February 24, 1994

The Honorable John D. Waihee
Governor, State of Hawaii
Office of the Governor
State Office Tower
235 South Beretania Street
Honolulu, Hawaii 96813

Dear Governor Waihee,

In 1981, True Geothermal Energy Company, together with Mid-Pacific Geothermal Inc. and the Estate of James Campbell, initiated plans to develop Hawaii's geothermal resource potential in the Puna District on the Island of Hawaii. Since that time all of us, together with the people of the State of Hawaii, have been hopeful that Hawaii could move toward a successful achievement in better energy security and independence. All of the participants believed that the development of geothermal energy and this project could add substantially to the success and furtherance of this state goal.

Regretfully, during the past decade it became increasingly apparent that the obstacles and delays facing the project were taking a heavy toll on our ability to go forward in a prudent, businesslike manner. Despite these obstacles and delays True, along with Mid-Pacific and the Campbell Estate, persevered for a long time, due to the overwhelming support for geothermal development, we witnessed on a recurring basis from all stratum of the citizens on the Big Island, as well as throughout the State of Hawaii. The degree of that support was attested to in an overwhelming gathering of supporters for geothermal development in a rally held in Hilo in May of 1992. This great show of concern and support so encouraged the managers of this project, that decisions were made to continue even as obstacles were increasingly being encountered.

Moreover, it was also evident that the development goals of the project and the plans for achieving them were sound and in concert with the policies and objectives of the State of Hawaii, as clearly reflected in its State Energy Functional Plan. This harmony between the state's energy policies and goals and the vocal support of the people of the State of Hawaii have been the chief underlying impetus for the continuance of our efforts to make this a successful project.

DLNR REF. NO. 38
However, we now realize that the barriers to the successful achievement of the project goals are too great to warrant continuing. Accordingly, it is with great regret that we must inform you of our intention of beginning our efforts to wind down our participation with the project and to return the land and development rights to the Campbell Estate. The timetable for this task is not as yet completely certain as there are preliminary issues that must be first settled. We believe, however, it is imperative to inform you of our intentions in the event our actions become the subject of media interest and publicity.

Our decision to relinquish our rights to participate in Hawaii, should not deter the State of Hawaii from further pursuing the policies and goals of its State Energy Plan. The state must still continue efforts to move away from its dangerous reliance on oil for its electrical needs and encourage private sector participation in geothermal development from local developers and those from outside the state. We still firmly believe that the great majority of the people of Hawaii want and support prudent geothermal energy development.

We will work closely with your administrative agencies and staff in order to assure that our obligations and responsibilities of a regulatory and other nature are complied with in full. We intend to keep our obligations to the people of the State of Hawaii as we wind down our participation in this project.

Lastly, we wish to thank you for and acknowledge the assistance of certain members of your past and present administrative staff who were determined and courageous in the face of a vocal minority and without whom geothermal development in Hawaii would have been much more difficult. On behalf of all the members of the True Family, I wish to say thank you to the wonderful people of the State of Hawaii for their long support and encouragement.

Should there be any questions regarding our plans, please do not hesitate to call me or Allan Kawada our Project Coordinator in Hawaii.

Sincerely,

Hank True
Managing Partner

HAT/r1
GEOTHERMAL WELL PERMIT APPLICATION CHECK LIST

Operator: True Geothermal Energy Company

Well Designation: KA2-2 and KA3-1

Type of Well: Exploration

DLNR Rule 13-183-65 Applications for permit to drill, modify, modify use, or abandon well; permits. Prior to drilling, modifying, modifying use, or abandoning of any well, the operator of the well shall file with the Chairperson an appropriate application for a permit to do any work and shall obtain approval thereof. Each application for a permit shall contain the following:

- **YES** Name, Signature and Address of the Applicant. Allan Kawada letter dated 11-1-93.
- **YES** Owner of the Mining Rights. True/Mid-Pacific Geothermal Venture.
- **YES** Land Owner. Estate of James Campbell.
- **YES** Proposed Well Designation (subject to Chairpersons approval).
- **YES** Plot plans showing Well Location on TMK, Site Elevation, and proposed Bottom Hole Location (optional) in reference to established property corners. KA1-1 application Referenced.
- **YES** Statement of Purpose and Extent of Proposed Work. KA1-1 application referenced.
- **YES** Estimate of Depths between which Discovery will be attempted.
- **YES** Detailed Description of Proposed Drilling and Casing Program.
- **YES** Figure accurately showing the Proposed Work and Vertical Section of the well.
- **YES** Statement by the applicant agreeing to file a bond meeting the requirements of Rule 13-183-68 within ten calendar days after permit approval. KA1-1 application referenced.
- **YES** Statement by the applicant to perform the work and thereafter to operate and maintain the well in accordance with Title 13, Chapter 183 Rules, and all other federal, state and county requirements. KA1-1 application referenced.
- **YES** Application accompanied by a non-refundable $100 filing fee. Received 11-29-93.
GEOTHERMAL WELL DRILLING PERMIT

True/Mid-Pacific Well KA2-1
Puna District, Hawaii

TO: True Geothermal Energy Company
Central Pacific Plaza
220 South King Street, Suite 868
Honolulu, Hawaii 96813

Your application dated November 1, 1993, for a permit to drill a geothermal well on lands located within the Kilauea Middle East Rift Geothermal Resource Subzone and covered under the State of Hawaii, Geothermal Resource Mining Lease No. R-5 is Approved.

Well Designation: True/Mid-Pacific Well KA2-1
Location: TMK 1-2-10:03, Puna, Hawaii
Leased to: Estate of James Campbell (GRML R-5)
Subleased to: True/Mid-Pacific Geothermal Venture
Operator: True Geothermal Energy Company
Ground Elevation: 1,440 +/- ft. Above Mean Sea Level
Projected Depth: 10,000 +/- feet

You are hereby granted permission to drill the geothermal well described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, HAR, and under the following conditions:

(1) All work shall be performed in accordance with the permission and terms of the occupiers of the land, the Drilling and Completion Program submitted with your application, the Department's Administrative Rules (Chapters 13-183 and 13-184, HAR), and all other applicable Federal, State, and County laws, ordinances, rules, and regulations;

(2) The permittee, its successors and assigns shall indemnify, defend, and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;
(3) The permittee shall observe and comply with all valid requirements of County, State, and Federal authorities and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws and those relating to the environment;

(4) The well and bottom-hole location shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling, unless modified by the Chairperson upon request;

(5) The permittee shall notify the Division of Water and Land Development (DOWALD), in writing, of the date of the start of drilling operations;

(6) Class "G" cement shall be used in the casing cementing operations and shall contain a high temperature resistant admix;

(7) All Blow-Out Prevention Equipment (BOPE) and cemented casing strings shall be pressure tested before commencing any other operation on the well. The minimum test pressures shall be approximately one-third of the casing internal yield pressure rating, provided that the test pressure shall not be less than 600 psig nor greater than 2500 psig, and shall be applied for a period of thirty minutes. The results of the pressure tests shall be reported on forms provided by the Department. If a drop of more than ten percent of the casing test pressure is recorded, the operator shall run a caliper log and/or other appropriate well test to determine if the casing is defective and if corrective measures will be required before commencing any further operations. The results of the prescribed casing tests and any remedial work conducted shall be submitted to the Department within sixty days after completion;

(8) All personnel shall have BOPE training with periodic BOPE drills conducted and logged on daily tour sheets;

(9) Direct communications shall be installed between the rig floor, and both rig supervisor and the Operator's supervisor;

(10) A real time monitoring device shall be installed for the driller and a pit alarm system shall be included with this monitoring device. All toolpushers, drillers, and derrickmen shall be schooled in the use of the recommended monitoring equipment;
(11) If changes to the proposed drilling program are contemplated, the permittee shall obtain the Chairperson's approval before executing such changes;

(12) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified, with reasonable time allowed for travel to the site, to witness the retrieval of a representative groundwater sample and the measurement of the static water level. The permittee shall have the sample analyzed by an independent laboratory and have the results submitted to the Department;

(13) During the use of the well for testing, monitoring, production and/or injection purposes, the well and site shall be properly maintained until the well is plugged and abandoned in accordance with the Department's Administrative Rules, Chapter 13-183, HAR;

(14) The Permittee shall submit to the Chairperson, the results of any exploration, all drilling and testing records, down-hole surveys of the well, bottom-hole location, date of completion, and a survey of the well location and elevation above mean sea level taken by a Hawaii licensed surveyor within six months after completion of the well;

(15) A well completion report, an as-built drawing of the well, and the location of the well plotted on an U.S.G.S. quad map shall be filed with the Department within six months after completion of the well;

(16) The bond covering the well shall remain in full force and effect until the well is properly abandoned and the surface is restored as near as possible to its original condition; and

(17) This permit shall expire 365 days from the date of issuance.

KEITH W. AHUE, Chairperson
Department of Land and Natural Resources

Date of Issuance

cc: Land Board Members
    Hawaii County Planning Dept.
    DBEDT
    Department of Health
    OEQC
GEOTHERMAL WELL DRILLING PERMIT

True/Mid-Pacific Well KA3-1
Puna District, Hawaii

TO: True Geothermal Energy Company
Central Pacific Plaza
220 South King Street, Suite 868
Honolulu, Hawaii 96813

Your application dated November 1, 1993, for a permit to drill a geothermal well on lands located within the Kilauea Middle East Rift Geothermal Resource Subzone and covered under the State of Hawaii, Geothermal Resource Mining Lease No. R-5 is Approved.

Well Designation: True/Mid-Pacific Well KA3-1
Location: TMK 1-2-10:03, Puna, Hawaii
Leased to: Estate of James Campbell (GRML R-5)
Subleased to: True/Mid-Pacific Geothermal Venture
Operator: True Geothermal Energy Company
Ground Elevation: 1,480 +/- ft. Above Mean Sea Level
Projected Depth: 10,000 +/- feet

You are hereby granted permission to drill the geothermal well described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, HAR, and under the following conditions:

(1) All work shall be performed in accordance with the permission and terms of the occupiers of the land, the Drilling and Completion Program submitted with your application, the Department's Administrative Rules (Chapters 13-183 and 13-184, HAR), and all other applicable Federal, State, and County laws, ordinances, rules, and regulations;

(2) The permittee, its successors and assigns shall indemnify, defend, and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;
(3) The permittee shall observe and comply with all valid requirements of County, State, and Federal authorities and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws and those relating to the environment;

(4) The well and bottom-hole location shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling, unless modified by the Chairperson upon request;

(5) The permittee shall notify the Division of Water and Land Development (DOWALD), in writing, of the date of the start of drilling operations;

(6) Class "G" cement shall be used in the casing cementing operations and shall contain a high temperature resistant admix;

(7) All Blow-Out Prevention Equipment (BOPE) and cemented casing strings shall be pressure tested before commencing any other operation on the well. The minimum test pressures shall be approximately one-third of the casing internal yield pressure rating, provided that the test pressure shall not be less than 600 psig nor greater than 2500 psig, and shall be applied for a period of thirty minutes. The results of the pressure tests shall be reported on forms provided by the Department. If a drop of more than ten percent of the casing test pressure is recorded, the operator shall run a caliper log and/or other appropriate well test to determine if the casing is defective and if corrective measures will be required before commencing any further operations. The results of the prescribed casing tests and any remedial work conducted shall be submitted to the Department within sixty days after completion;

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(11) If changes to the proposed drilling program are contemplated, the permittee shall obtain the Chairperson's approval before executing such changes;

(12) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified, with reasonable time allowed for travel to the site, to witness the retrieval of a representative groundwater sample and the measurement of the static water level. The permittee shall have the sample analyzed by an independent laboratory and have the results submitted to the Department;

(13) During the use of the well for testing, monitoring, production and/or injection purposes, the well and site shall be properly maintained until the well is plugged and abandoned in accordance with the Department's Administrative Rules, Chapter 13-183, HAR;

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(15) A well completion report, an as-built drawing of the well, and the location of the well plotted on an U.S.G.S. quad map shall be filed with the Department within six months after completion of the well;

(16) The bond covering the well shall remain in full force and effect until the well is properly abandoned and the surface is restored as near as possible to its original condition; and

(17) This permit shall expire 365 days from the date of issuance.

KEITH W. AHUE, Chairperson
Department of Land and Natural Resources

Date of Issuance

cc: Land Board Members
Hawaii County Planning Dept.
DBEDT
Department of Health
OEQC
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Note: Burst and collapse values are minimum with no safety factor on 9.5 ppg mud and vertical well is assumed.
MEMORANDUM FOR THE RECORD

TO: William W. Paty, Chairperson
FROM: Manabu Tagomori
SUBJECT: Staff Analysis of 3,500-Foot Buffer Zone Established by Board of Land and Natural Resources’ Decision and Order of April 11, 1986. (CDUA HA-12/20/85-1830)

BACKGROUND

The Board of Land and Natural Resources’ Decision and Order (D/O) of April 11, 1986 authorizes geothermal development activities within the Conservation District identified as TMK 1-2-10:03, located on the island of Hawaii. The D/O also establishes a 3,500 foot buffer zone which is described in Conditions # 2 and # 3 of the D/O (page 4), and is shown on the map identified as Appendix A of the D/O (attached).

Condition # 2 states that "No wells or power plants shall be sited within 3,500 feet of the eastern boundary of the Applicant’s property line near Kaohe Homesteads (see Appendix A)," the applicant in this case being the Estate of James Campbell.

Similarly, Condition # 3 states that "No wells or power plants shall be sited within 3,500 feet of the southeastern boundary of the Applicant’s property line near Upper Kaimu Homesteads (see Appendix A)." In both instances, each condition (#2 and #3) bears specific reference to the map identified as Appendix A.

The buffer zone shown on the referenced map is a contiguous 3,500 foot corridor along the Conservation District and parallels the eastern boundary and portions of the southeastern boundary of Applicant’s property (TMK 1-2-10:3).

Our review of the buffer zone description (Conditions #2 and #3) and the buffer area drawn on the map (Appendix A) indicates a potential for possible misinterpretation and the need for clarification of the actual shape of the buffer zone.
The immediate question concerns the language in the D/O which states that the "Applicant's property line" at both the eastern (Kaohe) and southeastern (Upper Kaimu) boundary shall be the point of measurement for the 3,500 foot buffer zone.

Potential debate may arise concerning the use of the phrase "Applicant's property line", where such property boundary is different from that of the Conservation District boundary. While there is no question concerning the buffer zone area near Kaohe and Upper Kaimu (where the Applicant's property line and the Conservation District boundary line are the same), clarification is warranted for the area between these two points where Applicant's property also includes lands within the Agriculture District.

At this point between Kaohe and Upper Kaimu, Applicant's property line deviates toward the easterly direction away from the conservation boundary. However, the buffer zone drawn on the map continues to be measured from the parcel identified as TMK 1-2-10:3 rather than from Applicant's property line, and extends along the entire length of the eastern border of the conservation boundary.

In view of the possible misinterpretation of the Board's intent, staff has prepared the following analysis to clarify the issue of the buffer zone established by the Board's D/O.

**ANALYSIS**

The clarification of the buffer zone matter requires the analysis of two issues: (1) jurisdiction of the Board in permitting geothermal development activity, and (2) Applicant's property under consideration at the time of issuance of the Conservation District Use Permit.

**Jurisdiction**

In the regulation of geothermal development activity within designated geothermal resource subzones, the Board of Land and Natural Resources authorizes such activity within a Conservation District. Approval of the activity is through the issuance of a Conservation District Use Permit (CDUP).

Similarly, only the County Planning Commission has the authority to regulate geothermal activity within non-conservation districts by the issuance of a Geothermal Resource Permit (GRP).

As statutorily provided, the Board's jurisdiction (to issue a CDUP with conditions and establish a buffer zone restricting geothermal development activity) is limited to the Conservation District. Therefore, the establishment of a buffer zone can only be within the boundary of the conservation land upon which the activity is being permitted.
Applicant's Property

Notwithstanding Applicant's total land ownership, which includes the adjacent Agriculture District parcel (TMK 1-2-10:1), and the fact that Applicant's property line deviates from that of the conservation boundary in the area between Kaohe and Upper Kaimu, the buffer zone is intended to be a continuous 3,500 foot corridor within the permitted parcel of the Conservation District.

