PLAN OF STUDY
for
DESIGNATING GEOTHERMAL RESOURCE SUBZONES
State of Hawaii

C-97

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

Honolulu, Hawaii
September 1983

GEORGE R. ARIYOSHI
Governor

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INTRODUCTION

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, production and distribution of electrical energy may be conducted only in the designated geothermal resource subzones.

This Plan of Study outlines the implementing strategy of the Department of Land and Natural Resources in designating geothermal resource subzones in the State of Hawaii.

STUDY OBJECTIVES AND SCOPE

The objective of the study is to designate geothermal resource subzones in the State of Hawaii for the purpose of concentrating all geothermal related activities in areas having minimum social, economic, environmental, and hazard impacts. To the extent provided by Act 296, SLH 1983, all existing statutory, ordinance, and rules are to be respected and are not superseded by this effort.

The State of Hawaii will be reviewed for geothermal resource potential and assessments will be conducted for each island and presented on a county-by-county basis as provided by Act 296, SLH 1983.

HIGHLIGHTS OF ACT 296, SLH 1983

- Amends Chapter 205, Land Use Commission
- Provides for the designation of Geothermal Resource Subzones in each of the four State land use districts--conservation, agriculture, urban, and rural.
- Geothermal resource exploration, development, production, and distribution of electrical energy may be conducted only in designated geothermal resource subzones.
- 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 resources 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 agricultural, 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.
- 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.
- 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 assessment of potential geothermal resource subzones shall examine factors to include but not be limited to:
  - * Potential geothermal energy production.
  - * Use of the geothermal energy in the area.
  - * Geologic hazards.

* Social and environmental impacts.
* Compatibility with present and planned use.
* Potential economic benefits.
* Compatibility with conservation principles where a subzone falls within a conservation district.

- The assessment may be based on currently available public information.
- The BLNR shall propose potential areas for designation based upon assessment factors and hold public hearings in close proximity to the proposed area. The hearings shall be held before the Board and not be conducted by any agent or representative.
- At the close of the hearing, the BLNR may designate the subzones. Upon request, the BLNR shall issue its findings and principal reasons for its decision.
- Designated areas may be withdrawn by the BLNR.
- The Act shall not apply to active exploration, development, or production of electrical energy taking place on the effective date of the Act. Expansion of such activities however are subject to the provisions of the Act.
- The Governor signed Act 296 into law, effective June 14, 1983.

STUDY APPROACH

Based upon the provisions of Act 296, SLH 1983, the following four-phase study approach has been developed for designating geothermal resource subzones.

Phase I. Statewide Geothermal Resource Assessment

This phase will focus upon geotechnical information, its interpretation and analysis of potential geothermal resources on all of the major islands. Due to the time constraint of completing the work by December 1984, available studies will be heavily used with minimal new studies and data gathering. First-cut subzones based only on the availability of geothermal resources will be mapped to conclude Phase I work.

Phase II. Social, Economic, Environmental, and Hazard Impact Analysis

Impact analysis of social, economic, environmental, and hazard will be conducted on the first-cut subzones completed in Phase I. Several disciplines are expected to participate in this phase. Overlay mapping of the impacts will be extensively used to identify highly sensitive impact areas. Adjustments to the first-cut subzones will be made to conclude Phase II work.

Phase III. Public Participation and Information

This phase will extensively involve communities located in close proximity to the identified subzones. Informational meetings will be conducted to explain the technical work and the impact analyses. Comments from the public will be solicited and the further adjustments to the subzone are expected to be made.

Phase IV. BLNR Designation of Geothermal Resource Subzones

This phase is expected to involve the Board of Land and Natural Resources. Briefing sessions will be conducted by the staff on both the technical analysis and the impact analysis. Public input will be described and documented.

The BLNR is expected to hold public hearings and formally designate the geothermal resource subzones.

STUDY MANAGEMENT AND BUDGET

Lead Agency and Study Participants

Act 296, SLH 1983, designated the Board of Land and Natural Resources with the responsibility for designating geothermal resource subzones. The Chairperson has assigned the subzone task to the Division of Water and Land Development (DOWALD) and has designated the Division's Manager-Chief Engineer as the principal contact person.

