE R. ARIYOSHI  
Governor

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Division of Water and Land Development



## PREFACE

This proposal for designating geothermal resource subzones by the Board of Land and Natural Resources summarizes the results of a statewide assessment of potential geothermal resource areas which best demonstrate an acceptable balance of factors set forth in Act 296, SLH 1983.

The assessment was conducted by the staff of the Division of Water and Land Development with the participation of an interagency technical committee; federal, state, and county agencies; private industry; and the general public.

This proposal is published for review by the public and to receive comments at the public hearings scheduled at the following dates, places, and time:

August 7, 1984 - Pahoa Elementary School Cafetorium,  
Pahoa, Hawaii - 7:00 p.m.

August 8, 1984 - Hilo State Office Conference Room,  
Hilo, Hawaii - 9:00 a.m.

August 8, 1984 - Hawaii Volcanoes National Park,  
Visitor Center Auditorium - 7:00 p.m.

August 9, 1984 - Kula Elementary School,  
Kula Highway, Maui - 7:00 p.m.

BOARD OF LAND AND NATURAL RESOURCES /



## ACKNOWLEDGEMENTS

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

Puna Community Council  
Volcano Community Association  
Ulupalakua and Kanaio Residents  
Environment Capital Managers, Inc.  
Hawaii County Department of Planning  
Maui County Department of Public Works  
Hawaiian Electric Company, Inc.  
Hilo Electric and Light Company  
Maui Electric Company, Ltd.  
Barnwell Geothermal Corporation  
Puna Joint Venture  
True Geothermal Energy Company  
Mid-Pacific Geothermal, Inc.  
Geothermal Resources Technical Committee  
Department of Health  
Department of Planning & Economic Development  
Hawaii Institute of Geophysics  
University of Hawaii  
Hawaii 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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### PUBLIC INFORMATION MEETINGS

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 the meetings:

May 8, 1984	- Hilo, Hawaii
May 9, 1984	- Kahului, Maui
May 29, 1984	- Hilo, Hawaii
May 30, 1984	- Kahului, Maui
July 10, 1984	- Pahoia Community Council
July 11, 1984	- Volcano Community Association

The Board acknowledges all the persons who participated in the public information and participation meetings.



## CONCLUSIONS AND RECOMMENDATIONS

Based upon currently available information on geothermal resources, twenty separate areas in the State of Hawaii were identified as having potential geothermal resources. Of these, five sites on the island of Hawaii and two on the island of Maui were determined to have sufficient probability of locating high temperature geothermal resources with the potential of producing electrical energy. High temperature is defined to be greater than 125 degree celsius or 257 degree fahrenheit at depths less than 3 kilometers or 9,840 feet. After subjecting the seven areas to impact analysis by examining factors on geologic hazards, social and environmental impacts, compatibility with present uses of surrounding land, potential economic benefits, and compatibility with conservation areas, it is concluded that three areas warrant consideration for designation of geothermal resource subzones by the Board of Land and Natural Resources under authority of Act 296, SLH 1983 and Act 151, SLH 1984. The areas are described below.

### Kilauea Lower East Rift, Island of Hawaii

This area shown in Figure 1 identifies two separate sites, the Kapoho section and the Kamaili section. The percent probability of locating high temperature geothermal resources has been estimated to be greater than 90 percent and the prospect for utilizing this resource 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 the resources.

The area contains two subzones established by the Legislature in Act 151, SLH 1984.

The proposed areas provide for an approximate 2000-foot buffer zones to sensitive environmental areas, such as the Natural Area Reserve System and sensitive forest areas.

Moderate impacts are expected in scenic and aesthetic values, air quality, employment and housing needs. These impacts can be reasonably expected to be mitigated in subsequent State and County permitting processes on a case-by-case basis.

#### Kilauea Upper East Rift, Island of Hawaii

This area shown in Figure 2 has a 90 percent or greater probability of locating high temperature geothermal resources and the prospect of utilizing the resource is good.

Significant 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. Moderate impacts include scenic and aesthetic values, air quality, employment and housing needs.

Since early 1983, active volcanic activity centered on Puu O has been taking place in the area. The current volcanic flows are viewed as temporary in nature and when the activity ceases, drilling over the volcanic flow is considered feasible and desirable considering the effects on other environmental values in the surrounding areas.