The Board's Findings of Fact and Conclusions of Law (FOFCOL), dated June 18, 1986, clearly identifies the property upon which the activity is permitted. The particular parcel of land (TMK 1-2-10:3) is referenced twice on page 6 of the FOFCOL under Section #4 entitled "Location" and Section #5 entitled "Description of Area". (It should be noted that while the FOFCOL identifies other parcels contained within the Kilauea Middle East Rift GRS, reference is specifically made to TMK 1-2-10:3 as the Applicant's property.)

In addition, the required documents (Plan of Operations, Environmental Monitoring Plans and Programs, and Application for Permit to Drill) submitted by True Geothermal Energy Company for approval by the Department all identify the same subject property TMK 1-2-10:3.

The specific references to this property in both the FOFCOL and the documents submitted to DLNR preclude any suggestion of ambiguity concerning which property was under consideration at the time the permit was issued and, more importantly, which property line is being referenced as the point of measurement for the buffer zone.

Therefore, since the Board's jurisdiction is limited to the Conservation District, and the fact that Applicant's property under consideration lies entirely within the Conservation District, it appears without question that all references to "Applicant's property line" regarding the establishment of a buffer zone clearly applies to that boundary line marking both the limits of the Conservation area and the eastern/southeastern borders of Applicant's property (TMK 1-2-10:3).

CONCLUSION

It must be recognized that the intent of the Board was to establish a buffer area along the Conservation District's eastern, and portions of the southeastern, boundary for the purpose of mitigating potential impacts from geothermal development activity.
This analysis reaffirms the Board's original intent when it imposed the buffer conditions of the D/O, and sets forth that the map identified as Appendix A should prevail if questions concerning the buffer zone area arise.

Because the Conservation boundary coincided with the property line of Applicant's permitted parcel (TMK 1-2-10:3), the use of the phrase, "Applicant's property line", was appropriate and correct when referencing the measurement point for the buffer zone.
SURVEY OF LAVA TUBES IN THE FORMER PUNA FOREST RESERVE AND ON ADJACENT STATE OF HAWAII LANDS

H. McEldowney and F. D. Stone

This study was initiated after members of the Puna community brought to the attention of the Historic Preservation Office that major lava tube systems extended from the Pahoa area into at least portions of the former Puna Forest Reserve. They were concerned that planned geothermal exploration and development could damage these lava tubes which they said contained extensive evidence of past Hawaiian use including fortifications, shrines, platforms and burials. Geothermal development is currently being planned by Campbell Estate and True Geothermal Energy Company in the southern portion of the former Reserve which has been designated by the State of Hawaii as one of the three Geothermal Sub-Zones in Puna.

To demonstrate these claims, two staff members of the Historic Sites Section were shown examples in a lava tube makai of the Campbell Estate boundary. After reviewing the archaeological and historical reports commissioned for geothermal exploration, it was agreed that if these lava tubes did extend inland and continued to contain archaeological sites or burials then the potential of significant sub-surface sites had not been adequately addressed in the Historic Sites Section review process. Most reports acknowledged the possibility of lava tubes in the area and that they could contain burials, but no tube systems were ever identified or explored during any of the field surveys. These surveys primarily assessed the presence or absence of cultural properties that occur on the surface or as deposits within the soil layer (see discussion below).

With the assistance of the Division of Water Resource Management (DWRM), the Historic Sites Section agreed to conduct this survey because those community members who came forward requested that this information be handled by a neutral party. They asked that documentation occur in such a manner that it could be kept as confidential as possible while still providing enough information to protect any sites from damage.
tubes and openings in areas where construction includes bulldozing or excavation.

This report has been produced in two forms; one that remains confidential because of the numerous burials found and one that is available to the public. In the confidential report, specific locations of the lava tubes, their entrances and any burials found are documented. In the following report, only general locations are given along with enough information to characterize the nature of the lava tubes and archaeological features encountered. The Hawaii Island Burial Council helped determine the extent to which various kinds of information should be included in this report and how they should be presented.

ENVIRONMENTAL AND ARCHAEOLOGICAL BACKGROUND

The parcel acquired by Campbell Estate through a land exchange with the State in 1985 encompasses approximately 25,738 acres and lies between elevations of 1,000 and 2,280 ft above sea level (Fig. 1 - confidential). The average annual rainfall is high, between 120 and 150 inches, and the vegetation is primarily composed of wet, ohia-dominated (Metrosideros sp.) plant communities distributed in a mosaic pattern that reflects, at least in part, differing substrate types and ages (True Mid-Pacific 1986:ix and Appendix A). In structure and density, these plant communities range from dense, closed canopy forests to pioneer assemblages that are only beginning to establish on recent, nearly barren lava flows. Native or mixed native/exotic plants form dense understories in the forested areas while thick mats of uluhe fern (Dicranopteris spp.) are found in open canopy communities or where the trees are widely spaced. The latter, called an ohia-uluhe woodland by Char and Lamoureux, covers a large proportion of the study area (True Mid-Pacific 1986:Appendix A). In 1911 and 1928 these lands were designated the Puna Forest Reserve by the Territorial Government in two increments and in 1981 an area (16,847 acres) bordering the western and southern sides of the parcel became part of the State of Hawaii Natural Area Reserve System (Holmes 1985:4). This portion of the study area then became known as the Wao Kele o Puna Natural Area Reserve. Because there is no single place name for the
believed that tangible remnants of all these activities should be present but they expected them in low numbers and to be difficult to recognize, particularly when compared to those found in the more intensely used coastal areas or prime agricultural lands. The dominant activities were seen, at least in this region, as being less prone to produce stone, structural remains or substantial deposits of durable food remains, debris from tool manufacture or charcoal. The distribution of potential remains was not only predicted to be sparse but uneven. Greater concentrations were expected along trails, in areas where lava tubes could provide shelter or burial sites and in the seaward portions of the parcel where limited agriculture may have taken place. All studies emphasize the problems of dense vegetation which compound the difficulty of finding what is already hypothesized to be scant evidence. The vegetation cover severely restricts mobility and access during conventional ground surveys, greatly reduces ground visibility and obscures what are often hazardous ground conditions.

Holmes (1982) and Hommon (1982) first summarized these characterizations in their reviews of historical and archaeological information for the neighboring land of Kahaualea. Hommon reported that no historic or archaeological remains were found during his reconnaissance survey in Kahaualea which covered 8.75 miles of access road and a 5 acre proposed well site. When the proposed geothermal exploration shifted to the Puna Forest Reserve following the land exchange, Holmes (1985) expanded this document search to encompass the former Forest Reserve and essentially applied the same themes to what he saw as a similar landscape. The known historic period activities were portrayed as more diverse than Kahaualea and included timbering and cattle raising along the eastern portion of the property. Since these studies, two documents have repeated and refined some of the major points made on past land use patterns and their expected archaeological correlates. One is the Research Design (required under CDUA HA-1839) which sets guidelines for all archaeological work conducted for geothermal exploration in the former Forest Reserve (Cordy 1989) and the other assesses the archaeological potential of the three Geothermal Sub-Zones designated in Puna (Cultural Surveys of Hawaii 1989).

The six archaeological surveys conducted thus far within the Puna Forest Reserve seemed to confirm predictions that site probability is relatively low
Pacific 1985:Appendix A) and a few examples of 'awapuhi were noted during the survey of three proposed well pads and access roads (Bonk 1990:7; Lamoureux, Whistler and Imada 1990a:5; Lamoureux 1990b:9). These plants, particularly kukui, ki and banana, are considered probable indicators of past use for two reasons: they were of great value and utilitarian importance to the Hawaiian culture and are unlikely to become established in rain forest communities without the aid of man either through propagation, clearing or initial tending.

In regard to lava tubes, a major oversight of these studies was the omission of Yent's survey (1983) of a "Pahoa Cave" (called the Middle Tube System here). Although the report shows the location of a single entrance on State land to the east of Campbell Estate property, the distances and bearings given in the report indicate that Yent explored at least 2,000 ft into the Forest Reserve and found defensive structures, burials, midden deposits and terracing within this stretch. Despite this omission, three overviews did consider the possibility of lava tubes with archaeological remains. The Research Design calls for surveys to pay special attention to pahoehoe flows where lava tubes could be present and could contain remnants of campsites and burials. The assessment of archaeological potential for all three Geothermal Sub-Zones simply stresses that lava tubes with remains rank as one of the major site types of Puna (Cultural Surveys of Hawaii 1989). Holmes felt that it "would not be unreasonable" to "conjecture" that there were caves in the Forest Reserve (Holmes 1985:6). Their significance, however, would be "minimal" because they would be "occasional shelter or possibly but not likely burial (because of distance from regular habitation)" (Ibid.). Our survey demonstrates that, to identify lava tubes within a study area, it may be necessary to begin the search, either in the literature or on the ground, from neighboring parcels.

Native Invertebrates and Lava Tube Ecosystems

Hawaiian native invertebrates as a whole have won recognition in the world scientific community as being an integral part of Hawaii's unique "evolutionary experiment." An important dimension of studying these evolutionary processes in Hawaii has been to contrast these cave-dwelling
Fig. 2 Known Lava Tube Entrances within Campbell Estate Land and the Geothermal Sub-Zone.

Known Cave Entrances

- $S$ = GEOTHERMAL WELL
- $o$ = CAVE ENTRANCE W/O HUMAN USE
- $\beta$ = CAVE WITH BURIALS
- $X$ = CAVE OF REFUGE
- $+$ = CAVE ENTRANCE SEEN FROM AIR

Legend:
- CAMPBELL LAND
- GEOTHERMAL SUB-ZONE
- TRUE WELL
- U.H. WELL
slope portions of the Campbell Estate land and on neighboring State land because vegetation is less dense than that found up-slope and nearby roads make access less time consuming. Differences in vegetation between the higher and lower elevations can be traced, at least in part, to the first half of this century when cattle grazing maintained more open plant communities at lower elevations and periodic bush fires have continued to keep them more open. Once an entrance was located, all attempts were made to follow the tube up-slope as far as possible.

Most of the time was spent locating and exploring three tube systems which Holcomb (1980) shows as hypothesized tubes. The locations of these three tubes made it possible to see if the tube systems themselves or evidence of Hawaiian use varied from north to south across the property or with elevation. Also, the course of two tubes indicated that they could extend into the Geothermal Sub-Zone or near the proposed well sites. This remained a strong possibility because the up-slope extent of all three tubes and their eruptive sources have never been identified because dense vegetation obscures evidence of tube directions or flow boundaries throughout much of the property.

In the following report, these three tube systems, or segments of them, will be referred to as the Southern, Middle and Northern Tube systems. A total of 11 days was spent in the field searching for tube entrances above ground and mapping those which could be followed. In addition, a three-hour helicopter survey helped locate entrances on aerial photographs and probable access routes to them. In all, 42 tube entrances were visited, about nine miles of lava tube were traversed, and approximately 6.6 of these were mapped (Fig. 2). Another 12 to 13 miles were covered above ground by foot in attempts to find additional entrances. This effort still represents coverage of less than 1/4 of the area which could have lava tubes or tube segments on Campbell Estate land.

The lava tubes were mapped by the pace and compass survey method with corrections in alignment and distance being made where tube entrances could be identified and plotted on aerial photographs. This method was chosen primarily for its speed. Although relatively less accurate than other methods, it was the most efficient for documenting the course of tube systems.
The Lower Segment stretches for approximately 3300 ft between the elevations of 700 and 780 ft and is broken by three entrances (Fig. 3). The uppermost 1300 ft of the segment is about 15 to 20 ft wide and 10 to 15 ft high while the lower 2000 ft of the tube averages 20 ft in width and 10 ft in height. Natural features within the upper section include three lava falls and two side passages which truncate after 50 and 100 ft. The central third has alternating sections of large passages and large break-down piles while only a few small collapse piles occur in the lower 1125 ft of tube.

We estimate that at least 60 to 80 individuals were buried in this tube segment. Counting the number of individuals is very difficult because most of the human remains are badly decomposed and have been disturbed or mixed by natural processes and possibly some vandalism. This problem is compounded by the number of burials that could be hidden amongst the roof fall debris and in side recesses. This problem became apparent several months after our initial survey when a section of the tube was mapped in more detail and 10 to 15 additional burials were found in a debris filled depression along the edge of a collapse pile.

Most of the burials are concentrated in three sections of the tube. The first is the 175 foot stretch (Stations U13 to U17) at the uppermost extent of the tube which is 430 ft from the nearest accessible entrance (Fig. 4a). About 13 to 17 individuals lie in this stretch, either on the floor, in crevices along the tube wall or within an elevated passage. The second section includes a 375 foot stretch (Stations U7 and U3) above and below the middle of the three entrances (Entrance 2) in which 10 to 15 burials were placed on six elevated shelves along either side of the tube (Fig. 4a & 4b). The third concentration begins at the lowest entrance (Entrance 1) and extends approximately 375 ft down-slope (Fig. 4b). It includes, in order of occurrence down-slope, an estimated 10 to 15 burials concealed among debris at the base of the entry collapse; at least three burials on shelves immediately down-slope of the entrance; four more placed in or on artificially arranged portions of a break-down pile; two individuals on a broad shelf and the burial of a single individual on another shelf. Only scattered human bones or bone fragments were found between the concentrations. Below the lowest concentration, single, isolated burials occur at 765 ft and 1095 ft from the entrance (Fig.
Fig. 3 Southern Tube System – Lower Segment

COMPASS/PACE SURVEY: 20.III.1990

--- Stone, McEldowney
--- North = Vertical
tube course curves substantially in some segments. Instead, anything noted as being on the Hilo side lies on the right hand side of the tube as one faces up-slope and that on the left hand side is noted as being on the Ka‘u side.

**Detailed Description**

St. U16 to U13 - The up-slope extent of this tube segment ends in a 10 ft high lava fall and a small, upper level passage that extends for approximately 40 ft beyond the fall. One burial is located at the base of the fall and at least six individuals were placed in crevices along the tube wall and on an elevated shelf. Although widely dispersed, the configuration of the piles suggests that they were bundle instead of extended burials. Scattered pieces of small bones cover much of the surrounding tube floor including those which appear to have washed down from the passage above. In the elevated passage, remains of 5 to 10 individuals cover the floor and are tucked in crevices along the tube walls. The remains are mixed with charcoal or decayed organics throughout and one red glass bead and some bottle glass were also present, suggesting that at least some of the burials date to the historic period. A strong breeze from a nearby entrance can be felt through cracks in the ceiling above the passage suggesting that an opening may have been artificially sealed with break-down rubble and roof fall slabs.

St. U12 to U11 - Up-slope from the St. U11, badly deteriorated human bone and charcoal are dispersed for a 20 ft stretch of the tube floor. The occasional scatter of charcoal and wood splinters continues beyond the bone scatter.

St. U10 to U9 - With the exception of horse bones and old bottles which were probably used as kerosene lamps, nothing was found between these stations and an upper level passage of the tube which truncates after 150 ft.

St. U9 (Entrance 3, Fig. 4a) to U8 - The double entrance at Station 9 is separated by a natural bridge. What appears to be an artificial or modified gap (2 m wide, 5 m long) crosses the down-slope end of the collapse pile under the lower entrance. The tube splits into an upper and lower passage below this entrance. The lower area has the appearance of having been roughly paved with a layer of flat, roof fall slabs.
Fig. 4a Detail of Southern Tube System – Lower Segment (Map 1)

COMPASS/PACE SURVEY: 20.111.1990

B = HUMAN BURIAL
H = HORSE BONES

LEVELLED ROCK FILL

MANY BURIALS

10' LAVA FALL

FT

(Thousands) FT

— Stone, McEldowney

— North = Vertical
Fig. 4b Detail of Southern Tube System – Lower Segment (Map 2)

COMPASS/PACE SURVEY: 20.11.1990

B = HUMAN BURIAL
H = HORSE BONES
C = CHARCOAL

Stone, McEldowney
Fig. 4c Detail of Southern Tube System — Lower Segment (Map 3)

COMPASS/PACE SURVEY: 20.III.1990

- Stone, McEldowney
- North = Vertical
Fig. 4d Detail of Southern Tube System – Lower Segment (Map 4)

COMPASS/PACE SURVEY: 20.III.1990

- CRAWL
- CHARCOAL

---

Stone, McEldowney

North = Vertical
St. 1 (Entrance 1) to St. D2 - The collapse pile beneath this entrance shows no sign of structural modification. Bone from at least three, badly disturbed burials is scattered on shelf formations along both tube walls and on the floor beneath them. The burials were probably placed on the shelves originally and later fell to the floor as a result of natural or human disturbance. In most cases, the long bones remain the most recognizable of all the skeletal parts. A bead and chain necklace mixed with some of the bones suggest that at least some of the burials occurred during the historic period.