Other offices within the Department of Land and Natural Resources identified to assist DOWALD in their respective functional areas are:

* The Deputy to the Chairperson - coordination
* Division of Land Management - leasing of state geothermal resources
* Planning Office - management of conservation district lands

Role of Other Agencies

1. Hawaii Institute of Geophysics (HIG), University of Hawaii

   The HIG has technical expertise on its staff and has completed preliminary assessments of geothermal resource in the State of Hawaii. This available information and expertise will be utilized by DLNR for the assessment phase. Under HIG, the resource and production data for the existing HGP-A geothermal well will be made available for the assessment work.

2. Department of Planning & Economic Development (DPED)

   The Energy Division has made available $50,000 for use by DLNR in the subzoning work. Arrangements are being made for DLNR to use the funds. DPED also has a resource library on geothermal resource development. This information will be made available for the subzoning.

3. Department of Health (DOH)

   The Health Department is expected to establish odor and noise standards and to promulgate these requirements into Administrative Rules for implementation. Impact analysis relating to the health of people will be based upon available standards or guidelines.

4. State Land Use Commission (LUC)

Land use activities on agricultural district lands of at least 15 acres or more in size require State Land Use Commission approval. The administration of subzones designated on these lands will involve the LUC.

5. County Planning Departments

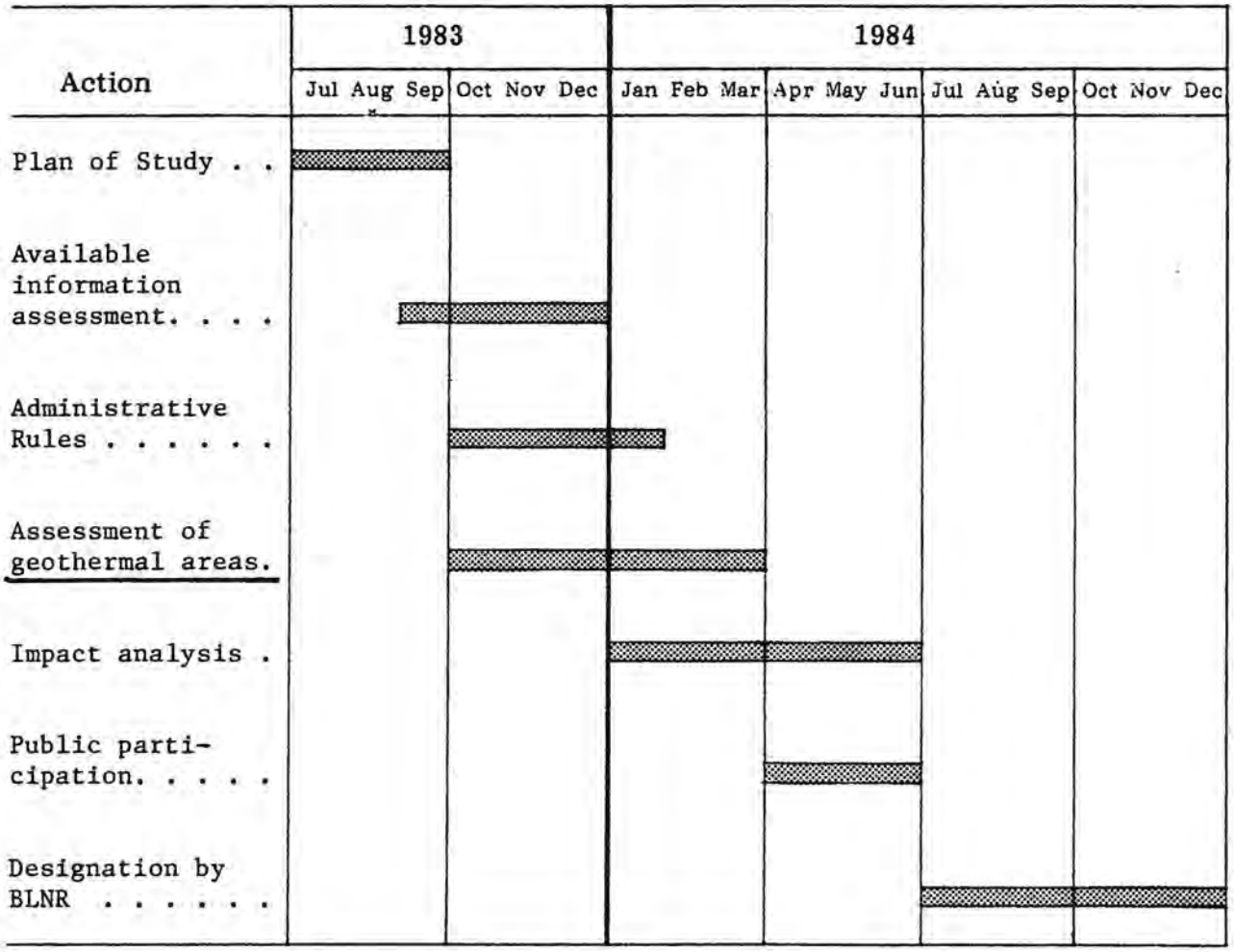
Agricultural, urban, and rural district lands are administered by the County Planning Departments. As such, geothermal development activities within designated subzones would require County zoning approvals prior to implementation.