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 2,000-foot buffer area to both the Volcanoes National Park and the Natural Area Reserve System. In addition, the encroachment into the native forest area has been minimized to concentrate exploration, development, and production activities towards the rift or volcanic flow areas. The northern boundary extends approximately 25 percent into the native forest area.

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

#### Haleakala Southwest Rift, Island of Maui

The area shown in Figure 3 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.

Significant impacts expected are the scenic and aesthetic values. Moderate impacts include noise, lifestyle, culture and community setting, air quality, employment and housing needs.

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

#### Recommendations

Based upon the above conclusions, the Board of Land and Natural Resources proposes to designate the following areas as geothermal resource subzones for the purpose of exploration, development, and production of geothermal resources:

- \* Kilauea Lower East Rift, Island of Hawaii
- \* Kilauea Upper East Rift, Island of Hawaii
- \* Haleakala Southwest Rift, Island of Maui

The specific areas are mapped and identified in Figures 1, 2, and 3.



## Kamaili Section

Total area: 5519 acres

## Kapoho Section

Total area: 7524 acres

Area: 816 acres

Existing Subzones

Area: 769 acres

Figure 1.

## Kilauea Lower East Rift

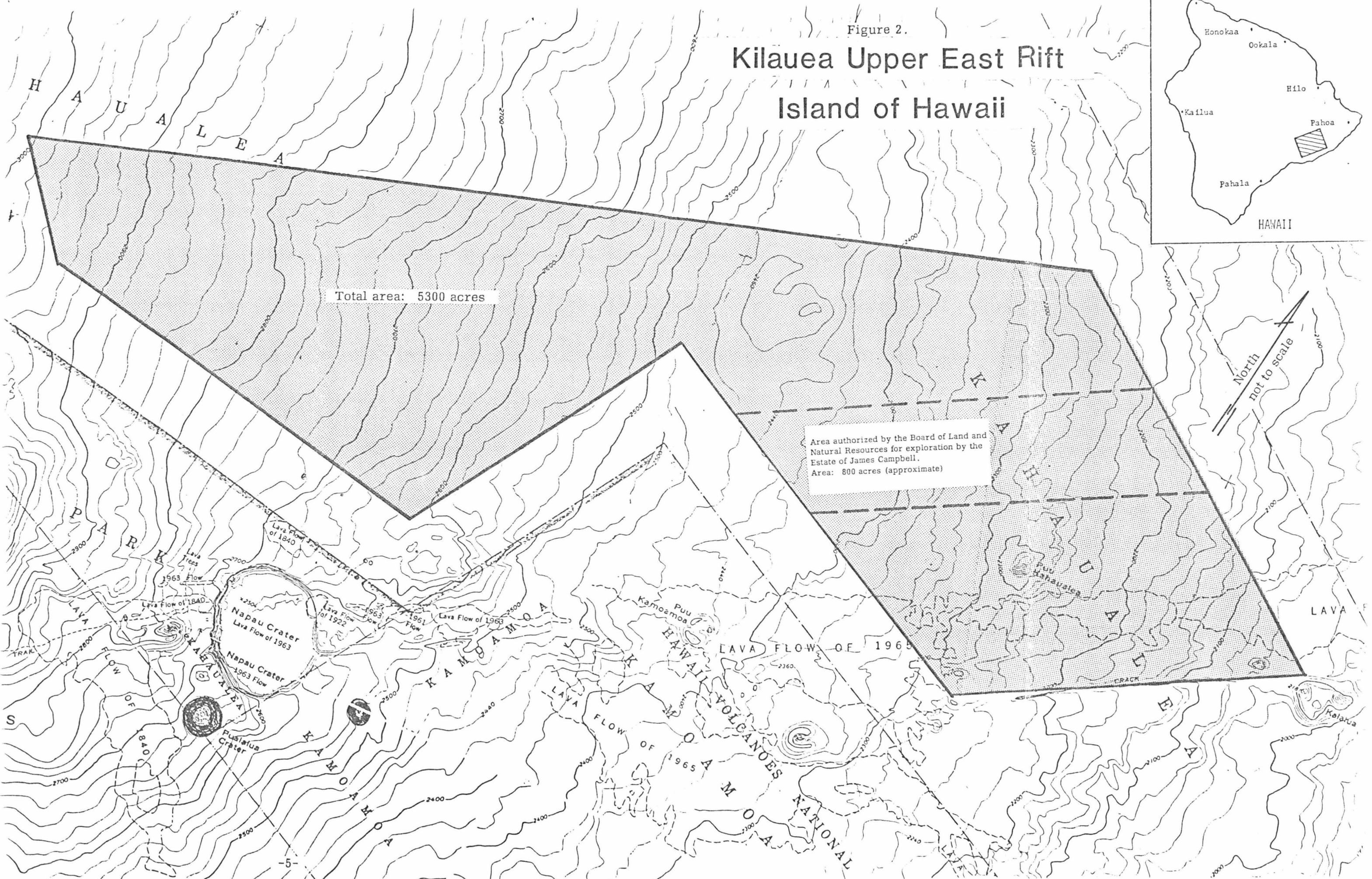
## Island of Hawaii





Figure 2.

# Kilauea Upper East Rift Island of Hawaii









## 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.

## LEGAL AUTHORITY

Act 296, SLH 1983, relating to geothermal energy, provides the legal basis for this assessment. The Act requires the Board of Land and Natural Resources to designate geothermal subzones. Section 3 of the 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. Act 151, SLH 1984, clarified various aspects of existing geothermal development activities within the State and the roles of State and County governments.

## STATEWIDE ASSESSMENT OF GEOTHERMAL RESOURCES

A Geothermal Resources Technical Committee, selected by the Department of Land and Natural Resources on the basis of their specific expertise, examined on a county-by-county basis geothermal resource areas having the potential for production of electrical energy. Due to the complexity of Hawaii's geologic structure and the variable nature of groundwater 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.

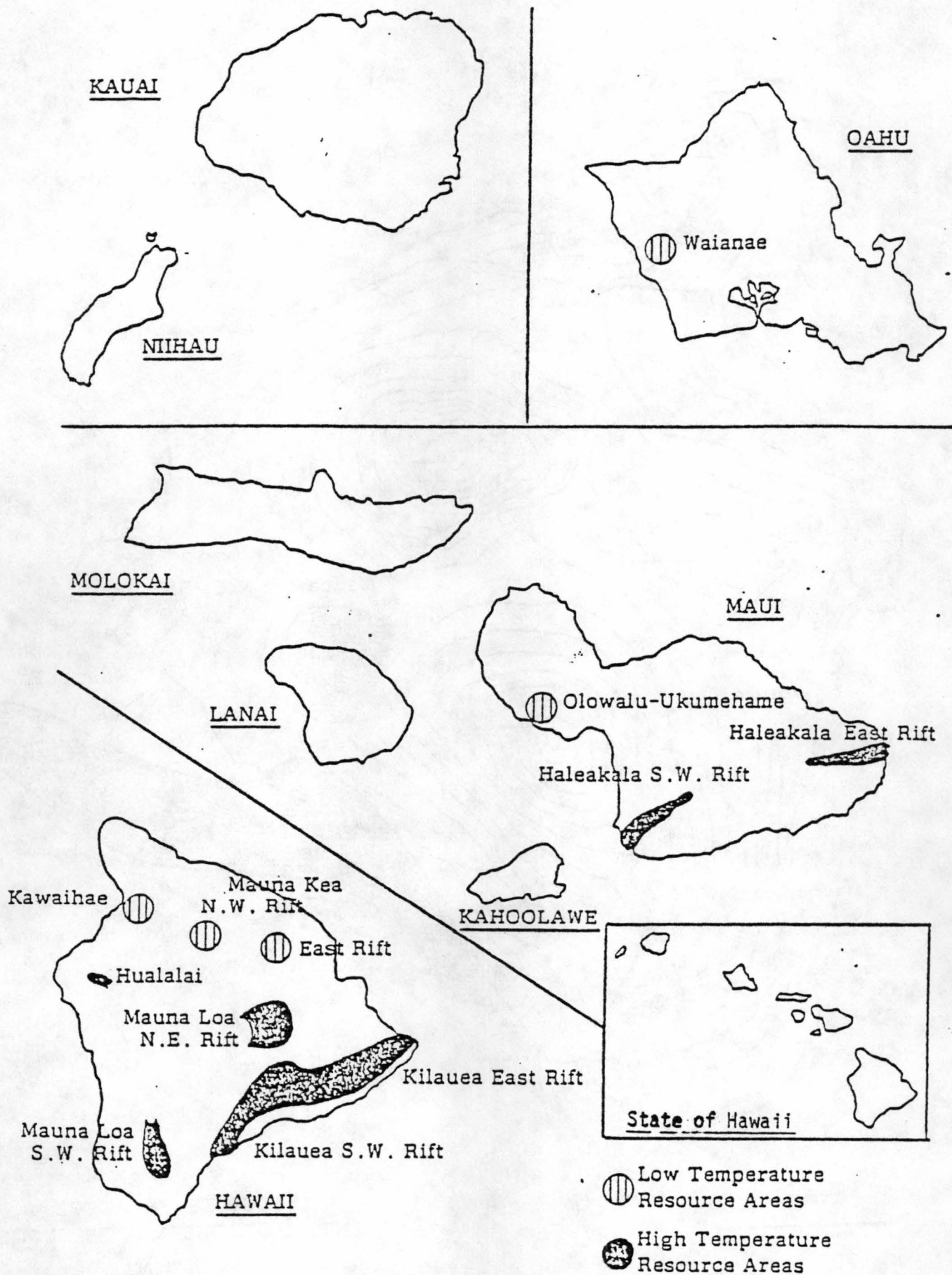
The Committee identified nine locations in Hawaii County having geothermal resources. Six locations were identified in Maui County and two in the City and County of Honolulu. Kauai, Molokai, and Lanai were determined not to have geothermal resources of any significance based upon available information. A map of the locations examined is shown in Figure 4.