St. D2 to St. D3 - At least four burials are visible within a large break-down pile. These badly decayed concentrations of human bone were covered or mixed with charcoal and organic debris. One individual lay on a portion of the collapse pile that was artificially leveled with small rock debris. The other three skeletons were placed in the collapse debris with some attempt having been made to arrange rocks around or over the bones.

St. D3 - St. D4 - Only a fragment of a skull was found on the floor of the lava tube.

St. D4 to St. D5 - A triangular piece of roof fall was laid in an upright position in the middle of the tube floor, possibly to serve as a marker of some sort. Its placement had to have been artificial because there were no holes or fractures in the ceiling from which it could have fallen. Between this possible marker and a collapse pile down-slope, at least two individuals were placed on a broad triangular shaped shelf (2 m at the widest point). Within these deteriorated burials, broken skull fragments formed two distinct piles.

St. D6 - On the Ka'u side of the station, remains of a single individual lie on a broad shelf (1.5 m wide). The badly fragmented skull indicates that it is the remains of a single individual. An old bottle was also placed on the shelf but it is not clear if it was associated with the burial or if it was left by someone passing through.
intentionally leveled rubble pile or platform. As was the case in the lower segment, estimating the number of burials was difficult because the bones are badly deteriorated or disturbed and some skeletons may have been incomplete when buried. In this segment, there are more instances of individuals being intentionally covered by rock debris, which raises the possibility that some burials remain hidden and the number of burials may be underestimated. More skulls were recognizable throughout the segment suggesting that it may not have been looted or impacted as heavily as the lower segment. No historic goods or materials were seen with any of the burials indicating that use of the tube occurred predominantly during the prehistoric period.

The burials within the segment begin directly across from the small opening where at least three line the tube wall. Some were intentionally covered by slabs of roof fall and a long piece of wood, probably the remnants of a litter stick, parallels the wall. The disrupted remains of three more individuals were placed among the break-down rubble in the middle of the broad passage while another three, all extended burials, lie on the tube floor where it rises to form a low ledge.

Within the next c. 100 ft, there are at least 19 more individuals buried either along the edges of the tube or within the collapse rubble where some have been covered or surrounded by the rubble. Several structurally distinct and intentionally stacked piles (.50 x .50 and .75 x .75 km) are located 50 ft farther down-slope and could have been built to conceal burials. Another four burials were placed on a break-down pile located 50 ft down-slope from the artificial piles. One of these lies on a crude platform formed in the rubble.

The tube segment ends in a small chamber where five individuals rest in discrete piles, indicating that they were probably bundle burials. The remains of one individual lies just outside this last chamber.

MIDDLE LAVA TUBE

What we are calling the Middle Lava Tube (Site 50-10-45-14,900) can now be shown to run continuously for approximately 10 miles between the elevations of 470 and 1620 ft (Fig. 5). Diverse evidence of Hawaiian use occurs at least
Fig. 5 Middle Lava Tube System and Known Tube Entrances to the Northern Tube System

o = lava tube entrances
An additional lava tube was entered near entrance U20 of the Middle Tube. Only a few hundred ft was explored and no evidence of human use was found. This tube should be fully explored in the future, particularly if there are any planned development activities to the north of the Middle Tube.

Despite occasional sections where the tube narrows to crawl ways or is constricted by break-down piles, the average width and height of the tube chamber remained relatively similar throughout the length mapped. Between entrances U20 and U27 (3.5 miles), the width of the tube averages 15 to 16 ft and, above U27 (1.6 miles), it averages 20 ft. The average heights vary from 11 to 13 ft throughout the 5.1 mile stretch. Some of the larger chambers mapped reach maximum widths of 35 to 40 ft and have heights of 20 to 25 ft.

Not only is this tube notable for its size, but two long sections run continuously without any openings or entrances to the surface, one being 1.4 miles long (U20 to U21) and the other 1.5 miles long (U26 to U27) (Fig. 5). A one mile segment between U20 and U21 is particularly striking because the chamber remains intact with no major roof or wall collapses. Within the lower 3.5 mile stretch (U20 to U27), the six openings that do occur are clustered in two groups where the distance between the openings is less than 1000 ft (290 to 721 ft) (Fig. 5). This contrasts with the upper 1.6 miles where four of the five openings have a scattered distribution (1200, 1360, 2365, 3120 ft apart) and break-down piles increase substantially in frequency and size with elevation (Fig. 7c-7e). This upper section of the tube crosses an area shown on the geologic map as having a large number of faults and cracks which may explain the greater frequency of break-downs. Overall, only about half of the openings, seven of 13, provide ready access to the tube without the aid of ladders or ropes.

Archaeological evidence in the Middle Tube is dominated by structural features which are almost all constructed of break-down rubble at entrances or within the tube. In seven cases, artificially stacked rocks block or constrict passage through the tube. Of these, five are interpreted as having been constructed for fortification during civil conflicts or wars while the function of the other two remains less certain. In three cases, two at entrance U20 and one at U27, the shared attributes which suggest fortification
down either the up-slope or down-slope sides of the collapse pile. Their position just within the drip-line affords protection from the rain or sun while still providing access to the light or the surrounding terrain. Similar features elsewhere in Hawaii are generally interpreted as having been modified to create a comfortable sleeping, resting or working surface for those who come to cultivate, hunt, gather, fish or pass through an area.

The remaining structural features noted vary from distinctly formed walls and platforms to less formalized modifications in which alignments or leveled surfaces were created by simply rearranging the rubble. Most occur in a 600 ft stretch above entrance U20 and were fashioned out of collapse debris. Several of the alignments appear, for lack of any other explanation, to delineate and possibly differentiate use areas on the tube floor.

Deposits of shell and bone midden, organic debris, and charcoal or ash occur in varying densities near four of the eight entrances that have other signs of human use, and two additional deposits lie near the burial and blockade located in the long stretch between U26 and U27. Of the food refuse, 'opihi shell (Cellana sp.) is by far the dominant remain with some bone (dog, pig, bird and fish) and other unidentified shells being only sporadically represented. In the more heavily used areas, midden is scattered continuously across the tube floor, but in some sections the shells and some bone form a pattern of dispersed or evenly spaced clusters that may represent refuse from a single sitting. Most of the organic debris, excluding the occasional kukui nut, was decomposed beyond recognition although the form of the decayed matter indicated that some had been sticks or poles. Charcoal and ash are generally mixed with these deposits but they sometimes occur in concentrations which probably represent individual fireplaces. Some of the thicker deposits, including decayed organics, charcoal and smaller bone and shell fragments, have been badly disturbed and redistributed by water runoff from the tube walls and floor but even the most dense deposits are little more than thick scatters with no true or consistent depth. This probably reflects the relative youth of the tube as well as the degree to which it was used. Away from these distinct deposits, the occasional piece or pieces of charcoal are the only indication that those sections had been visited or explored in the past.
of entrance U20 and U23, most are located in areas that are spatially discrete or removed from areas where other major activities took place. In two cases, both reported by Yent, roof fall debris was used either to cover the burial or surround it. No grave goods were found with any of the burials which again may indicate that the lava tube may have been looted. The lack of any historically manufactured items, particularly small glass beads, suggest that the burials are more likely to be prehistoric than historic period burials. Most burials appeared to be those of adults although we caution that neither author has the background to make definite age determinations.

Detailed Archaeological Descriptions of the Middle Tube between Entrances U20 and U32

U20 (900 ft el., Fig. 6a, 7a) - Of all the tube sections described below, that which extends from this entrance contains the greatest amount and diversity of evidence for past Hawaiian use. The following description essentially summarizes that given by Yent (1983) with some of our own observations and interpretations added.

In the down-slope direction, the width of the collapse pile has been modified to form a series of five terraces just beyond the drip-line. Three of these form a tiered alignment along the Hilo side of the tube, a single one lies along the Ka'u wall and a fifth crosses the center of the pile, forming a base which links the terraces to either side. All were constructed with a retaining wall, some faced with upright slabs, and rubble fill. The leveled areas range in size from 1 to 2 m wide by 2 to 4.5 m long and have retaining walls from 1 to 1.2 m in height. Five burials were found including three which were on a ledge; one covered by stacked stone and one placed on the floor of a small side passage.

The main focus of activity was, however, along the up-slope section of the tube where some form of cultural remains, including scatter midden and features constructed out of roof-fall debris, occurs for approximately 1,240 ft. The first feature encountered lies at the base of the collapse pile and covers the entire width of the tube floor. In basic construction and form, it resembles an incomplete large platform that is 2 to 2.5 m wide and has a 1 m
Fig. 6a Middle Lava Tube with Numbered Entrances – Up-slope End of State Land


U14: Fortification Walls, Platforms, Charcoal
U15: Fortification Walls, Platforms, Charcoal
U18: Fortification Walls, Platforms, Charcoal
U20: Fortification Walls, Platforms, Midden Deposits, Burials

Gap will be closed in final report.

——— Stone, Irvin
——— McEldowney
Fig. 6b Middle Lava Tube with Numbered Entrances – Campbell Estate Land

Pace/compass survey: 1990

U21: Fortification Wall Blocks Passage Near Skylight Entrance
U22: Fortification Wall Blocks Passage, Burial
U23: Platforms, Entrance in Closed Forest
U24: Platforms
U25: Platforms, Burials
U26: Concealed Lower Passage, Charcoal

Gap will be closed in final map.
Fig. 6c Middle Lava Tube with Numbered Entrances - Campbell Estate Land and Geothermal Sub-Zone

Compass/tape survey: 1990

U29: Burials, Entrance in Rich Native Forest
U30: Skylight
U31: Large Pit Entrance
U32: Upper End in Old Ohia/ Uluhe Forest

U27: El. 1460'
U29: El. 1500'
U31: El. 1620'

F. Stone, T. Stone
H. McEldowney
burials or as resting surfaces. Another, smaller platform (1 by 2 m, 40 cm high) lies just beyond this continuous stretch of modified rubble and, directly beyond it, two 5 m long parallel alignments lie in the center of the tube floor. In some respects, they resemble alignments that delineate trails.

Evidence for human use occurs continuously for the next 425 ft (600 ft from the entrance) but with less over all density. Included in this stretch are more leveled and rearranged break-down piles and several instances where single rock alignments appear to delineate portions of the tube floor. The stones in some of these alignments had to have been brought into that specific locale because the ceiling and walls of the surrounding tube remained unbroken. Distinct scatters of bone (pig and bird), shell (mostly ʻopihi), organic debris and charcoal concentrations occur along the tube floor in four sections. In many cases, the midden form small clusters adjacent to the tube walls, leaving the center of the floor free of refuse. Yent collected a basalt pestle and two adze from these midden areas. From 600 to 1264 ft from entrance U20, the only indications of past use were very scattered pieces of shell, bone, charcoal, organic material and roof-fall that had obviously been shifted from its original location.

U21 (1090 ft el., Fig. 6b & 7b) - About 25 ft up-slope from the skylight the tube divides into a shallow, dead-ended upper passage and a lower passage through which the main tube continues. Below this divide, a false or greatly enhanced collapse pile blocks the main tube, allowing only a narrow passage along the Kaʻu side of the pile and a small gap at the roofline which could be used for observation. Looking from the down-slope side, the blockade appears natural with the exception of a small (1.5 x 1.5 m), slightly leveled area on the Hilo side of the rubble slope. The break-down pile below the skylight is uncharacteristically flat and uneven, suggesting that it was robbed of stone to build the blockade. The artificiality of the pile is obvious on the up-slope side and along the narrow passage where the rocks clearly form a stacked face. Charcoal and decayed sticks, with some ʻopihi, are prevalent along the up-slope side of the tube floor for approximately 25 ft.

U22 (100 ft el.) - At 133 ft from U22, another break-down pile has been modified to block passage through the main tube, probably for defensive
m) sitting immediately above the leveled area (4.5 x 2 m) which is distinctly edged with stacked rocks. These modifications themselves seem to suggest shelter more than fortification although the difficult entrance may have provided some defense.

U25 (1180 ft el.) - The lava tube here divides into an upper and lower passage, with the skylight being accessible only through the upper passage. Two leveled terraces were built on the down-slope and Hilo side of the collapse pile 2.5 m from the drip-line. Passage through the main tube was blocked, naturally, by a large collapse pile which can be skirted by crawling through a narrow space at the edge of the pile. About 50 ft past the collapse, the tube narrows into a crawl way, and at the juncture of the collapse and the narrowed tube two bundle burials were placed in a small alcove.

U26 (1185 ft el., Fig. 6b, 6c) - Again, the outside entrance leads to an upper level of the tube while that to the main tube is a narrow segment blocked by break-down-debris. To a great degree, this break-down appears to have been rearranged to conceal the passage. Access is only through an artificially created hole (50-60 cm wide) that is faced with flat roof fall slabs and leads to a drop of about 2 m. A conveniently placed stone underneath the hole provides a foothold so that access is through lifting oneself in and out of the hole.

U26 (1185 ft el) to 27 (1435 ft el.) - A number of features are present in the long stretch between entrances 26 and 27. Heading up-slope 1,972 ft, the first is an area of scattered charcoal concentrations and midden composed mostly of shell (ʻopih) and some bone (including dog). Shortly beyond this area (205 ft), but clearly distinct from it, is a burial with three individuals. One is fully extended, lying on the floor perpendicular to the tube walls, while the bones of the other two are mixed with the lower half of the extended burial. A long, decaying stick lies along the length of the extended burial.

Approximately 3,890 ft above these burials is another artificial barrier which blocks the main passage at a point where the lava tube divides into an upper
Fig. 7a Middle Lava Tube with Numbered Entrances -- Distribution of Natural Features, Collapse Piles, Archaeological Features, Cave Invertebrate Species and Tree Root Formations

Compass/pace survey: Mar. 1990

- walls, platforms
- platform
- ophi
- human bones
- ophi
- collapse, roots, cave species
- ophi, charcoal
- ophi, charcoal
- collapse, roots, cave species
- charcoal, ophi
- charcoal
- roots
- ophi
- walls, platforms, ophi
- F.Stone, T.Stone
- H.McEldowney
Fig. 7b Middle Lava Tube with Numbered Entrances – Distribution of Natural Features, Collapse Piles, Archaeological Features, Cave Invertebrate Species and Tree Root Formations

Compass/pace survey: Mar. 1990

- collapse
- collapse, roots
- collapse, roots, cave species
- roots, cave species
- charcoal, opihis
- wall collapse
- wall collapse
- 10' lava fall
- platforms
- opihis, charcoal
- rock wall, fortified
- platforms, opihis
- opihis, charcoal
- human bones
- roof collapse, roots, cave species
- roots, cave species
- collapse
- platforms
- small pieces of bones
- concealed passage
- burials: 2-3 individuals
- scattered charcoal
- roots, cave species

--- F. Stone, T. Stone
--- H. McEldowney
Fig. 7c. Middle Lava Tube with Numbered Entrances—Distribution of Natural Features, Collapse Piles, Archaeological Features, Cave Invertebrate Species and Tree Root Formations

Compass/pace survey: Mar. 1990

- charcoal
- roots, cave species
- collapse, leveled, charcoal
- double walls
- U27 El. 1460': Machaerina bog
- U28
- large collapse, roots, cave species
- large collapse
- collapse
- human skull, skeleton
- roots, cave species

F. Stone, T. Stone
H. McEldowney
Fig. 7d Middle Lava Tube with Numbered Entrances – Distribution of Natural Features, Collapse Piles, Archaeological Features, Cave Invertebrate Species and Tree Root Formations

Compass/pace survey: Mar. 1990

---roots
---collapse, roots, cave species
---charcoal, opiihi, dog bones
---charcoal, roots
---3 human skeletons
---rock cairn, roots
---abundant roots, cave species
---roots
---roots, cave species
---large collapse
---rock wall with mud mortar
---charcoal, opiihi, dog teeth
---collapse

--- F.Stone, T.Stone
--- H.McEldowney
Fig. 7e Middle Lava Tube with Numbered Entrances — Distribution of Natural Features, Collapse Piles, Archaeological Features, Cave Invertebrate Species and Tree Root Formations

Compass/pace survey: Mar. 1990

--- 10' lava fall
large collapse

collapse
roots, cave species

collapse

collapse, roots, cave species

collapse
roots, cave species

U30

U31

U32: El. 1620': Ohia regrowth, native spp. understory

--- collapse

F.Stone, T.Stone

H.McEldowney
part, by the large number of break-down piles in this stretch of the lava tube, which made access through the tube substantially more difficult than it had been in the lower segments.