6. Puna Geothermal Resource Developers

Currently, two private developers are actively engaged in the exploration of geothermal resource in the Puna area. The Puna Joint Venture (Thermal Power Co., Amfac, Dillingham) and Barnwell Corporation have developed information and may be willing to share their information and expertise with the State in subzoning assessmentactivities.

Schedule for Designating Subzones

The overall time schedule for completing the work is estimated to be December 1984. The critical dates and actions are identified below:



Budget

In enacting Act 296, SLH 1983, the Legislature did not provide funds for implementation. The Department nonetheless selected Act 296 as a high priority DLNR program for implementation for Fiscal Year 1983. Existing staff is being utilized on a part-time basis to develop a strategy for implementation and to lay the groundwork for full implementation.

Fiscal Year 1983-84

A $50,000 budget has been made available by DPED and arrangements are being made to fully utilize this fund for F.Y. 1983-84 activities. The breakdown of expenditures are listed below:

Hire full-time Geologist I @ $1800.00 (SR-24) October 1983 - June 1984 (9 months)	$16,200.00
Fringe benefits (25%)	4,000.00
Other miscellaneous expenses (travel, supplies, etc.)	2,000.00
Information gathering, including mapping	2,000.00
Promulgation of Administrative Rules	2,500.00
Assessment of Geothermal Areas, $2000/mo. x 6	12,000.00
Impact Analysis, $3000 x 3	9,000.00
Public participation	2,300.00
Total FY 1983-84	$50,000.00

Fiscal Year 1984-85

Principal activities for FY 1984-85 involve the designation of subzones by the BLNR. Six months are allotted for this purpose at a budget of approximately $5,000.00. This amount, together with funds for the employment of a Geologist I position has been requested in the FY 1984-85 Supplemental Budget. The details are listed below:

Personnel services	$20,897.00
Other current expenses	8,400.00
Equipment	200.00
Total FY 1984-85	$29,497.00

ADMINISTRATIVE RULES

Following is a preliminary outline of the Administrative Rules for the designation of geothermal resource subzones in the State of Hawaii. The legal authority is Act 296, SLH 1983.