Of the areas reviewed, five locations on the Island of Hawaii and two on the Island of Maui were determined to have a sufficient probability (greater than 25%) of locating a high temperature resource (greater than 125°C) at depths less than 3 kilometers. These locations are shown in Figures 5 and 6.

### EVALUATION OF IMPACTS ON POTENTIAL GEOTHERMAL RESOURCE AREAS

The potential geothermal resource areas were evaluated on the basis of potential and real impacts which may occur within each of the areas. Based on available information evaluations were made of geologic hazards, social impacts, environmental impacts, compatibility of development and economic impacts. Within each of these factors, sub-factors were identified. Each of these sub-factors were evaluated as to the potential impact(s) it may have on the potential zones. This evaluation process was made on the basis of each expert's knowledge and available information obtained. The results of this evaluation process is summarized in Figure 7.

Figure 4  
POTENTIAL GEOTHERMAL RESOURCE AREAS





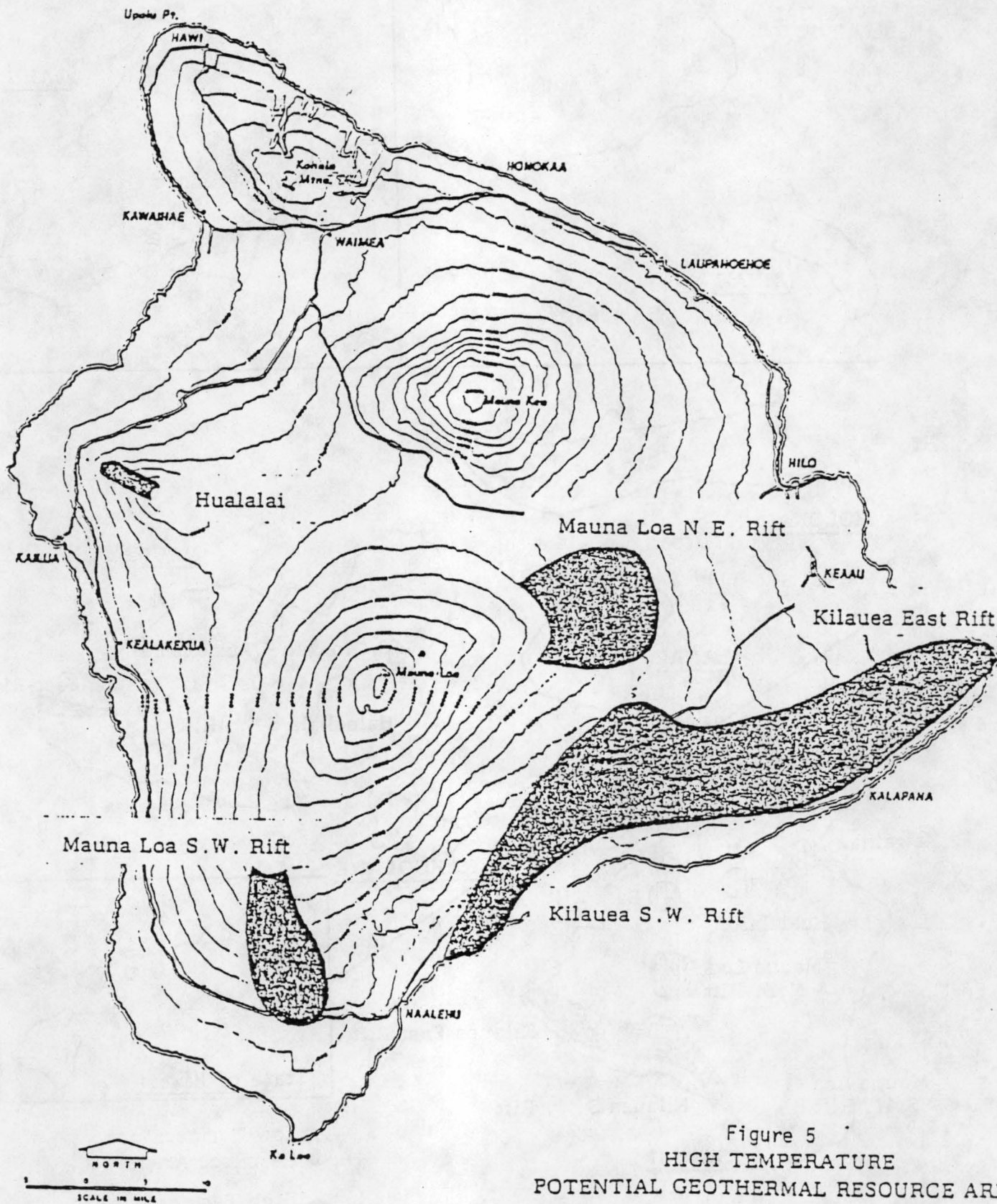


Figure 5  
 HIGH TEMPERATURE  
 POTENTIAL GEOTHERMAL RESOURCE AREA  
HAWAII

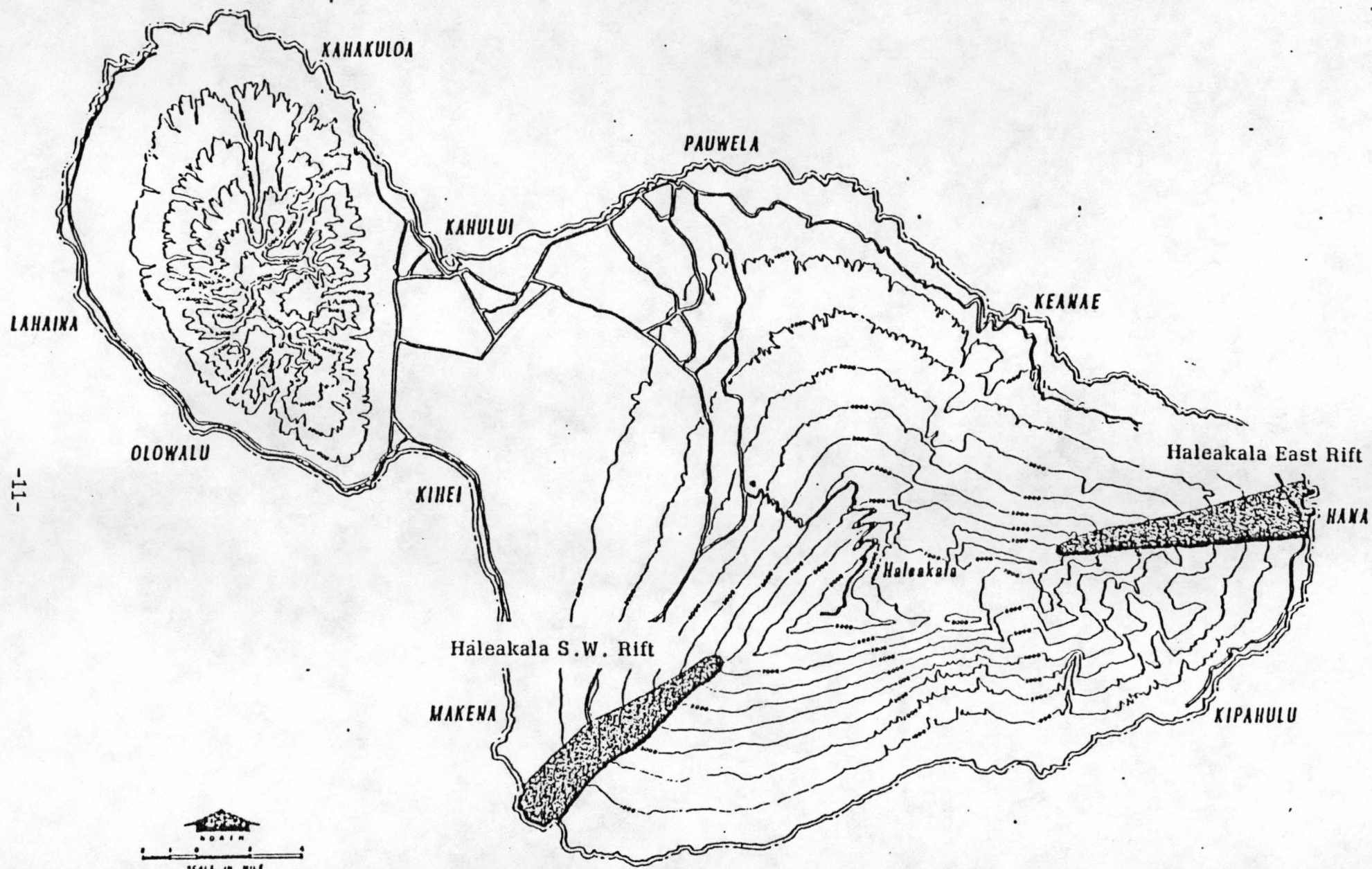


Figure 6  
HIGH TEMPERATURE  
POTENTIAL GEOTHERMAL RESOURCE AREA  
MAUI

Figure 7. EVALUATION OF IMPACTS ON POTENTIAL GEOTHERMAL RESOURCE SUBZONE AREAS

Basis for Evaluation	Island of Hawaii					Island of Maui		
	Kilauea Lower	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



## 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 9,840 feet.

### Prospects for Utilization

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