U29 (1495 ft el.) - At this entrance, access through the main chamber is entirely blocked by break-down. On the up-slope side of the opening, an upper level passage lies above the main chamber. The height of the passage is low and, for much of its distance (25 to 40 ft), access is only by crawling. At least three individuals were buried in this passage. The remains of two are mixed with the break-down pile directly behind the entrance and the other, located at the narrow end of the truncated passage, was clearly a flexed burial. With no evidence of human use in the main tube between entrances 27 and 32, it seems probable that these burials were carried to this entrance over land instead of underground through the tube.

U29 to U32 (1620 ft el) - This portion of the lava tube is again characterized by increasing numbers of large break-down piles which make passage difficult. The lack of human evidence within the tube continues to entrance U32.

NORTHERN TUBE SYSTEM

What we designated the Northern Tube is a series of sizable tube openings that run diagonally across the northern half of Campbell Estate land for at least 3 miles (Fig. 2). Beginning near the border of Hawaiian Acres subdivision, it heads towards the Geothermal Sub-Zone and reaches a minimum elevation of 1660 ft. The two tube entrances we were able to enter did not lead to segments of any great length suggesting that the system, like that of the Southern Tube, is fragmented. The large size of the tube openings indicate that it had been the main channel of a very-high volume flow but the flow probably did not run consistently or long enough to create a stable or continuous tube.

A total of 3 days was spent locating access routes to this tube system and finding the two segments which we mapped. Approximately eight to nine miles were covered in these efforts which included a brief reconnaissance of a forested kipuka to the southeast of the tube system. It was clear from the air that kukui trees (Aleurites moluccana) and ki plants (Cordyline
Fig. 8 Northern Lava Tube System – Lower Segment

9.IV.1990: Pace-compass survey

ABOVE ENT. A: CAVE SPECIES PRESENT

NO HUMAN USE

Ent A: Three Burials, Pit Entrance 20' Deep
Ent B: Platform, Paving, Skylight
Ent C: Small Opening, Not Passable

- Stone,McEldowney
- Howarth
- NORTH = VERT.
Fig. 9 Northern Lava Tube System – Upper and Lower Segments

8.IV./13.IV.1990: Pace–compass

No Human Use

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Stone, McCauley, Howarth

N = vertical
reach the skylight. The tube floor leading to the platform on the up-slope side was paved with flat, roof fall slabs forming a pathway about 5 m long. The location of these features beneath a small skylight suggests restricted access and the possibility that they were used for refuge or defensive purposes. No midden was seen in association with these features.

Beyond the second skylight, we followed the tube for another 350 ft to an opening too small to enter and a very small crawl way which we did not pursue. The average size of the tube remained similar to the up-slope extent with average widths of 8 ft and heights of 20 ft.

NATIVE INVERTEBRATES

Preliminary observations made during the current study indicate that native invertebrates are abundant both in the native forests and in the cave ecosystems. This is true for the Campbell Estate property as well as the designated Geothermal Sub-Zone. Although not listed here, native cricket species were observed around tube entrances, and moths, flies and other insects swarmed the lamps at night.

The cave-adapted species now known to be present within the Geothermal Sub-Zone include:

- Oliarus sp. (Cixiidae): cave plant-hopper
- Caconemobius varius, C. sp. A (Gryllidae): cave crickets
- Lycosa howarthi (Lycosidae): cave hunting spider
- Schrankia sp. (Noctuidae): cave moth
- Dimerogonus sp. (Cambalidae): cave millipede
- Forcipomyia sp. (Ceratopogonidae): fly
- Isopoda sp.: cave isopod

Additional species can be expected to occur in lava tubes within the Campbell Estate land based on their documented presence in the lower part of the Middle Tube and in near-by Kazamura Cave (Howarth 1981: 323 and Stone data files). These taxa include:
It was suggested in the Supplemental EIS (1986:134) that disturbed wildlife may have to relocate to another area. If disturbance proves to be substantial and extensive it is unfounded to assume that native invertebrate fauna would migrate or that they could become established in neighboring areas where the forests may already be supporting a maximum number of native species. Given the great diversity of native species, neighboring forests or other lava tubes even a few miles away will have different species or varieties which may not be compatible with intruding migrants. More important, however, is the fact that the amount of forest to which species could migrate is diminishing. Substantial portions of neighboring forest land to south, west and north have been removed or depleted by the current eruption, expansion of papaya plantations, woodchipping and development within private subdivisions. Apart from the Kahaualea area, very little of the adjacent land currently has preservation zoning.

If the native invertebrates and the lava tube ecosystems in the Middle Tube are to be provided positive protection, the native forest above the course of the tube must be protected by an adequate buffer zone. These tube ecosystems are primarily dependent on tree roots, mostly those of *Metrosideros* sp. ('ohia), through which essential organic nutrients are continually renewed.

**GEOLOGY AND GEOLOGIC FEATURES**

Despite its considerable archaeological and biological value, the Middle Tube merits attention in its own right as a significant geologic or natural feature. It has now been mapped for about 10 miles, making it one of the longest known lava tubes in the world.

Identifying the location of these lava tubes, particularly that of the Middle Tube, could provide valuable information for improving the accuracy of the current geologic maps. Holcomb discusses the difficulty of dating lava flows, especially in Kilauea's densely vegetated Middle East Rift Zone where the study area is located (Holcomb 1987:267). As previously noted, Holcomb groups roughly half of the study area as being part of the Ai-Laau series based on magnetic and vegetation similarities with flows dated by C-14 dating methods at 350 to 500 BP. He estimates the remaining half to be older than 1500 BP.
identified during the survey: the justification and means for preserving the Middle Lava Tube System; procedures for predicting lava tubes and significant archaeological remains within the study area; identifying and protecting unknown lava tube segments which could contain historic remains (including burials); approaches that could minimize disturbance of undetected tubes during construction activities and drilling.

Most recommendations apply specifically to geothermal exploration and development within this Geothermal Sub-Zone and accommodate the guidelines stipulated in the CDUA Decision and Order (No. Ha-12/20/85) for these projects. In some cases, the suggested approaches could serve as guidelines for geothermal or other development projects in areas where lava tubes with historic remains are likely.

SIGNIFICANCE EVALUATIONS:

These initial significance assessments are based on criteria set out in the Draft Rules and Regulations of the State Historic Preservation Division which, with the exception of Criterion "e", conform with those used to determine eligibility for inclusion in the National Register of Historic Places. (36 CFR Part 60). All sites possess a high degree of integrity in location, setting, feeling and association.

1. Southern Tube Segment (Sites 14,901 – 3). These three tube segments were all used for burial and are therefore significant for their importance or value to the Hawaiian culture (Criterion "a"). They are also significant for the information they could yield (Criterion "d").

2. Middle Lava Tube (Site 14,900). This extensive lava tube and the combined historic properties found over at least 9 miles of its length, is significant under several criteria. Despite probable looting of artifacts, most of the lava tube above the Pahoa Highway is essentially undisturbed. It contains burials and is therefore significant to the Hawaiian culture (Criterion "e"). The numerous structural features and midden deposits found are significant for information they could yield on the prehistory of the region, particularly concerning past resource use and conflict
accidental impacts from activities occurring on adjacent lands and protect a belt of ohia forest whose roots are essential for the viability of the cave-adapted invertebrate populations. It should also be sufficient to accommodate any minor or cumulative errors that may occur in the mapping and plotting of the lava tube.

The buffer zone will also help to minimize potential dispersal of air pollutants. The existence of a 20 to 40 foot diameter lava tube passing from the Middle Rift Zone to Pahoa could have a bearing on the potential dispersal of pollutants which was not addressed in the Supplemental EIS. Under normal trade wind patterns, air flows up the mountain during daytime and down the mountain at night. Air flow through the lava tubes is linked to the surface pattern, with flow generally up-tube during the day and down-tube at night. Surface air flow might be expected to disperse pollutants, but lava tubes could allow a heavier-than-air substance such as hydrogen sulfide to be channeled for a long distance.

3. Definition of Buffer Zone Boundary. The boundary of the buffer zone should lie 1,500 ft to either side of a line which averages, in increments, the many bends and meanders in the tube's course. This places Alternative Well Site #2 about 3,200 ft from the boundary and Alternative Well Site #3 about 3,500 ft from it. At the closest point, the Alternative Well Sites are 4,800 ft and 4,500 ft from the lava tube itself. If development plans followed that depicted in the Supplemental EIS (Fig. 5), development areas A and C would lie on the boundary of the buffer zone. An adequate buffer reduces the possibility of damage due to construction activities, accidental waste spillage or destruction of the forest above the tube. Final definition of this buffer zone should follow a more accurate survey of the portion of Middle Tube where it passes beneath Campbell Estate land.

4. Complete Mapping of the Middle Tube System. The Middle Lava Tube was only mapped to an elevation of 1,620 ft and, based on its size at this point, we assume that it continues. We expect that continuous and diverse evidence of human use is unlikely in the upper, unmapped portions of the Middle Tube although burials could be present at entrances as is the case at entrance U29. If any exploration or development is planned for that portion of the
contain lava tubes than those grouped with the massive, tube-fed Ai-Laau lava flow series.

3. Re-evaluation of Prehistoric Land Use Intensity in the Study Area. Most of the historical and archaeological reports, including the Research Design, depict the area as forested and remote. Land use is seen as leaving few tangible remains because of the kinds of land use associated with these areas and their periodic use. Our survey suggests that the intensity with which the study area was used should be broken into two sections; those areas below 1,500 ft in elevation and those above. While there are similarities in the kinds of land use that occurred in both areas, the diversity and intensity of this use appears to have been greater below 1,500 ft. This is demonstrated by the distribution of three factors: evidence of human use is continuous in the Middle Lava Tube up to an elevation of 1,420 ft; cultigens or plants considered to reflect past Hawaiian use are documented up to an elevation of 1,600 on the north and south flanks of the Middle East Rift Zone; several, presumably agricultural lands were surveyed as lying within the Forest Reserve between the elevations of 1,400 and 1,550 ft during the mid 1800's (Baldwin 1902). Overall, this probability would still be less than that of the coastal or prime agricultural lands. The Research Design should be amended to reflect this difference.

Some perceptions of the study area being remote probably arose when many of the basic themes and approaches used for the Kahaualea study were applied to the former Puna Forest Reserve. In the case of Kahaualea, the land division was a single ahupua'a and more conventional land use patterns could be applied when predicting the probability of historic remains. Major settlement areas were depicted as being located near the coast while the agricultural or planting areas stretched up-slope until reaching the vast forested area which grew increasingly remote with elevation. This general orientation becomes more complex in the case of the Puna Forest Reserve. At least six ahupua'a converged in the study area from the south and the east (Holmes 1985) and generalized assessments of land use would have to be viewed as converging from these directions. A combination of factors, however, tended to focus attention on the southern approach to the
period may not have been readily available in these younger and developing vegetation communities. Use that did occur would probably be distributed unevenly in that it would be concentrated or intensified in those areas with older flow surfaces or where advanced vegetation communities developed more quickly. This pattern would probably be reinforced by open pahoehoe with no or little vegetation which is relatively easy to traverse and would allow increased access to any resources available. If substantial portions of the landscape were open at various time, this could significantly lessen the over all degree to which the project area was remote and inaccessible. This uneven and concentrated distribution of potential sites should be given greater emphasis in the Research Design where it discusses predicting and identifying archaeological remains. In preparing for an inventory survey and reporting its results, even greater attention should be paid to identifying areas with older flow surfaces or those in which vegetation communities may have advanced more quickly.

4. Probability of Burials within the Study Area. Based on survey results from below and within Campbell Estate land, at least half the tube segments found were used for burial. Thus, if tube segments are found, we can roughly estimate that the probability of burials is approximately 50%, particularly below 1,500 ft in elevation.

5. Relocation of the "Wilkes Trail" within the Forest Reserve. While reviewing historic documents for references to lava tubes, we noted a possible error in the proposed location of the "Wilkes Trail" (Holmes 1985:Fig. 22a). In his literature review, Holmes reconstructs what he believes to be the route taken by the U.S. Exploring Expedition under the command of Charles Wilkes in 1840-41 when they crossed through inland Puna. Based primarily on the map presented in the Narrative of the Expedition, Holmes plots the route as passing almost directly through the East Rift Zone before heading slightly south to pass north of Heiheiahulu and south of Ilewa. Wilkes also shows a series of other trails passing east and west of the hill "Kalalua" which, to Holmes, indicates that other trails passed through the southern and eastern portions of the Forest Reserve. In the Research Design required by the CDUA (HA-1830), the identification of trail routes is singled out as an important step in predicting areas of
would have to reflect the dominant flow direction of that particular area. Although two segments of the Middle Tuba System run for 1.4 and 1.5 miles without openings, we feel a 2,000 ft long survey corridor would have located many entrances from different points along the tube's course. The 1,000 ft width of the corridor accommodates the degree to which the tube meanders between most entrances.

2. Coverage within the Survey Corridor. To locate entrances within the survey corridor we feel that visual coverage should be as close to 100% as possible unless a sampling design can be devised which targets particular flow types or formations that prove, over time, to be associated with a high incidence of lava tubes. The analysis of clear, low level aerial photographs and maps of the vegetation, geology and surface topography could help identify indicators of tube openings or trends. A sampling design would help lessen problems of reduced mobility and low ground visibility due to dense vegetation and hazardous ground conditions.

3. Treatment of Tuba Segments Found. The treatment of archaeological remains found should be in keeping with the policies of the State Historic Preservation Division and the stipulations of the CDUA Decision and Order. If burials are discovered, the Hawaii Island Burial Council should be consulted. Mitigation measures, like those for all historic properties, will depend on their significance evaluation and, to some degree, the feasibility of shifting the well or road location. A possible problem with long tube segments, is that indirect damage could be caused down-slope, particularly by fluids or fumes. To minimize this possibility, any tube segment found should be followed for a considerable distance down-slope or until it is no longer passable.

4. Identifying Suspected Lava Tubes Not Discovered During Surface Surveys. In areas with a high probability of lava tubes with archaeological remains or burials, we recommend the steps outlined below. We stress that it is difficult to prescribe specific mitigative measures to deal with every possibility because there are no well defined and tested archaeological precedents upon which to base these decisions. We expect our recommended procedures to be refined by experience. For the time being, many decisions
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August 19, 1992

Mr. Manabu Tagomori  
Chief Engineer  
Division of Water and Land Development  
Department of Land and Natural Resources  
Kalanimoku Building, Room 227  
P.O. Box 621  
Honolulu, Hawaii 96809

SUBJECT: SUBMITTAL OF CORRECTION SHEET TO DRILLING PROGRAM FOR WELL SITES NUMBERS 2 AND 3 (DATED OCTOBER 1991).

Dear Mr. Tagomori:

Enclosed is a corrected page 2 to be substituted into the drilling programs for the above described well sites.

The purpose of the substitutions is to correct typographical errors in Items 10 and 11 of the program.

In recent discussions with your staff engineers, these errors were found and in response to those discoveries, we are submitting these corrections.

Should you have any question, please do not hesitate to call me at 528-3496.

Very truly yours,

TRUE GEOTHERMAL ENERGY COMPANY

AGK/reg

enclosure
possible, take drift shots every 100'. Maximum rate of change 1 degree per 100'. Install mud loggers at surface to log entire well from 0' to total depth. Catch three clean and dry samples every 10'.

6. Rig up and run 20" casing to total depth as per attached 20" casing program with 20" stab-in float collar and float shoe on bottom.

7. Once 20" casing has been run to bottom, run in hole with stab-in tool on bottom of drill pipe and stab into float collar. Circulate hole clean with at least two full circulations.