TITLE 13

DEPARTMENT OF LAND AND NATURAL RESOURCES
SUB-TITLE 7. WATER AND LAND DEVELOPMENT

Chapter 184

Rules on Designation and Regulation of
Geothermal Resource Subzones

Subchapter 1. General

§13-184-1 Purpose
§13-184-2 Definitions
§13-184-3 Geothermal resource subzones
§13-184-4 Effective date and applicability
§13-184-5 Severability
§13-184-6 (Reserved)
§13-184-7 (Reserved)

Subchapter 2. Designation of Geothermal Resource Subzones

§13-184-8 Procedures for designation
§13-184-9 Initial and 5-year assessments by Board
§13-184-10 Petition by landowner
§13-184-11 Criteria for designation of subzones
§13-184-12 Public hearings
§13-184-13 Findings of fact report
§13-184-14 Designation of subzones by Board
§13-184-15 Amendment and withdrawal of subzones by Board

Subchapter 3. Regulation of Geothermal Resource Subzones

§13-184-16 Geothermal Uses of subzones
§13-184-17 Administration of subzones in Conservation Districts
§13-184-18 Administration of subzones in Agricultural, Rural and Urban Districts
§13-184-19 Application for permits to drill and test, use for injection, use for production, and abandon geothermal wells
§13-184-20 Application for permits to construct and operate power plants and related facilities
§13-184-21 Term of permits
§13-184-22 Contested case hearings
§13-184-23 (Reserved)
§13-184-24 (Reserved)

Schedule for Adopting the Administrative Rules

Item	Target Date
First-cut review draft	October 31, 1983
Agency reviews	November 30, 1983
Public hearing draft	December 31, 1983 ✓
Public hearings	January, 1984
BLNR action	February, 1984
Governor's action	February, 1984

ASSESSMENT OF AVAILABLE INFORMATION

A major task already underway is the search for available technical information. Principal agencies having geothermal related information include:

* Hawaii Institute of Geophysics
* DPED, Energy Division
* DLNR, Planning Office
* U.S. Geological Survey, Geologic Division

An example of geothermal surveys conducted to date include:

Preliminary Geothermal Assessment Surveys for the State of Hawaii. Donald M. Thomas, et al. (See Appendix B).

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

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.

* IMPORTANT, ALWAYS INCLUDE IN REPORT * (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

References

PRELIMINARY GEOTHERMAL ASSESSMENT SURVEYS FOR THE STATE OF HAWAII

Donald M. Thomas, Malcolm E. Cox, Barry R. Lienert, James P. Kauahikaua, Mark D. Mattice

Hawaii Institute of Geophysics, Honolulu, Hawaii 96822

ABSTRACT

The Geothermal Resource Assessment Program of the Hawaii Institute of Geophysics has conducted a series of geochemical and geophysical surveys in ten separate locations within the State of Hawaii in an effort to identify and assess potenital geothermal areas throughout the State. The techniques applied include groundwater chemistry and temperatures, soil mercury surveys, ground radon emanometry, time-domain electromagnetic surveys and Schlumberger resistivity soundings. Although geochemical and geophysical anomalies were identified in nearly all the survey sites, those areas which show most promise, based on presently available data, for a geothermal resource are as follows: Puna, Kailua Kona, and Kawaihae on the island of Hawaii; Haiku-Paia and Olowalu-Ukumehame canyons on Maui; and Lualualei Valley on Oahu. Further surveys are planned for most of these areas in order to further define the nature of the thermal resource present.

INTRODUCTION

The Hawaii Institute of Geophysics Geothermal Resource Assessment Program has conducted a series of geochemical and geophysical field surveys in ten prospective geothermal areas of the State of Hawaii to assess their potential. The exploration techniques which have been applied include groundwater chemistry, isotopic analysis, soil mercury and radon surveys, time-domain electromagnetic soundings, and Schlumberger resistivity surveys (Thomas et al., 1980). These surveys were conducted in areas selected from a state-wide assessment of all available data, including the likelihood of subsurface heat from geological criteria, regional geophysics and chemistry of groundwater (Thomas et al., 1979). The areas in which studies have been conducted (Figures 1, 2, and 3) are as follows:

On Hawaii: Kawaihae, Hualalai northwest rift, Kailua Kona, Mauna Loa southwest rift, Kilauea lower east rift, and Keaau;

On Maui: Kaanapali-Lahaina, Olowalu-Ukumehame and Haiku-Paia;

On Oahu: Lualualei Valley.