### Significant or Moderate Impacts

#### 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. 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 air quality (smell) and aesthetics (visual - plumes, towers, etc.). These impacts are expected to be moderate.

#### 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 both Land Use Commission (LUC) classified 75% as "agricultural" and 25% as "conservation, limited", due to lava flow hazards which can be mitigated. Geothermal development is considered to be of moderate significance.

### Economic Impact

Geothermal development within this proposed subzone will provide additional jobs. Based upon past growth rates in Puna, the housing situation will be tighter.

### 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 9,840 feet.

#### Prospects for Utilization

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

#### Significant or Moderate Impacts

##### Geologic Hazards

At the present time, there is volcanic activity in the area especially in the 90% (chance of finding a high temperature resource) zone. In the long term, the well sites would be located near the source. Upon reasonable subsidence of lava flow activity in the future, the decision and risks of drilling would rest upon the developer.

##### Social Impact

The principal social factor affected by geothermal development would be in terms of lifestyle, culture, and community setting as they are experienced in the Volcano area. The impact is expected to be moderate. 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 air quality (smell) and aesthetics (visual - plumes, towers, etc.). These impacts are expected to be moderate.

A significant impact on the flora and fauna would possibly occur within the proposed subzone area. A major portion of this subzone area consists of Category 1 forests classified as "exceptional native forest; closed canopy, over 90% native cover".