8. Cement 20" casing through drill pipe as per attached program. Circulate cement back to surface between 20" and 30" casing. Observe cement level. If cement falls back in annulus, bring same back to surface with 1" pipe.

9. Wait on cement 8 hours.

10. Land 20" casing. Cut off and remove 30" conductor drilling nipple. Cut off 20" casing and weld on 20" S.O.W. x 21-1/4" 2000 psi wellhead. Install two 3" valves and diverter. Install 20" blow out preventer equipment as per attached Figure 003.

11. Test 20" casing and blow out preventer equipment to 1000 psi for 30 minutes.

12. Drill out cement and float collar and float shoe from 20" casing with 17-1/2" bit using mud. Drill 30' of formation and trip to pick up stabilization.

13. Continue to drill 17-1/2" hole as vertical as possible with mud to 3500'+/- as indicated by formation. Directionally survey well at least every 100'. If lost circulation presents severe problems, an aerated mud system may be utilized. Severe loss circulation zones should be cemented off prior to drilling ahead.

14. Once 17-1/2" hole has been completed to casing point, rig up and run logs if indicated by geologic staff.

15. Upon completion of logging program, run in hole with bit and circulate to condition hole for casing.

16. Rig up and run 13-3/8" casing as per attached 13-3/8" casing program and running procedure. If lost circulation presents severe problems during drilling it may be necessary to set 13-3/8" pipe as a liner then tie it back to the surface rather than a full string of casing. See running procedure for alternative options.
TRUE GEOTHERMAL ENERGY COMPANY

CENTRAL PACIFIC PLAZA

FAX TRANSMITTAL LETTER

DATE: JUNE 12, 1991  TIME: 2:10  ( ) AM  ( ) PM  ( ) FM

TRANSMITTED BY:  ALLAN G. KAWADA
FAX NO. (808) 526-1772

TO:  FAX NO. 548-6052

COMPANY:  DEPARTMENT OF LAND AND NATURAL RESOURCES

ATTENTION:  MR. DEAN NAKANO

RE:  SUMMARY OF EVENTS - DRILL SITE #1

NUMBER OF PAGES TRANSMITTED:
9 (including transmittal)

REMARKS:  SORRY THIS WAS LEFT OUT OF THE REPORTS DELIVERED THIS
AFTERNOON, WE WILL FOLLOW WITH A COPY.

IF TRANSMITTAL NOT COMPLETE, CONTACT (808) 526-3496.
SUMMARY OF EVENTS - WELL KA1-1

11/17/89  Construction of well began by setting and cementing 30" casing.
01/09/90  Set and cemented 13-3/8" casing.
01/10/90  Continued drilling with mud.
01/27/90  Stopped drilling and plugged back for redrill.
01/28/90  Began sidetrack.
02/14/90  Set and cemented 9-5/8" casing.
02/16/90  Started to drill with air. Turned on pumps to abate dust. No detectable H2S.
02/18/90  First entry of steam. H2S approximately 100 ppm. Continue drilling with air.
02/22/90  Turned on abatement pumps for 3.5 hrs.
03/05/90  Stop drilling. Kill well to plug back and sidetrack.
03/11/90  Cut window in 13-3/8" casing to sidetrack.
03/23/90  Set and cemented 9-5/8" casing.
03/25/90  Continued drilling with mud.
03/30/90  Started to drill with air. Turned on pumps to abate dust. No detectable H2S.
04/06/90  Continue drilling with air. Turned on abatement pumps.
04/07/90  Kill well with mud. No flow. Fishing for stuck pipe.
04/15/90  Resume drilling with air. Turn on abatement pumps.
04/22/90  Stop drilling. Begin well test.
04/25/90  End well test. Shut-in well.
08/09/90  Startup abatement pumps. Open well for flow.
08/10/90  Kill well to plug back and sidetrack.
08/30/90  Set and cemented 9-5/8" casing.
08/31/90  Drill ahead with mud.
09/14/90  Started to drill with air. Turned on pumps to abate dust. Turned on abatement pumps.
SUMMARY OF EVENTS - WELL KA1-1 (cont'd)

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<th>Date</th>
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<td>Kill well to plug back and sidetrack.</td>
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<td>10/01/90</td>
<td>Drill ahead with mud.</td>
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<td>Remove mud and start to flow well. Turn on abatement pumps.</td>
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<td>Turn on abatement pumps and flow well.</td>
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<td>10/29/90</td>
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<td>Flow well for 20 hrs. Shut-in well.</td>
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</tr>
<tr>
<td>12/18/90</td>
<td>Shut-in well.</td>
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Attachment 1 B

Well events which resulted in the release of $\text{H}_2\text{S}$ emissions.

4-19 to 22-90  drilling with air
4-23 to 25-90  flow testing well
9-24, 26, 27-90 abated releases of steam due to blowing down the well
10-13, 14-90  flow well to clean out prior to shutting in
11-14 to 16-90 flow testing well; cleaning up well bore
11-23-90     $\text{H}_2\text{S}$ registered, cause unknown, well shut in
12-14 to 17-90 flow testing well, running logs, cleaning up well bore
Attch 2

Description of measures taken to shut-in the well.

The well was shut-in by closing the master valves on the well head. Secondarily, over the first two weeks the well is shut in it cools from the top down causing condensation which "kils" the well making it necessary to artificially induce the well to flow again.

No H₂S measurements were taken at the well head once shut-in. Pressure builds and oscillates when the well is shut in, pressure readings were not taken following shutting in the well.
## SUMMARY OF WET CHEMICAL TESTS - KA1-1

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"--" had test
TRUE/MID-PACIFIC GEOTHERMAL CASING PROGRAM

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Note: Burst and collapse ratings are minimum values with no safety factor
9.5 ppg mud and vertical well is assumed
**WELL SURVEY DATA**

Well Name: TRUE/MID-PACIFIC KA1-1

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Ext. TD
Plug back to 3482 ft.
Closure = 42.25 ft., North 72 deg 32 min 13 sec West
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Ext. TD
Plug back to 3096 ft.
Closure = 2623.11 ft., South 0 deg 24 min 41 sec East
Well Name: TRUE/MID-PACIFIC KA1-1 RD#2

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Ext. TD
Plug back to 3091 ft.
Closure = 1849.00 ft., South 73 deg 33 min 59 sec East
WELL SURVEY DATA
DIMITT DIRECTIONAL DRILLING

Well Name: KA1-1, RD #3

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Closure = 1675.80 ft., North 40 deg 47 min 48 sec East
## WELL SURVEY DATA

### DIMITT DIRECTIONAL DRILLING

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<th>Heading N/S E/W (deg)</th>
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Closure = 1804.72 ft., North 40 deg 24 min 19 sec East
WELL SURVEY DATA
KA1-1 OH and 4 RDs
TRUE/MID-PACIFIC
GEOTHERMAL VENTURE
FROM: J. Florez

DATE: 11-2-94

TO: INITIAL:

Please:

ー See Me
ー Call
ー Review & Comment
ー Take Action
ー Investigate & Report
ー Draft Reply
ー Acknowledge Receipt
ー Type Draft
ー Type Final
ー Xerox ___ copies

REQUESTED BY: REQUESTED DATE:

FOR YOUR:

ー Approval
ー Signature
ー Information
ー File

FILE IN: ___________

REMARKS:

Draft Minutes of mtg. w/ Campbell Estate on 11-1-94.


So...

We need to meet w/ Mason before needing again w/ Campbell. When can you meet?
November 2, 1994

MEMO

To: Manabu Tagomori

From: Jon Florez

Subject: Minutes from Campbell Estate meeting.

Participants: Gordon Akita, Hiram Young, Jon Florez, Mason Young and Glenn Abe (Land Management) and, Susan Sublett and Bill DeMent from Campbell Estate.

At the meeting held on November 1, 1994, in the DOWALD conference area, we discussed the preliminary draft license between Campbell and DLNR. Hiram opened the meeting by saying that we have reviewed the draft license and everything seems to be okay. It’s a generic license...pretty basic. Mr. DeMent replied that he only took about 5 minutes to mark-up the license and he is sure DLNR and Campbell will be hashing out many versions before the final is acceptable to both parties.

Mason Young then asked what exactly the license will cover? Mr. DeMent replied that Campbell is willing to accommodate DLNR for the geothermal wells only or the whole geothermal subzone or partial surrender of the property.

Mr. DeMent then said that Campbell would prefer to be a silent landlord and have their real property tax and mining lease fee reduced. Currently, Campbell pays $40,000 to $50,000 in real property tax and $9,000/year for their mining lease. Mason then said, what you (Campbell) want is to have the State pay your property taxes and mining fee but not have any liability for the property. Mr. DeMent replied, well yes, Campbell has no interest in geothermal activity; our intent is to have the State revoke the mining lease. Campbell is open to anything that will benefit the State and us. The possibility of a partial surrender that would reduce the land used and therefore reduce the property tax and possibly the mining lease fee is open for discussion also. We tried to attract a geothermal developer to no avail.

Mason then asked Hiram about the purpose of DLNR acquiring these two wells. Hiram replied that KA1-1 and SOH-4 are to be monitoring wells for monitoring the resource. These two wells will be specially useful if a developer decides to produce geothermal energy on Campbell land. Mason then asked Hiram if the wells will go into production of geothermal energy? Hiram replied, the SOH-4 well is strictly a monitoring well, and the future use of KA1-1 is not an issue right now. We do not even know about the condition of the well at this time. ThermaSource did do mechanical integrity testing over the weekend, so we should know about the integrity of the well soon enough.
Mason then said he needs more information about the mining lease and the license. Mason then said that DLNR and Campbell should talk about the possibility of producing geothermal energy and include a section in the license about possibly producing steam from KA1-1. Ms. Sublett then said that maybe we can include a clause that would allow for the possibility of producing the well, so we do not close ourselves off in the future. Hiram replied that this subject needs more discussion before making a decision.

A meeting between DOWALD, Land Management and Campbell is set for November 15, 1994, at 8:30 am at DOWALD's conference table to discuss the terms of the license.

Mason and Mr. Abe left after setting the November 15, 1994, meeting. DOWALD and Campbell then discussed other issues of the license.

Mr. DeMent said that Mr. Moulds of Hawaii County told him that the State needs to renew the Geothermal Resource Permit for SOH-4. He went on to say that True Geothermal is planning to do a "topical" environmental assessment of the KA1-1 well site and that DOWALD may need to review and/or approve the procedure. He then said that after all DOWALD will be accepting the responsibility of the site once True completes their work.

Mr. DeMent then discussed Campbell's desire to install a fence at the property boundary (end of the paved road and beginning of the dirt road). Currently, there is a gate well inside the property boundary. Placement of the gate allowed the trucks to park on a flat surface. The concern is that once the State takes over responsibility of the land, they are liable if someone gets hurt outside the present gate.

Mason is requesting a meeting between Land Management and DOWALD before the meeting with Campbell Estate, set for November 15, 1994.
Gerry Niimi called - has prepared thru Alum Kanada - be submitting Plan & Abandonment plan for KAI-X. They're mobilizing already & looking toward doing the work be end of February - Per Gerry Alum will be faxing us in advance copy today -
TO: Mr. Hiram Young
Engineer
Dept. Of Land & Natural Resources
State of Hawaii
1151 Punchbowl Street
Honolulu, Hawaii 96813

DATE: February 3, 1994


DESCRIPTION
True Mid-Pacific Geothermal Venture
Well KA1-1
Abandonment - ThermaSource,

TRANSMITTED FOR:
{ xx } Your Information and Files
{ } Signature and Return
{ } Further Action

Your Review and Comment Per Your Request
See Remarks Below

TRUE GEOTHERMAL ENERGY COMPANY

By: Allan G. Kawada
True/Mid-Pacific Geothermal Venture

Well KA1-1
Abandonment Plan

ThermaSource, Inc.

1-4-94

Pertinent Data

1. Well KA1-1 was spudded on November 17, 1989.

2. 30" conductor pipe was set in a 42" hole to a depth of 90' below Kelly Bushing.

3. 20", 94 ppf, K-55, Buttress casing set in a 26" hole to a total depth of 704' below Kelly Bushing. 20" casing cemented to surface using Class G Cement.

4. 13-3/8" casing was set in 2 phase, 1st a liner made up of 78 joints (2389') of 72 ppf, L-80, Buttress casing set in a 17-1/2" hole hung from the 20" by means of a 20" X 13-3/8" Midway liner hanger set at 448' in the 20" to a depth of 3370' and cemented across entire interval. 2nd phase set as a tie-back made up of 12 joints (452') of 68 pff, L-80, Buttress casing and cemented from total depth to the surface.

5. A section was cut from the 13-3/8" casing from 2728' to 2778'. The well was then sidetracked out section and 12-1/4" hole drilled to 5350.


7. 8-1/2" open hole drilled to a total depth of 7850'.

8. 7" combination blank and slotted liner (12 joints of 26 pff blank above 56 joints of 26 pff slotted) hung in the 8-1/2" open hole from 5115' to total depth of 7850'.

9. Well completed and suspended on 10-14-90.

10. Potential hole in 13-3/8" casing from 1774' to 1782'.

Abandonment Procedure

**Time** | **Sequences of Operations**
--- | ---
1. | Prepare location for appropriate rig to complete abandonment procedure.
0.5 days 2. | Install blow out preventer stack consisting of hydraulically controlled dual ram-type preventers equipped with CSO rams and Pipe rams.
4.0 days 3. | Move in rig to abandon well. Install flowline on top of blow out preventer stack. Rig up rig and test stack. Start pumping water and mud down well to insure well is dead. Bleed off any gas pressure that may have accumulated below master valve.
0.5 days 4. | Open well and pick up 8-1/2" bit and run in hole with drill pipe of tubing to top of 7" slotted liner at 5110' to insure cement retainer can be run to setting point.
0.5 days 5. | If successful in running bit to 5110' then trip out of hole and lay down bit and pick up Halliburton EZSV cement retainer and run in hole with retainer on drill pipe to setting point and set same, then proceed to step 6 of this procedure. If unsuccessful in running bit to 5110' setting depth, attempt to determine cause for stoppage, determination should be made as soon as possible on location by drilling personnel present and State Representative to remove cause of stoppage or alter abandonment procedure.
0.5 days 6. | After EZSV cement retainer is set at 5110' mix and pump enough cement to fill 100 linear feet in 8-1/2" hole through retainer and then full out of retainer. Fill hole with mud above retainer. Mix and pump enough cement to fill 200 linear feet of 9-5/8" casing and displace cement to be place directly on top of retainer. Pull out of cement plug and wait on cement for 8 hours. Run and tag top of cement to verify location of plug.
True/Mid-Pacific
KA1-1 Abandonment Procedure
1-4-94
Page 3

0.5 days 7. Pull up in hole with opened ended drill pipe and set second cement plug from 2385' to 2585'. 200 linear feet plug straddling top of 9-5/8" liner located at 2485'. Pull out of cement plug and pull above top of cement and wait for 8 hours. Tag top of cement and verify location. Pressure up on 13-3/8" casing above cement plug at 2385' to 750 psi. If casing holds pressure proceed with abandonment, if casing leaks then locate leak with packer and squeeze off same with cement. Note: if 13-3/8" does not hold pressure above cement plug at 2385' an available option would be to set an additional 13-3/8" EZSV cement retainer above the leak and plug well with cement above the retainer. See optional procedure below.

0.25 days 8. Pull up in hole to 100' and set surface cement plug in 13-3/8" casing from 100' to 6' below wellhead.

0.5 days 9. Wait on cement while laying down drill pipe. Feel for cement and if cement is in place then nipple down blow out preventers.

0.5 days 10. Cut off and remove master valves and wellhead assembly. Cut and remove casing below ground level and weld plate on top of casing.

1.0 days 11. Rig down and remove rig from location.

12. Fill in cellar and mark location of wellhead. Restore location.

8.75 days  Total time on Location including Rig up and down

Optional Procedure to Abandon well above 13-3/8" casing leak

Time Sequence of Operations

0.5 days 1. Locate leak using 13-3/8" Halliburton RTTS if 13-3/8" casing does not hold pressure above cement plug at 2385'. Pull out of hole with
True/Mid-Pacific
KA1-1 Abandonment Procedure
1-4-94
Page 4

RTTS, pick up and run in hole with 13-3/8" EZSV on bottom of drill pipe and set same approximately 50' above leak.