SUMMARY OF RESULTS

Kawaihae. Geochemical sampling in the Kawaihae area has delineated an east-west trending zone of anomalously high soil mercury concentrations and ground radon emanation which correlate well with above ambient groundwater temperatures in the immediate vicinity. Groundwater chemistry, specifically Cl/Mg ratios, also indicate that the local groundwater chemistry may have been thermally altered.

Schlumberger resistivity soundings in the Kawaihae area suggest a highly resistive body to the northeast of the mercury and radon anomalies; this feature is interpreted to be a shallow intrusive body which may be associated with a nearby 80,000 year old eruptive vent (Malinowski, 1977).

Although these data indicate potential for low temperature geothermal prospects, further studies will be necessary before any estimate of the thermal potential can be made.

Hualalai Northwest Rift. Geochemical surveys on the northwest flank of Hualalai volcano yielded only very slight evidence of geothermal activity. Soil mercury concentrations and radon outgassing were relatively low throughout the region however slightly elevated mercury concentrations were found to be associated with the eruptive vents along the trend of the rift system; radon values were not significantly anomalous. There are few groundwater wells in this area and thus only two sets of chemical data are available; only one of these, to the south of the rift system, showed a significant Cl/Mg anomaly.

Schlumberger soundings along the rift were able to identify a conductive zone at 500 m depth near the summit of Hualalai; this anomaly has been interpreted to be associated with dike-impounded groundwater which may or may not be above ambient temperatures.

The presently available geochemical and geophysical data do not provide convincing evidence that a thermal anomaly is present in this survey area. However, the last eruptive activity on Hualalai took place in 1801 and it seems likely that this volcano could have some geothermal potential. Continued surveys are planned for Hualalai on a limited scale.

Kailua Kona. Geochemical surveys conducted in the north Kona district have identified several areas in which mercury and radon anomalies are