### Compatibility of Development

The proposed subzone located in the upper rift zone, rests within LUC classified "conservation, limited", and geothermal development is considered to have a significant impact. Excluded from the subzone is the Hawaii Volcano National Park and the Natural Area Reserve.

### Economic Impact

Geothermal development within this proposed subzone will provide additional jobs. The housing situation will be tighter.

## 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 concluded 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 proposed Pahala subzone area.

### Significant Impacts

#### Environmental Impacts

The general impact of geothermal development to the environment will be in the area of air quality (smell). This impact is expected to be moderate.



### Economic Impacts

Geothermal development in the proposed subzone will have a moderate impact on employment.

### Mauna Loa Northeast Rift, Hawaii

### Potentials for Production

Based on available data it was concluded that there was a 35% 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 developers would drill for geothermal resources in this subzone area.

### Significant or Moderate Impact

#### Social Impacts

The aesthetic impact of geothermal development would have a moderate impact on the community.

#### Environmental Impacts

There would be a moderate impact upon the environment in the areas of air quality (smell) and scenic/aesthetic values (visual).

Any development in the proposed subzone area would have a significant impact on the flora and fauna. Some 60% of the proposed subzone 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 forest bird species: Hawaii Creeper, Akepa, Akiapola'au, the 'O'u, and the Nene. The impact is considered to be significant.