0.5 days 2. Mix and pump approximately 100 linear feet of cement below EZSV then mix and pump enough cement to fill 100' of 13-3/8" casing on top of the EZSV. Pull out of cement and wait on cement. Tag top of cement after 8 hours and pressure test remaining 13-3/8" casing above plug.

3. Proceed to Step 8 of above Abandonment Procedure.

1.0 days Additional Time Required if 13-3/8" casing contain leaks.
13-3/8' casing at 2728'.

9-5/8' liner cemented in a 12-1/4' hole from 2485' to 5335'.

7' slotted liner uncemented in a 8-3/4' hole from 5115' to 7850'.

8-1/2' open hole drilled to 7850'.

True/Mid-Pacific
Geothermal Venture
Well KA1-1
Existing Well Profile
ThermaSource, Inc.
1-5-94
True/Mid-Pacific
Geothermal Venture
Well KA1-1
Abandonment Plan
ThermaSource, Inc.
1-5-94

Surface Abandonment
Cement plug 0 to 100'.
20' Casing set at 704' in a 26' hole.

Cement Plug set from
2395' to 2585'.
13-3/8' casing at 2720'.

9-5/8' liner cemented in a 12-1/4' hole from 2485' to 5335'.

Halliburton EZSV Cement Retainer set in 9-5/8' Casing at
5110'. Cement set above EZSV from 5110' up to 4910'.

7' slotted liner uncemented in a 8-3/4' hole from 5115' to 7850'.

8-1/2' open hole drilled to 7850'.
the permit issued for such well by the Chairman shall be rescinded. If it is determined that damage is occurring, the Chairman may order that the repair work be done immediately.

Injection pressures shall be recorded and compared with the pressure reported on the appropriate forms. Any discrepancies shall be rectified immediately by the operator. A graph of pressures and rates versus time shall be maintained by the operator. Reasons for anomalies shall be promptly ascertained. If these reasons are such that it appears damage is being done, the permit issued by the Chairman may be rescinded, and injection shall cease.

At the discretion of the Chairman, when an injection well has been left idle for a period of two years or longer, the operator shall be informed by letter that the permit issued for use of the well for injection purposes has been rescinded. In the event the operator intends again to use the well for injection purposes, he shall be required to file a new Application for Permit and demonstrate to the satisfaction of the Chairman by means of surveys that the injected fluids will be confined to the intended zone of injection.

RULE NO. 11
WELL OPERATION AND MAINTENANCE

All wells and their appurtenances such as well head, separators, pumps, mufflers, scrubbers, manifolds, valves and pipelines shall be operated and maintained by the operator in good working condition in order to prevent unacceptable pollution, waste and the loss of or damage to life, health, property, natural resources, and environment. The well head and appurtenances of all wells shall meet a test pressure of at least one and a half times the calculated or known pressure of the geothermal reservoir tapping or to be tapped by the well.

Periodic corrosion surveillance of any well and appurtenances may be conducted by the Chairman or his authorized representative and any leakage, waste, or hazard shall be promptly corrected by the operator.

The operator of any well shall notify the Chairman of any blowout, break, leak or spill of any well or appurtenant facilities. The notification to the Chairman shall consist of a written report submitted within ten days after discovery of the incident.

The Chairman shall notify the operator of any well not being operated or maintained in accordance with these Regulations to take whatever steps may be necessary to remedy the defect at the operator's expense within the period of time specified in such Notice. If the operator fails to comply with such Notice and remedy the defect within the specified period, the Chairman may do such work as may be necessary to plug and abandon the well or put it in proper condition at the expense of the operator or his surety and he may take necessary action to enforce the penalty provided in these Regulations.

RULE NO. 12
WELL ABANDONMENT

12.1 Notice of Intent to Abandon; Permit; Filing Fee.
The operator of any well proposed to be abandoned must file with the Chairman an Application for Permit to Abandon, prior to said abandonment. The operator’s proposed plans for abandonment shall be subject to approval and revision prior to the issuance of a permit by the Chairman. Each such application to abandon a well shall be accompanied by a non-refundable filing fee of $100.

12.2 General Requirements.

a. The operator of any well shall promptly plug and abandon any well that is deserted, not in use, is deemed not to be potentially useful, is wasting geothermal or ground water resources, or is irreparably damaged. No well shall be plugged and abandoned until the manner and method of plugging have been approved or prescribed by the Chairman.

b. Before any work is commenced to abandon any well, notice shall be given by the operator to the Chairman, which notice shall show the condition of the well and the proposed method of abandonment. Unless otherwise specified in the Plan of Operation, no well may be abandoned except as prescribed herein. However, the operator of a lease shall promptly plug and abandon any well that is deserted, not used or deemed useful by the Board. No well capable of producing in commercial quantities may be abandoned until receipt of written approval by the Chairman. Equipment shall be removed and premises at the well site shall be restored as near as reasonably possible to its original condition immediately after plugging operations are completed on any well except as otherwise authorized by the Chairman. When drilling operations have been temporarily suspended drilling equipment shall not be removed from any well without taking adequate measures to close the well and protect subsurface resources. Upon failure of lessee to comply with any requirements under this rule, the Chairman is authorized
to cause the work to be performed at the expense of lessee and the surety.

(c) Good quality, heavy drilling fluid approved by the Chairman shall be used to replace any water in the hole and to fill all portions of the hole not plugged with cement.

d. Subsequent to plugging and abandonment operations in the hole, casings shall be cut off at least 6 feet below the surface of the ground, all concrete cellars and other structures shall be removed, and the surface location restored, as near as practicable, to original conditions.

e. A History of Geothermal Resources Well shall be filed within 60 days after completion of abandonment; except in the case of an exploratory well such report shall be filed within six months after abandonment.

f. Any bond or rider thereto covering the well shall remain in full force and effect until the well is properly abandoned and the surface properly restored. Written approval of the abandonment must be obtained from the Chairman before any bond is released.

12.3 Cementing Requirements.

(a) Cement used to plug any well, except that cement or concrete used for surface plugging, shall be placed in the hole by pumping through drill pipe or tubing. Such cement shall contain a high temperature resistant admix unless this requirement is waived by the Chairman in accordance with the particular circumstances existing in that well or area. All open annuli shall be filled solid with cement to the surface.

(b) One hundred (100) lineal feet of cement shall be placed straddling the bottom of the conductor pipe and at the shoes of all casings.

(c) Cement shall be placed solidly across geothermal zones and extending 100 lineal feet above and below such zones, whether in uncased or cased (perforated) hole, except as follows:

1. One hundred (100) lineal feet of cement shall be placed straddling casing stubs and laps. If unable to enter casing stubs or laps, 100 lineal feet of cement shall be placed above the top of the stubs or laps.

2. If casing is collapsed, etc., cement shall be placed solidly in geothermal zones or perforated sections of casing and extending 100 lineal feet above such zone or perforated section by squeezing with a retainer or braden head.

(d) Fifty (50) lineal feet of cement shall be placed above the top of casing liners.

e. A surface plug consisting of a minimum of 50 lineal feet of neat cement or ready mix concrete shall be placed below the surface of the well.

(f) Where a well has been drilled with air, a bridge plug may be placed at the deepest cemented casing shoe and the bridge plug shall be capped with a minimum of 200 lineal feet of cement.

RULE NO. 13

WELL RECORDS AND REPORTS

13.1 Well Records.

The operator of any geothermal well shall keep, or cause to be kept, a careful and accurate log, core record, and history of the drilling of the well, including lithology and depths of formations encountered; cores; water-bearing and geothermal heat-bearing strata and their depths, pressures and temperatures; and such other well surveys and logs of temperature, chemical, radioactive, and electrical characteristics of the well. These records shall be kept within the State of Hawaii in the local office of the operator or his designated agent and together with all other reports of the operator, shall be subject, during business hours, to the inspection of the Chairman. The Board may also require such additional data or reports relating to production or utilization of geothermal resources and by-products as may appear to be necessary or desirable, either generally or specifically, for the prevention of waste and the optimum use of geothermal, water and other natural resources of the State.

13.2 Reports to be Filed.

Within six months after the completion of any well or completion of any deepening, redrilling, plugging, altering or abandonment work, the operator shall file with the Department of Land and Natural Resources in Honolulu, Hawaii, the following well reports on forms provided by the Department:

(a) Drilling Log and Core Report. The Drilling Log and Core Report shall show the lithologic characteristics and depths of formations encountered, the depths and temperatures of ground water-bearing and geothermal resources-bearing strata, and the temperatures, chemical compositions, and other chemical and physical charac-
TO: True Geothermal Energy Company
Central Pacific Plaza
220 South King Street, Suite 868
Honolulu, Hawaii 96813

Your application dated October 30, 1991, for a permit to drill a geothermal well on lands located within the Kilauea Middle East Rift Geothermal Resource Subzone and covered under the State of Hawaii, Geothermal Resource Mining Lease No. R-5 is approved.

Well Designation: True/Mid-Pacific Well KA2-1
Location: TMK 1-2-10:03, Puna, Hawaii
Leased to: Estate of James Campbell (GRML R-5)
Subleased to: True/Mid-Pacific Geothermal Venture
Operator: True Geothermal Energy Company
Ground Elevation: 1,440± ft.
Total Depth: 12,000 feet

You are hereby granted permission to drill the geothermal well described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, HAR, and under the following conditions:

(1) All work shall be performed in accordance with the permission and terms of the occupiers of the land, the Drilling and Completion Program submitted with your application, the Department's Administrative Rules (Chapters 13-183 and 13-184, HAR), and all other applicable Federal, State, and County laws, ordinances, rules, and regulations;

(2) The permittee, its successors and assigns shall indemnify, defend, and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;
(3) The permittee shall observe and comply with all valid requirements of County, State, and Federal authorities and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws and those relating to the environment;

(4) The applicant shall observe and comply with all requirements and conditions as set forth in the Board of Land and Natural Resources' Decision and Order dated April 11, 1986;

(5) No well shall be sited within 3,500 feet of the eastern boundary of the property line near Kaehe Homesteads, nor within 3,500 feet of the southeastern boundary of the property line near upper Kaimu Homesteads;

(6) The well and bottom-hole location shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling, unless modified by the Chairperson upon request;

(7) The permittee shall notify the Division of Water Resource Management (DWRM), in writing, of the date of the start of work;

(8) Prior to drilling, the permittee shall submit to the Department the bottom-hole target location and direction of any proposed deviation;

(9) All blow-out prevention equipment (BOPE) and cemented casing strings shall be pressure tested before commencing any other operations on the well. Test pressures shall not be less than 600 pounds per square inch nor greater than 1,500 pounds per square inch, and shall be applied for a period of thirty minutes. The results of the pressure tests shall be reported on forms provided by the Department.

If a drop of more than ten percent of the casing test pressure is recorded, the operator shall then run a caliper log and/or other appropriate well test to determine if the casing is defective and if corrective measures will be required before commencing any further operations. The results of the prescribed casing tests and any remedial work conducted shall be submitted to the Department within sixty days after completion;

(10) Class "G" cement shall be used in the casing cementing operations and shall contain a high temperature resistant admix;

(11) A real time monitoring device must be installed for the driller and a pit alarm system should be included with this monitoring device. All toolpushers, drillers, and derrickmen should be schooled in the use of the recommended monitoring equipment.
If changes to the proposed drilling program are contemplated, the permittee shall obtain the Chairperson's approval before executing such changes;

When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified, with reasonable time allowed for travel to the site, to witness the retrieval of a representative groundwater sample and the measurement of the static water level. The permittee shall have the sample analyzed by an independent laboratory and have the results submitted to the Department;

During the use of the well for testing, monitoring, production and/or injection purposes, the well and site shall be properly maintained until the well is plugged and abandoned in accordance with the Department's Administrative Rules, Chapter 13-183, HAR;

The permittee shall submit to the Chairperson, the results of any exploration, all drilling and testing records, down-hole surveys of the well, bottom-hole location, date of completion, and a survey of the well location and elevation above mean sea level taken by a Hawaii licensed surveyor within six months after completion of the well;

A well completion report, an as-built drawing of the well, and the location of the well plotted on an U.S.G.S. quad scale map shall be filed with the Department within six months after completion of the well;

The bond covering the well shall remain in full force and effect until the well is properly abandoned and the surface is restored as near as possible to its original condition;

This permit shall expire 365 days from the date of issuance.

WILLIAM W. PATY, Chairperson

Date of Issuance

cc: Land Board Members
    Hawaii County Planning Dept.
    DBEDT
    Department of Health
    OEQC
TO: True Geothermal Energy Company
Central Pacific Plaza
220 South King Street, Suite 868
Honolulu, Hawaii 96813

Your application dated October 30, 1991, for a permit to drill a geothermal well on
lands located within the Kilauea Middle East Rift Geothermal Resource Subzone and covered
under the State of Hawaii, Geothermal Resource Mining Lease No. R-5 is approved.

Well Designation: True/Mid-Pacific Well KA3-1
Location: TMK 1-2-10:03, Puna, Hawaii
Leased to: Estate of James Campbell (GRML R-5)
Subleased to: True/Mid-Pacific Geothermal Venture
Operator: True Geothermal Energy Company
Ground Elevation: 1,480± ft.
Total Depth: 12,000 feet

You are hereby granted permission to drill the geothermal well described above and
in your application in accordance with the Department's Administrative Rules, Chapter 13-
183, HAR, and under the following conditions:

(1) All work shall be performed in accordance with the permission and terms of the
occupiers of the land, the Drilling and Completion Program submitted with your
application, the Department's Administrative Rules (Chapters 13-183 and 13-184,
HAR), and all other applicable Federal, State, and County laws, ordinances, rules, and
regulations;

(2) The permittee, its successors and assigns shall indemnify, defend, and hold the State
of Hawaii harmless from and against any loss, liability, claim or demand for property
damage, personal injury and death arising out of any act or omission of the applicant,
assigns, officers, employees, contractors and agents under this permit or relating to or
connected with the granting of this permit;
(3) The permittee shall observe and comply with all valid requirements of County, State, and Federal authorities and regulations pertaining to the lands and permittee's operations including, but not limited to, all water and air pollution control laws and those relating to the environment;

(4) The applicant shall observe and comply with all requirements and conditions as set forth in the Board of Land and Natural Resources' Decision and Order dated April 11, 1986;

(5) No well shall be sited within 3,500 feet of the eastern boundary of the property line near Kaohe Homesteads, nor within 3,500 feet of the southeastern boundary of the property line near upper Kaimu Homesteads;

(6) The well and bottom-hole location shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling, unless modified by the Chairperson upon request;

(7) The permittee shall notify the Division of Water Resource Management (DWRM), in writing, of the date of the start of work;

(8) Prior to drilling, the permittee shall submit to the Department the bottom-hole target location and direction of any proposed deviation;

(9) All blow-out prevention equipment (BOPE) and cemented casing strings shall be pressure tested before commencing any other operations on the well. Test pressures shall not be less than 600 pounds per square inch nor greater than 1,500 pounds per square inch, and shall be applied for a period of thirty minutes. The results of the pressure tests shall be reported on forms provided by the Department. If a drop of more than ten percent of the casing test pressure is recorded, the operator shall then run a caliper log and/or other appropriate well test to determine if the casing is defective and if corrective measures will be required before commencing any further operations. The results of the prescribed casing tests and any remedial work conducted shall be submitted to the Department within sixty days after completion;

(10) Class "G" cement shall be used in the casing cementing operations and shall contain a high temperature resistant admix;

(11) A real time monitoring device must be installed for the driller and a pit alarm system should be included with this monitoring device. All toolpushers, drillers, and derrickmen should be schooled in the use of the recommended monitoring equipment.
(12) If changes to the proposed drilling program are contemplated, the permittee shall obtain the Chairperson's approval before executing such changes;

(13) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified, with reasonable time allowed for travel to the site, to witness the retrieval of a representative groundwater sample and the measurement of the static water level. The permittee shall have the sample analyzed by an independent laboratory and have the results submitted to the Department;

(14) During the use of the well for testing, monitoring, production and/or injection purposes, the well and site shall be properly maintained until the well is plugged and abandoned in accordance with the Department's Administrative Rules, Chapter 13-183, HAR;

(15) The permittee shall submit to the Chairperson, the results of any exploration, all drilling and testing records, down-hole surveys of the well, bottom-hole location, date of completion, and a survey of the well location and elevation above mean sea level taken by a Hawaii licensed surveyor within six months after completion of the well;

(16) A well completion report, an as-built drawing of the well, and the location of the well plotted on an U.S.G.S. quad scale map shall be filed with the Department within six months after completion of the well;

(17) The bond covering the well shall remain in full force and effect until the well is properly abandoned and the surface is restored as near as possible to its original condition; and

(18) This permit shall expire 365 days from the date of issuance.