HIG Contribution No. 1056

Fig. 1 Location of Survey Areas: Island of Hawaii

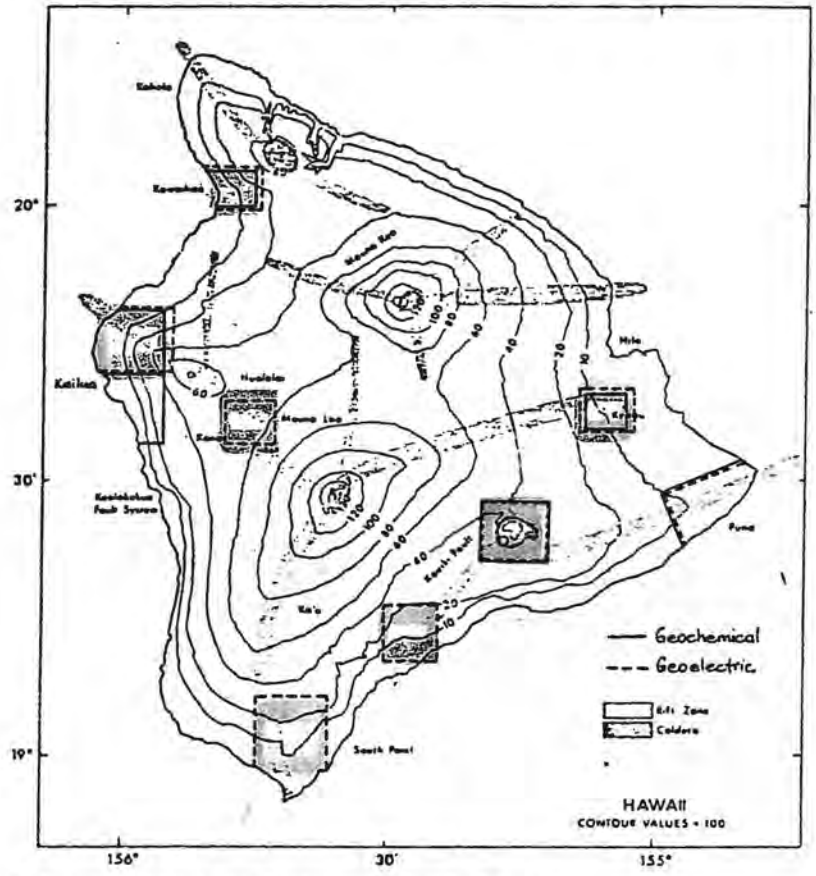


Fig. 2 Location of Survey Areas: Island of Maui

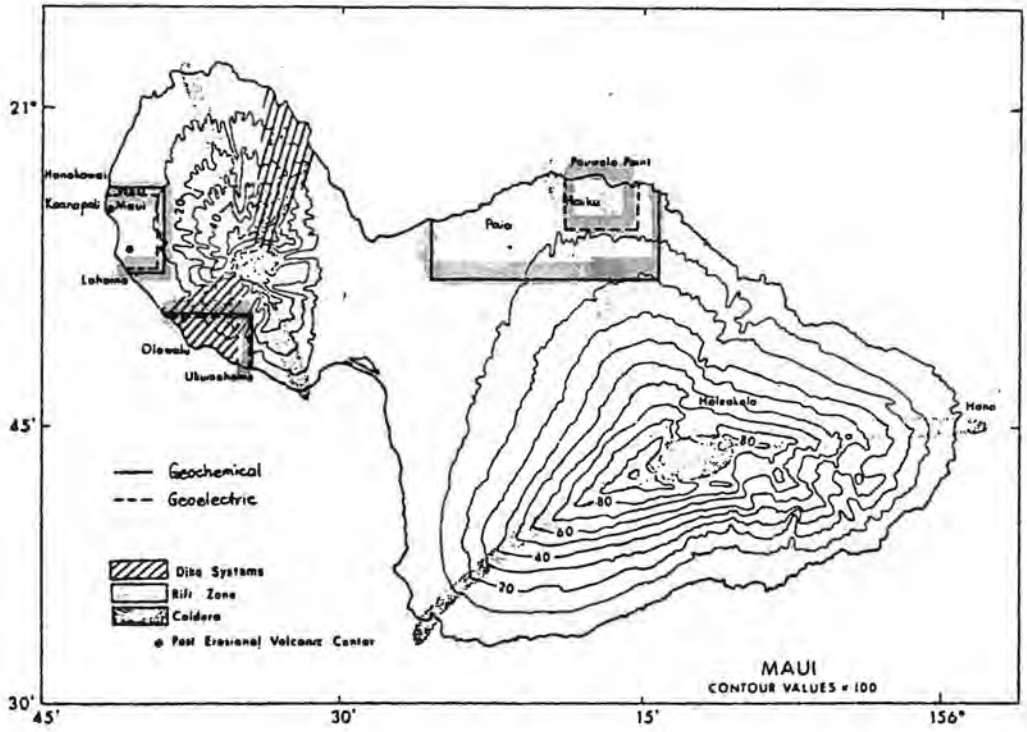
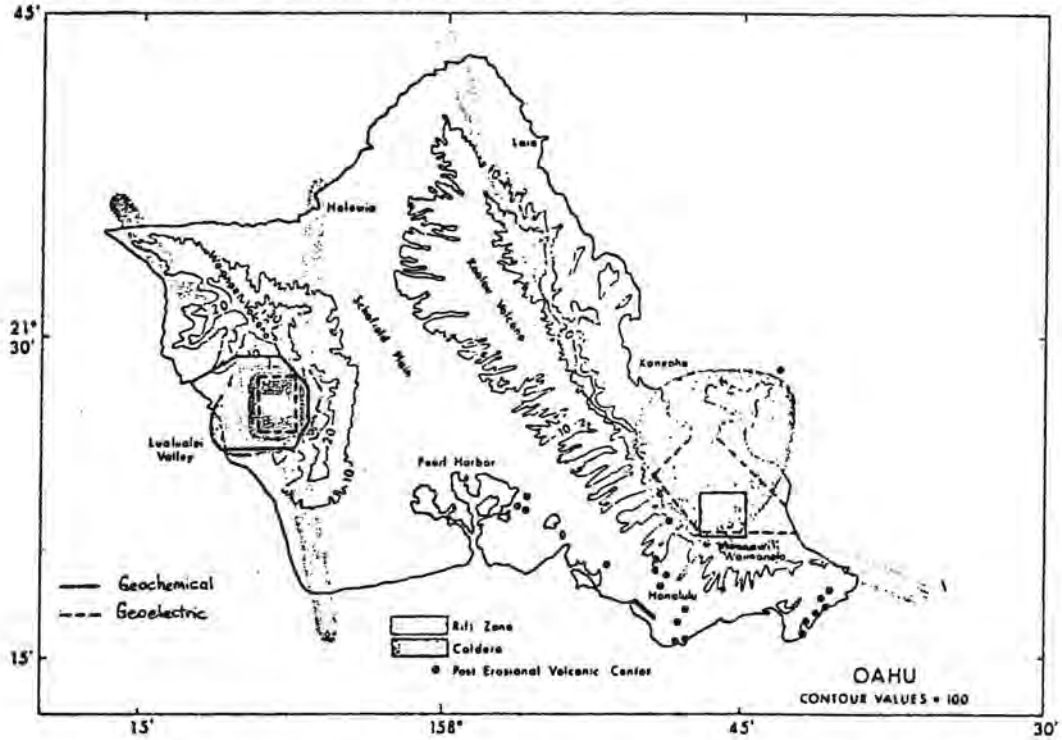