#### Compatibility of Development

Some 75% of the proposed subzone area is presently classified as "conservation, protective" lands under the State Land Use District Classification. Geothermal development is considered to have a significant impact.

#### Economic Impact

Geothermal resource activity in this proposed subzone area should enhance employment.

## Mauna Loa Southwest Rift, Hawaii

### Potentials for Production

On the basis of recent historic volcanic eruptions, seismic activity and taking into consideration the absence of any other significant geophysical or geochemical anomalies, it was found that there was a 35% 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 developers would drill for geothermal resources in this subzone area.

### Significant or Moderate Impacts

#### Social Impacts

Geothermal development within the proposed subzone area is expected to cause changes in the lifestyle, culture and community setting within the immediate area. In addition, the aesthetics of such a development would impact upon the community. The impact of both factors are considered to be moderate.

#### Environmental Impacts

There would be a moderate impact on the air quality (smell) and scenic and aesthetic values (visual) due to geothermal resource development. A significant impact would entail on the fauna in this area. Approximately 50% of the proposed subzone would encompass endangered bird species--Akepa, Akiapolaau and the Hawaii Creeper.

#### Economic Impact

Employment would moderately increase if geothermal development takes place within the area. The housing situation will be tighter.

## Hualalai Northwest Rift, Hawaii

### Potentials for Production

Based on positive geothermal indications from geophysical data (resistivity, magnetics, and self potential) and the geologically young age of vents along the upper rift and summit, there is a 30 to 35%

chance of finding a high temperature (greater than 125°C) resource at depths less than 3 kilometer.

#### Prospects for Utilization

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

#### Significant or Moderate Impacts

##### Social Impact

In this proposed geothermal subzone area, the impact on aesthetics expected to be moderate.

##### Environmental Impacts

Moderate impacts would occur in the areas of air quality (smell) and scenic and aesthetic values (visual).

Approximately 10% of the proposed subzone area consists of Category 1 forest, "exceptional native forest with over 90% native canopy cover". Species composition consist primarily of ohia lehua, koa and mamane. The fauna which inhabits the forest include the Alala, Hawaiian Creeper, Akepa and the Nene, which are considered endangered. Therefore, development in this area will have a significant impact on the flora and fauna.

##### Compatibility of Development

The proposed subzone area is currently classified as "conservation, protective & resource" under the State Land Use District Classification. geothermal development in this subzone area would have a significant impact.

##### Economic Impact

Development activity in the proposed subzone area would create a moderate increase in employment.

#### Haleakala Southwest Rift, Maui

#### Potentials for Production

Due to the geologically young age of the recent 1790 eruption and results of deep resistivity soundings, the conclusion drawn was that



there is a 25% 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 subzone area is good.

#### Significant or Moderate Impacts

##### Social Impacts

The potential effects on lifestyle, culture, and community introduced by geothermal production activities, as well as the impact of noise to the community is considered to be moderate. The visual impact of a geothermal development would have a significant impact on the community.

##### Environmental Impacts

Air quality (smell) will have a moderate impact upon the environment. However, a significant impact would occur to scenic and aesthetic values if development occurs within the proposed subzone area.

##### Economic Impacts

Geothermal development within the proposed subzone area will provide additional jobs for the community. The housing situation will be tight.

#### Haleakala East Rift, Maui

#### Potentials for Production

Based on the geologic age of the Hana Series lava flows, there is a 25% 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 subzone area.

## Significant Impacts

### Social Impacts

The potential effects on lifestyle, culture, and community introduced by geothermal production activities, as well as the impact of noise to the community is considered to be moderate. The visual impact of a geothermal resource development would have a significant impact on the community.

### Environmental Impacts

Air quality (smell) and scenic/aesthetic values will have a moderate impact upon the environment. However, the flora and fauna within the proposed subzone area will be significantly impacted. Approximately 50% of the area is Category 1 forest, "exceptional native forest, closed canopy with over 90% native cover", forest. The forested areas provide habitat for three endangered forest birds: the Maui Parrot bill, the Crested Honeycreeper, and the Akepa.

### Compatibility of Development

The proposed subzone area is presently classified as "conservation, protective" under the State Land Use District Classification. Geothermal development in the proposed subzone area would have a significant impact.

### Economic Impacts

Development within the proposed subzone area will provide additional jobs for the community. The housing situation will be tight.