DECEMBER 13, 1991

DATE OF ISSUANCE

WILLIAM W. PATY, CHAIRPERSON

cc: Land Board Members
    Hawaii County Planning Dept.
    DBEDT
    Department of Health
    OEQC
TO: True Geothermal Energy Company  
P.O. Box 2360  
Casper, Wyoming 82602

Your application, dated February 1, 1989, for a permit to drill a geothermal well as follows, on lands included in State of Hawaii, Department of Land and Natural Resources, Geothermal Resources Mining Lease No. R-5, is approved:

Well Designation: True/Mid-Pacific A1-1  
Location: TMK 1-2-10:03, Puna, Hawaii  
Leased to: Estate of James Campbell (GRML R-5)  
Subleased to: True/Mid-Pacific Geothermal Venture  
Operator: True Geothermal Energy Company  
Ground Elevation: 1,500 ft. ±  
Total Depth: 8,000 to 14,000 feet (maximum)

You are hereby granted permission to drill the geothermal well described above and in your application in accordance with the Department's Administrative Rules, Chapter 13-183, and the following conditions:

1) All work shall be performed in accordance with the permission and terms of the occupier of the land, the Drilling and Completion Procedures submitted with your application, the Department's Administrative Rules (Chapters 13-183 and 13-184), and all other applicable Federal, State, and County laws, ordinances, rules and regulations;

2) The applicant, its successors and assigns, shall indemnify and hold the State of Hawaii harmless from and against any loss, liability, claim or demand for property damage, personal injury and death arising out of any act or omission of the applicant, assigns, officers, employees, contractors and agents under this permit or relating to or connected with the granting of this permit;
(3) If any unanticipated sites or remains of historic or prehistoric interest (such as shell, bone, or charcoal deposits, human burials, rock or coral alignments, paving, or walls) are encountered during the operation, the applicant shall stop work and contact the Historic Preservation Office at 548-7460 or 548-6408 immediately;

(4) The applicant shall observe and comply with all valid requirements of County, State, and Federal authorities, and regulations pertaining to the lands and permittee’s operations including, but not limited to, all water and air pollution control laws, and those relating to the environment;

(5) The applicant shall observe and comply with all requirements and conditions as set forth in the Board of Land and Natural Resources' Decision and Order dated April 11, 1986;

(6) If there are any contemplated changes in the proposed drilling program, the applicant shall obtain the Chairperson's approval prior to the execution of any such contemplated changes of work;

(7) The applicant shall file with the Chairperson prior to the start of the permitted activity, indemnity bonds as required under the Department's Administrative Rules, Sections 13-183-34 and 13-183-68;

(8) The well shall be located more than 100 feet from the outer boundary of the parcel of land on which the well is situated, or more than 100 feet from a public road, street, or highway dedicated prior to the commencement of drilling unless modified by the Chairperson upon request;

(9) No well shall be sited within 3,500 feet of the eastern boundary of the property line near Ka’ohi Homesteads, nor within 3,500 feet of the southeastern boundary of the property line near upper Kaimu Homesteads;

(10) When drilling has reached a depth of not more than 50 feet below sea level, the Department's representative shall be notified with reasonable time allowed for travel to the site, to obtain a representative groundwater sample and to measure the static water level;

(11) The drilling permit shall be valid for a period of one year from the date of issuance;

(12) The applicant shall submit to the Chairperson, the results of the exploration, all drilling and testing records, date of completion, and a survey of the well location by a Hawaii licensed surveyor within 30 days after completion of the well;
(13) The applicant shall notify the Division of Water and Land Development, in writing, of the date of the start of work;

(14) During use of the well for testing, monitoring and/or production purposes, the well and site shall be properly maintained until the well is plugged and abandoned in accordance with Administrative Rules, Chapter 13-183;

(15) The site shall be restored as near as possible to its original condition after operations are completed.

MAY 30 1989
Date of Permit

WILLIAM W. PATY, Chairperson
Board of Land and Natural Resources

cc: Land Board Members
Hawaii County Planning Dept.
Land Management Division
DBED
Department of Health
OEQC
OCEA
Allan Kawada
February 1, 1989

Department of Land & Natural Resources (DLNR)
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Sirs:

Subject: Geothermal Exploration Activities in the Kilauea Middle East Rift Zone (KMERZ)

The Board of Land & Natural Resources in a Decision & Order (D&O) of April 11, 1986, authorized exploration and development of geothermal resources on Campbell Estate property, Island of Hawaii, Puna District, TMK 1-2-10:3. The D&O prescribed procedures, data requirements and preparation of plans related to abated venting of geothermal wells, meteorological, air and noise monitoring, biological and archaeological surveys, and emergency plans, which were to be submitted to the Department of Land & Natural Resources for ministerial approval. Accordingly, all of the foregoing data requirements and plans are contained in Appendices "A" through "F" and are submitted herewith for approval.

Modification of the D&O prescribed procedures on "abated venting" is required in order to permit, as a standard industry procedural and technical requirement, the flow testing of each geothermal well that intersects a reservoir on a continuous basis for up to 30-45 days. The flow testing must be accomplished in the normal open-flow, well-production and operational mode in order to properly and accurately measure and evaluate the resource and the reservoir characteristics. This analysis is the basis for determining whether or not a geothermal reservoir is capable of producing and sustaining at open-flow rate sufficient geothermal energy to enable economic generation of electricity over the 25-30 year life of a power plant. Equally critical is the need to avoid the periodic shutting down or significant changes in flow rates of a geothermal well because of the resulting thermal shocks and damage which would accrue to the well bore and cementing.
Department of Land & Natural Resources  
Page Two (2)  
February 1, 1989

There is no reasonable alternative known to be feasible in the industry that would allow reservoir analysis to the degree of accuracy that is necessary to justify the commitment and expenditure of millions of dollars for a power plant to utilize the resource. Flow testing is conducted under abated venting procedures which limit emissions to prescribed standards. Therefore, in accordance with D&O, the DLNR is requested to modify the restrictions imposed in the D&O which do not allow abated venting to be conducted on a continuous basis which is required in the 30-45 days of flow testing of each successful well and which is required to avoid serious damage to a geothermal well bore if the resource flow rate is periodically required to be shut down or significantly changed.

Very truly yours,

TRUE GEOTHERMAL ENERGY COMPANY  
(Operator for True/Mid-Pacific Geothermal Venture)

H. A. True, III, Partner

Appendices:  "A" Management Plan  
"B" Air Quality and Meteorological Monitoring Plan  
"C" Noise Monitoring Plan  
"D" Biological Survey Report  
"E" Archaeological Survey Report  
"F" Emergency Plan

cc: Mid-Pacific Geothermal, Inc.  
Estate of James Campbell
Environmental Monitoring Plans and Programs

Geothermal Exploration Activities

Kilauea Middle East Rift Zone
Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture
January, 1989

Encl. (1)
Letter to DLNR
dtd: _____.
Environmental Monitoring Plans and Programs

Geothermal Exploration Activities

Kilauea Middle East Rift Zone
Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture
January, 1989

Encl. (1)
Letter to DLNR
dtd:______.
Management Plan

Geothermal Development Activities
(Exploration Phase)

Kilauea Middle East Rift Zone
Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture
January, 1989

Appendix A
Letter to DLNR
DATED:________
Management Plan

1. Access and Parking Control. A gate will be installed at the road entrance to the Campbell Estate Property at the juncture of the State road easement and the project site access road. Access will be limited to Project Personnel, officials of government agencies having regulatory responsibilities and such other visitors that may be admitted by project management. Since there is a potential for emissions of \( \text{H}_2\text{S} \) to exceed safe exposure levels during drilling, testing and venting, requiring immediate use of a full face gas mask by personnel at the drill site, no person with a beard will be allowed at the site during these operations. All non-project personnel admitted to the project site will be escorted by project personnel. A limited vehicle parking area will be prepared at the entrance to each drill site for utility vehicles and vehicles of project personnel and authorized visitors.

2. Safety. This section describes the overall policies of the Operator on safety which are designed to maintain the highest level of safety possible during project activities associated with exploration and development of geothermal resources. Also included is a description of potential events that could disrupt operations, cause injury or loss of life, or create health hazards and the additional measures and actions that will be taken to minimize the potential for such impacts.

Safety Policy. True Geothermal Energy Company, as operator, considers safety as one of its highest priorities. The company safety policy states that:

"True, owners, management and middle management, firmly believe that
the continued success of any organization, or the successful completion of any project, can be achieved if it is done safely.

We realize the need to have quality people who have a positive attitude toward doing their jobs safely, with proficiency and with great concern for the safety and health of fellow workers."

In order to promote safety awareness, management is committed to a program of regular safety meetings at least once a month, for both the field and office staffs. At these meetings, personnel will receive training and lectures on the proper methods to handle hot valves, wellheads, pipelines, and bleed lines so that they will not become a source of injury. In addition to heat, H₂S safety will be emphasized. Personnel will be trained to use the emergency breathing equipment and recognize the danger signals of the presence of high levels of H₂S. First aid and C.P.R. sessions will be held periodically. Regular updates to the evacuation plans will be presented. A pyramid telephone calling system will be utilized to notify personnel of an evacuation order.

Many incentives are offered for safety such as monthly glove awards, yearly coverall awards, and yearly personal awards for drillers and toolpushers.

Specific Safety Considerations Related to the Well-Bore and Drill Rig. The drill rig will be equipped with proper blowout prevention equipment to prevent uncontrolled release of well fluids from the well-bore. Blowout prevention is approached from four aspects: proper equipment, proper mud weight, proper training, and experienced supervision. Equipment currently being recommended are ram-type preventers with blind and pipe rams and bag-type preventers. Also essential to blowout prevention is proper cementing -2-
of intermediate strings of casing and the use of appropriate mud weights to balance reservoir pressure so that drilling will be under controlled conditions. For example, a mud weight that is too light may speed drilling, but could be inadequate to suppress a sudden gas entry.

All employees are and will continue to be instructed in the proper procedure for closing and opening blowout preventers (BOP's) which will be hydraulically operated. Safety is stressed in all aspects of this type of operation. The operator has an on-the-job training program using video tapes and projectors pertaining to safety, BOP's and maintenance, etc. (True Drilling Company has been awarded the International Association of Drilling Contractors Safety Commendation Award for seven consecutive years.)

Proper training of crews on how to recognize the symptoms of impending blowout conditions and how to correct these conditions is of utmost importance. An alert, experienced crew can handle all blowout conditions as part of their normal duties. If this is done, conditions should return to normal in a short time. The rig supervisor or pusher is responsible for training the crew and insuring that safe practices are followed. The pusher also makes sure that all equipment is properly maintained so that it will do its job when an emergency arises.

Since high wellhead pressures have been reported on geothermal wells in the Kilauea east rift zone, all wellheads, valves, and pipelines will be designed to withstand at least 2000 psi. Because of the extreme heat and gas content of the well fluids, most equipment must be derated below their name plate value. It is intended that 2000 psi or higher rated equipment will be used to provide an acceptable margin of safety.

In geothermal drilling, particularly while using air, drill pipe will
wear quite heavily. Thus, frequent inspections of each length of drill pipe are conducted to detect stress cracking, corrosion, and general wear and tear. All tool joints are beefed up to provide a heavier wall to guard against erosion due to abrasion from the well-bore cuttings. A magnetic particle inspection unit will be available on site for conducting periodic pipe inspections. In addition to drill pipe inspections, all casing is inspected twice, once at the supply source and once on site before being used. These inspections are essential to prevent defective pieces of pipe being installed and creating a potential source of leaks.

Potential Hazards for Specified Events. The possible events, should they occur, that could create potential hazards to the health and safety of project personnel and other personnel within or near project activities are described below together with the actions that will be taken or planned in order to prevent or reduce the likelihood of such events occurring, or should they occur or not be preventable, to reduce the effects of the event on the health and safety of personnel that would be exposed to the event.

1) Volcanic Eruptions. Such events occurring without warning (which is very unlikely) at, within or immediately adjacent to project activity sites could cause serious injury or loss of life to personnel should they be at the point of eruption. This potential hazard to personnel is reduced in direct proportion to the amount of time between a warning of impending volcanic activity and the event and the distance of the event from a project activity site. An eruption directly under or adjacent to a project site could also rupture or destroy pipelines between well heads and power plants causing venting directly to the atmosphere of geothermal fluid if the volcanic activity also damaged the well head assembly and automatic well shut-off
system. If there were faulting associated with the eruption which intersected a well bore, there could also be a rupture of the well bore. If the rupture were near the surface and didn't seal itself off, it is possible there could be unabated venting to the atmosphere until an off-set well could be drilled. Eruptions not directly under or adjacent to a project site activity, even without warning, would pose far less hazard to personnel in the area.

Preventive or Mitigating Actions.

a) Establish and maintain continuous communications with the Hawaii Volcanoes Observatory to assure receipt of early warning of or impending eruption in the Kilauea East Rift Zone.

b) Instruct personnel on procedures to follow on receipt of a warning of an impending eruption and on actions to take in the event of an eruption within or adjacent to a project activity site including designation of evacuation or escape routes and industry procedures on protecting and securing the well head in the face of a threatening lava flow when it is feasible to do so.

c) Conduct an engineering analysis of each prospective drilling site and power plant site to be occupied, recognizing the potential of future eruptions at any point along the Kilauea East Rift Zone. When possible, sites will be selected to minimize the potential hazard of lava flows emanating uphill of project activity. In addition, the use of facility protection barriers, available high ground, and construction of facility platforms will reduce the hazards due to lava flowing into a project site.

2) Earthquakes and Sudden Ground Movement Due to Faulting. Earthquakes associated with volcanic activity in Hawaii are of small magnitude and have caused little damage. Tectonic earthquakes are larger in magnitude and occur
along or near major fault lines. The largest earthquake of record in Hawaii occurred southwest of Kalapana in 1975 and registered a magnitude of 7.2. Sudden subsidence may occur as a result of volcanic or tectonic earthquake, collapsing lava tubes and pit craters, or from subsurface intrusions. Such subsidence could, under some conditions, cause damage to project facilities including the possible rupture of a well bore if a sub-surface fault intersected the well bore. The result of the event could be a casing leak or perhaps venting to the atmosphere of the well flow if the well didn't seal itself off, in which case the venting would continue until an off-set well could be drilled to intersect the well below the rupture point.

Surface faulting and subsidence could rupture steam pipelines, again causing temporary venting of the well flow into the atmosphere if the faulting or eruptive activity caused the well head automatic shut-off system to malfunction.

Mitigating Measures. Analysis of past eruptions, often accompanied by cracking or subsidence near the vent area indicates there are areas in the rift zone where the potential for eruption is less than other areas. Siting of project facilities in such areas when possible can reduce the chances of eruptions and subsidence occurring at project sites so located. Siting of facilities outside the center of the rift zone when possible can significantly reduce the potential hazards of volcanic eruptions and accompanying subsidence and faulting. More predictable, the incorporation of design criteria into primary facilities and systems whose failure under such conditions could result in a health hazard, injury or loss of life will reduce the potential hazards of subsidence and earthquake activity in an active volcanic rift zone.
3) The Potential for Personnel to be Exposed to High Temperature Geothermal Fluids or Steam Under High Pressure. This potential hazard is increased in areas where personnel are working around pipelines, well heads, and tanks where space is restricted so as to prevent rapid movement or escape in the event of a rupture.

Mitigation Measures. Personnel working in such spaces will be required to wear protective clothing and masks. Back-up personnel will be present in a position adjacent to the restricted space while personnel are occupying such spaces in the performance of their duties.

4) Exposure to Chemicals Used in the Pollutant Abatement Systems. Personnel will be handling and mixing chemicals used in pollutant abatement systems and could be subject to overexposure that could cause injury or a health problem. Only experienced personnel will be utilized in this operation.