Fig. 3 Location of Survey Areas: Island of Oahu



present. Groundwater Cl/Mg ratios are generally elevated for these areas as well. The general trend of the anomalous zones suggest that they arise from beneath the higher slopes of Hualalai. Geophysical surveys have not yet been conducted in this area, larely due to the extensive pipe networks and other cultural interferances.

Although the presently available data on this area are by no means conclusive, they strongly suggest that thermal anomalies are influencing groundwater chemistry and ground gas movement. Continued surveys will be conducted in this area in an effort to determine whether the origin of the observed anomalies is a local one or is deeper within Hualalai volcano.

Mauna Loa Southwest Rift. Surveys on the lower Mauna Loa southwest rift zone have been restricted to time-domain electromagnetic and Schlumberger resistivity soundings. Estimated resistivities were about 100 ohm-m, suggesting that there is little thermal activity in the immediate survey area.

Keaau. Geochemical and geophysical surveys in the Keaau area were unpromising in regard to geothermal prospects. Mercury and radon surveys showed only slight elevation above the natural background and groundwater chemistry suggested a simple mixing of minor amounts of saline water with local meteoric recharge. Schlumberger and time-domain soundings identified a thick freshwater lens but no anomalous conductors at depths less than 5 km over the entire survey region. Few, if any, geothermal surveys are anticipated for this district of Hawaii.

Kilauea Lower East Rift. Schlumberger and time-domain electromagnetic surveys were completed over several areas of the lower east rift zone of Kilauea in the vicinity of the geothermal well HGP-A. Analysis of the data indicates that this area has a substantially lower resistivity than any of the other survey sites studied and that the HGP-A reservoir is elongated along the strike of the east rift zone and extends to the southeast toward Kapoho (Kanahikaua et al., 1980). Radon and mercury surveys suggest an elongate rift-confined reservoir, with some broadening uprift of HGP-A.

Lahaina-Kaanapali. Water chemistry from several wells in the Lahaina-Kaanapali district shows slightly elevated Cl/Mg ratios suggesting that a low order thermal anomaly may be present in this area; mercury and radon results to some degree substantiate the groundwater data although the anomalies as presently defined are restricted to the immediate vicinity of Kaanapali and a post-erosional cinder cone northeast of Lahaina. Five resistivity soundings were conducted in this area. Resistivities in the order of 20 to 40 ohm-m are interpeted as seawater saturated basalt, which are typical for Hawaii (Mattice & Lienert, 1980).

Our preliminary assessment of this area is that a low temperature anomaly may exist which is associated with the Lahaina post-erosional volcanic centers. Further geochemical and geophysical surveys are currently being carried out to more clearly define the source of the observed anomalies.

Olowalu-Ukumehame. The chemical analyses of three wells in the area are considered anomalous, one having a temperature of 33°C and a Cl/Mg ratio of 17.7 [greater than 15 is considered anomalous for Hawaiian groundwater (Cox & Thomas, 1979)] and two having temperatures greater than 25°C. Soil mercury concentrations are low, but radon survey results show a low order anomaly. Schlumberger resistivity surveys in Olowalu-Ukumehame canyons have identified a conductive layer at a depth of 90 m to 200 m and having a resistivity of 4 ohm-m. These results suggest that the basalts beneath the survey area are saturated with hot seawater (Mattice & Lienert, 1980).

The presence of anomalous groundwater chemistry and resistivities in this area suggests that at least a low temperature thermal anomaly is present.

Haiku-Paia. Groundwater chemical analyses have delineated several areas in which Cl/Mg ratios are substantially higher than normal Hawaiian groundwaters. The highest ratios (21 and 58) are located in the north central corner of the survey area near the intersection of the northwest rift zone of Haleakala and the coast. Groundwater temperatures show a pattern quite similar to that of the Cl/Mg ratios although at higher elevations temperatures decrease, presumably due to the wells penetrating perched groundwater.

Both radon and soil mercury values substantiate the observed anomalous groundwater chemistry and temperature patterns. The highest soil mercury and radon values were found along the western boundary of the rift zone (Cox & Cuff, 1980).

The resistivity values measured in this area average around 10 ohm-m but cannot as yet be ascribed to thermal water and may result from high porosity basalts. It is believed that the very strong geochemical anomalies observed in this area arise from a thermal source associated with the Haleakala northwest rift system. Continued geochemical and geophysical surveys will be conducted in this area to further define the source of heat.

Lualualei Valley. Extensive geochemical surveys have been conducted in the area within and around Lualualei Valley (Cox et al., 1979). Groundwater chemistry data on several wells located near the inferred Waianae Caldera boundary exhibit very strong chemical anomalies: seven wells have temperatures in excess of 25°C, five wells have Cl/Mg ratios in excess of 15, and six wells have silica concentrations greater than 80 ppm. The groundwater chemistry anomalies are generally coincident with strong soil mercury concentrations and ground radon anomalies. Schlumberger soundings in the survey area have identified a dike impounded groundwater layer which appears to overlie basalt saturated with fresh to brackish warm water. This layer is in turn underlain by a highly resistive layer of basement rock which is interpreted to be the dense volcanic intrusive complex associated with the Waianae volcano caldera.

Our interpretation of the results of the geochemical and geophysical data obtained for Lualualei Valley is that residual heat is present within the Waianae Caldera system, probably at considerable depth, and that there is convective transport by groundwater through the fracture system associated with the collapsed caldera. Further geophysical studies and deep drilling will be necessary before estimates can be made of the temperature and depth of the heat source.

CONCLUSION

Our preliminary assessment of the areas presently under study is as follows:

Kawaihae: low to moderate temperatures possibly associated with an ancient intrusion;

Hualalai Northwest Rift: low temperatures may exist but there is presently insufficient data for a more definite appraisal;

Kailua-Kona: a strong indication that subsurface heat has influenced the groundwater chemistry, the source for these anomalies indicated to be below Hualalai volcano;

Mauna Loa Southwest Rift: no indication of any significant subsurface heat;

Kilauea Lower East Rift: surveys suggest that the reservoir tapped by the geothermal well HGP-A extends eastward along the rift zone towards Kapoho;

Keaau: there is a very low probablity for a thermal resource in this area;

Lahaina-Kaanapali: surveys suggest that low order anomalous temperatures may be associated with the post erosional Lahaina volcanic vent system;

Olowalu-Ukumehame Canyons: available data have identified what is probably a low to moderate temperature thermal anomaly in Olowalu Canyon;

Haiku-Paia: very strong anomalies, apparently associated with the northwest rift of Haleakala, substantiate the presence of subsurface thermal conditions;

Lualualei Valley: a fracture-controlled low temperature thermal anomaly is indicated within the former Waianae caldera.

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