Mitigating Measures. Personnel will be instructed on the nature and hazards of each chemical being used, the methods of proper handling, storage and mixing of the chemicals and emergency procedures in the event of accident or over-exposure. Emergency water sources will be located near the chemical storage and mixing area. Special articles of protective clothing appropriate for the chemicals used will be available and required to be worn for handling or mixing specified chemicals. Appropriate fire suppression equipment will be positioned at the chemical storage container.

5) Possible Exposure to High (unsafe) Levels of Hydrogen Sulfide ($H_2S$). The geothermal resources in Hawaii that have been discovered and analyzed indicate the presence of $H_2S$ at concentration levels in the range of 900 - 1300 ppm. While these concentrations are rapidly diluted on mixing with air.
and/or as a result of the application of H₂S abatement procedures, an H₂S environment can be hazardous to personnel at or near the emission point unless adequate safety precautions are taken. During drilling operations, H₂S present in the geothermal resource would be emitted through the blooie line while drilling with air (after the reservoir is intersected), during venting of the well and during testing. H₂S emissions would be abated during drilling and testing, but unabated during well venting. Unabated emissions could also occur as a result of a blow-out of the well bore. Lower concentrations of H₂S gas have a sweet taste and the odor of rotten eggs and can be detected. Higher concentrations of H₂S (100 ppm) can impair the sense of smell in 2 – 15 minutes. Direct, continuous exposure to still higher concentration levels (500 ppm) over a period of 30 minutes to one (1) hour could cause lung paralysis and death.

**Mitigating Measures.** Project personnel are instructed at regularly conducted safety meetings on the hazards of H₂S as well as the proper procedures to be used during drilling, well completion and well testing which are designed to prevent uncontrolled emissions from the well bore. They are also instructed on how to use H₂S detection and air breathing equipment. Respiratory protection equipment is always available on site to be used by project personnel and authorized visitors as may be required. (See Emergency Plan, Appendix "F", for H₂S emergency procedures).

**6) Exposure to Excessive Noise Levels.** Project personnel will be exposed to continuous noise levels in the range of 60-80 decibels and impact noises exceeding that level and occasional noise levels of up to 120 decibels when venting a well.

**Mitigating Measures.** Project personnel will be required to have available and wear sound protection devices when in project areas generating
maximum noise levels. A noise monitoring/recording instrument will be maintained at the drilling site.

7) Well Blowouts. A well blowout could occur below surface or at the well head. A blowout would result in the full or partial free flow of the high temperature, high pressure geothermal resource from the reservoir until it could be secured. Such an event could cause injury, or a health hazard, or create a nuisance if project personnel or nearby residents were exposed to excessive or nuisance levels of H₂S. A blowout due to a well bore rupture below the surface or at the well head could take several days or longer to secure, the longer time depending on the depth of the rupture which would have to be reached by off-set drilling.

Very few geothermal wells have failed in the world-wide industry. Some of the few that have occurred were the result of improper well siting in areas susceptible to landslides; setting surface casing at a depth that is too shallow; cementing the surface casing in incompetent rock formations; or, due to errors in planning or executing the drilling medium (fluid) program.

Mitigating Measures. Continually improving industry standards are being applied by operators to further reduce the chances of a well blowout. A well trained crew and reliable equipment are the most important elements of a blowout prevention program and these two key elements will be used for this project. (See Application for Permit to Drill, submitted concurrently to DLNR)

3. Drainage. Surface alterations to accommodate project operations will be designed to assure that normal area drainage patterns are not disturbed.

4. Signs. "No-Trespassing", hazardous warning and safety signs will be posted at applicable sites in the project area.
5. **Lighting Provisions.** Lighting for night operations will be designed and arranged to assure that such operations can be performed safely and efficiently. Bright light requirements can generally be directed or sheltered to limit any impacts outside of the project area. Because of the isolation of the project area, it is unlikely that lights will disturb any residential areas. Proper hazard lights will be installed on the top of the drill rig for aircraft that may overfly the project site.

6. **Changes in Landscape.** The landscape will be altered in portions of the project area where clearing of the forest is required for drilling sites, roads and power plant sites. Land surface requirements for project operations are described in the Revised Environmental Impact statement and the supplemental EIS for this project. Metes and bounds description of all areas to be cleared will be submitted to DLNR prior to conducting any clearing operations.
PLAN OF OPERATIONS

Geothermal Development Activities
(Exploration Phase)

Kilauea Middle East Rift Zone
Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture
January, 1989

Encl (1) to
LTR to Chairman,
BLNR
dtd ________
February 1, 1989

Mr. William W. Paty, Chairman
State Board of Land & Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Subject: Plan of Operations for Geothermal Exploration Drilling in the Kilauea Middle East Rift Zone (KMERZ)

Dear Mr. Paty:

The subject Plan of Operations, Enclosure (1), is submitted for approval as directed by the Board of Land & Natural Resources Decision and Order (D&O) of April 11, 1986, on Campbell Estate's application for a land use permit on their land parcel on the Island of Hawaii, Puna District, TMK 1-20-10:3. The Plan of Operations was prepared in accordance with DLNR Administrative Rules, Chapter 183, Section 13-183-55.

The Plan of Operations provides the framework for conducting the level of geothermal exploration activities authorized in the D&O, including information on the physical, geographical and geophysical aspects of the project site, resource potential and non-drilling operating procedures. The data required on drilling operations and procedures has been included in the Application For Permit to Drill a Geothermal Well, submitted under separate cover to DLNR in accordance with DLNR Administrative Rules, Chapter 183, Section 13-183-65.

Data requirements for the Board's Decision and Order prescribed environmental monitoring plans and programs for the exploration of the project are submitted under separate cover to the Department of Land & Natural Resources for ministerial approval as provided in the Decision and Order. In addition, the D&O required that the noise monitoring plan, the biological survey report and the emergency plan be submitted to the County of Hawaii for review and comment. The air quality monitoring plan has also been submitted to the Director of Health, State of Hawaii Health Department, for approval as a matter under cognizance of that department. Concurrently, the Application for Authority to Construct (ATC) twelve geothermal exploration wells has been submitted to the Health Department for approval as a matter relating to air quality control.
Mr. William W. Paty, Chairman  
Page Two (2)  
February 1, 1989

Upon completion of sufficient exploration to support proceeding with development activities and upon evidence that a market exists on the Island of Hawaii for up to 25 MW of power, a Development Plan will be submitted to DLNR for approval to proceed with the applicable level of development. Additional Development Plans will be submitted for increments of development up to 75 MW (for a total of 100 MW) as the market for such power is established locally or on Oahu via deepwater transmission cable. Development beyond 100 MW would require a supplemental CDUA.

The preliminary schedule of project activity is included in the Plan of Operations.

Campbell Estate has reviewed and concurs in the Plan of Operations.

Very truly yours,

TRUE GEOTHERMAL ENERGY COMPANY  
(Operator for True/Mid-Pacific Geothermal Venture)

[Signature]

H.A. True, III, Partner

Encl: 1) Plan of Operations

cc: Mid Pacific Geothermal, Inc.  
    Estate of James Campbell
PLAN OF OPERATIONS

Geothermal Development Activities
(Exploration Phase)

Kilauea Middle East Rift Zone
Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture
January, 1989

Encl (1) to
LTR to Chairman,
BLNR
dtd ________
(Plan of Operations)

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Attachment 1

Metes and Bounds Description of Access Road and Drilling Site A1
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<td>Proposed Project Exploration/ Development Areas</td>
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PLAN OF OPERATIONS

Geothermal Project for the Kilauea Middle East Rift Zone, Puna District, Island of Hawaii (Campbell Estate Property, TMK: 1-2-10:3)

INTRODUCTION:
This plan of operations includes the map and data requirements for geothermal exploration activities as prescribed in Section 13-183-55, Chapter 183, DLNR Administrative Rules on Leasing and Drilling of Geothermal Resources, and the Decision and Order, (D & O), Board of Land and Natural Resources, dated April 11, 1986.

The environmental monitoring plans and programs including the Management Plan, the Emergency Plan and procedures on abated venting are submitted separately to DLNR for administrative approval as directed in the Board's Decision and Order. In addition, the Noise Monitoring Plan, the Biological Survey Report and the Emergency Plan are submitted concurrently to the County of Hawaii for Review and comment.

The initial exploration drilling activities to be undertaken within the scope of the Plan of Operations are described in Section II of the Final Supplemental Environmental Impact Statement for this project (February 1986) and subject to conditions imposed in the Board's Decision and Order. Additional exploration drilling will be conducted for the purpose of further determining, in conjunction with earlier drilling, the location and extent of
geothermal resources within the project area (geothermal resource sub-zone) and whether such resources could be economically developed and sufficient to produce and sustain the production of 100mw of geothermal generated electricity for 30 years.

Changes to the Plan of Operations will be requested as may be necessary due to the results of continuing drilling operations, natural phenomena, and cumulative environmental monitoring which establish the need to make adjustments in operating procedures, project impact mitigation measures and environmental monitoring plans and programs.

Following the completion of sufficient exploration activities to prove the existence of economically producible resources and upon negotiation of a power purchase contract with an electrical consumer, a Development Plan for the contracted amount of power (up to 25mw) together with required changes to the Plan of Operations will be submitted for approval.

It is expected that development of geothermal generated electrical energy will occur in increments up to a total of 100mw, the limit imposed under the current Conservation District Permit of April 11, 1986.
1. Exploration Drilling Program and Schedule
   a. The exploration drilling program including the planned sequence for drilling exploration wells within the project site is described in the Application for Permit to Drill submitted to DLNR in accordance with Section 13-183-65, Chapter 183, DLNR Administrative Rules on Leasing and Drilling of Geothermal Resources.
   b. Activity Schedule. (See Figure 1.)

2. Project Area/Drilling Site Description
   a. The project site is located along the Kilauea middle east rift zone, Island of Hawaii, Puna District, within a geothermal resource sub-zone covering an area of about 9,000 acres within Campbell Estate Property, TMK 1-2-10:3.
   b. Drilling Site Designation: True/Mid-Pacific A1 (TMP A1).
   c. Topographic features of the project site including the location of the first exploration drilling site (A1) are as shown on Figure 2. The principal topographic feature within the project site is Pu'u Heiheiahulu, located about 7,000 feet south of drilling site A1.
   d. Metes and bounds description of Drilling site A1. (See Attachment 1); As a result of the findings reported in the biological survey of proposed drilling site A1, it has been determined that by relocating the drill site 300 feet east of the position shown on Figure 2, the clearing of a portion of an 'Ohi'a class a-(2) forest which contains a resident population of a native bird (not endangered), the Hawai'i 'elepaio, can be avoided. Accordingly, the adjusted surveyed location of drilling site A1 is as indicated in Attachment 1.
### Baseline Studies, Kilauea East Rift
- Air Quality
- Biological Reconnaissance
- Archaeological Reconnaissance

### Contingencies & Impediments Resolved
- Submitted
  - Approved
  - Ops Plan
- Rig Mobilization
- Crew Recruitment, Training & Resettlement
- Security & Communications

### Access Road
- Site Construction
  - Access Road A or B
  - Access Road A or B

### Meteorological Sites Established
- Catchment Water Samples

### Activity Schedule
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**Figure 1**

**True/Mid-Pacific Geothermal Project**
e. Size and Configuration: Each drilling site will cover approximately 5 acres including 1 acre for a water catchment pond when required. (See Figure 3, Plot Plan).

f. Planned Excavation and Grading:
The access road to drilling site A1 which has been surveyed and staked as shown on Figure 4, will be graded as a 20 ft. wide construction road along the alignment shown. Due to the gradual slope of the project area cut and fill requirements will be limited. The depth of any cut is not expected to exceed 20 ft. At the drilling site, the area will be cleared and graded to accommodate the drill rig and ancillary equipment as identified in the drilling site plot plan, Figure 3. A sump for well effluent will be excavated adjacent to the drill rig as shown on the plot plan. Dimensions of the sump will be approximately 120' by 360' by 10'. In addition, a site for a water catchment pond will be excavated adjacent to the drilling site. Dimensions for the water catchment pond are approximately 200' by 300' by 10'. Excavated materials will be retained on site for future use or refill of the sump or pond.

g. Elevation of Drilling Rig Above Sea Level.

1,500 ft.

3. Well Bore
   a. Well Designation Number: True/Mid-Pacific A1-1
   b. Location Within Drilling Site: (See Figure 3)
c. Proposed Depth of Resource Discovery and Bottom Hole Location:
It is expected to encounter a geothermal reservoir beginning at a
depth of 4,500 ft. Total depth is expected to be in the range of
8,000 - 14,000 ft., true vertical depth.
d. Description of Drilling and Casing Program and Proposed Well
Completion and Testing Program: (Contained in Application for
Permit to Drill a Geothermal Exploration Well).

4. Planned Access and Lateral Roads
a. Location (See Figure 2)
(1) The primary route to the project site will be via State Road
130 to the Pahoa by-pass road north of Pahoa, to South Road to
Kaohe Homesteads to Middle Road and south along State Road
easement (20 ft. width) to the boundary of the Campbell Estate
property (TMK 1-2-10:1). The easement for the State Road was
granted by Department of Land and Natural Resources letter of
January 16, 1987 to the Estate of James Campbell.

(2) The planned access road to the first drilling site
(True/Mid-Pacific A1) is shown on Figure 1. However, as a
result of the findings of the biological survey of the proposed
access road alignment, the sighting of three trees being
considered for listing by the U.S. Fish and wildlife Service
as endangered species (Bobea timonioides and Tetraplasandra),
it has been decided to deviate the access road east of survey
stakes #48 and #58 (Figure 4) to avoid these trees as shown in
Attachment 1.
(3) Three turn-outs along the road will be selected after grubbing is completed and shown on a revised map. Grubbing will extend to 10 feet on each side of the bed. The initial width of the access road will be 20 ft. Segments of the road where cut and fill is required will be widened to 30-40 ft. During the development phase, the access road will be widened to 30 ft.

(4) A grubbing permit has been requested from the County of Hawaii for the access road including the unimproved portion of the State road easement. Application for a grading permit will be made to the County of Hawaii subsequent to completing the grubbing and engineering design.

(5) The location of planned lateral roads to subsequent drill sites are as shown in Figure 5, Exploration and Development Plan for the Project.

b. Metes and Bounds Description of the Access Road (Attachment 1)

c. Metes and Bounds of lateral roads and other drilling sites will be submitted together with required pre-clearing survey data when such sites and road alignments are determined.

d. Access Control (Described in the Management Plan, submitted separately to DLNR).
5. **Source of Water Supply and Road Building Materials**

a. Potable water for drinking, sanitation and for work force safety measures will be trucked in to the project site from an existing county water point.

The primary water source for drilling and testing operations and fire fighting will be catchment water. Every attempt will be made to recycle all water used in drilling and testing operations. A water catchment site with a total capacity of 500,000 to 1,000,000 gallons will be located adjacent to each drilling site when required. The catchment pond will be supplemented initially with water trucked in from the county water point. (During the development phase, plans may include the installation of a water pipeline from a nearby well.) Condensate from power plant operations will provide replacement water for the cooling tower system during the development phase as will be described in the future development plan.

b. During the initial exploration phase of the project, it is expected that only road topping cinders will be needed from outside of the project site. Off-site materials will be required in the development phase to widen and improve the access road.

6. **Major Project Facilities/Equipment for Drilling Activities**

a. The major project facilities and equipment for the exploration phase are the drilling rig and ancillary equipment including utility
vehicles, pumps, generators, compressors, drill pipe racks, and tanks for water, drilling mud and fuel. In addition, a sump for well effluent and a water catchment pond will be required.

b. This equipment will be arranged around the drilling rig, approximately as shown in Figure 3.

7. Other Areas of Potential Surface Disturbance

Figure 5 identifies the planned facility sites and connecting roads within the project area which may be used during the progression of project exploration and development activities depending on the extent and location of discovered geothermal resources and market demand for geothermal energy.

Field surveys will continue to be made of any of the areas to be occupied for project activities prior to clearing or construction and results reported to DLNR for review and approval.

8. Disposal Procedures for Well Effluent/Other Wastes

a. During the exploration phase, project wastes such as drilling effluent (cuttings from the well bore, drilling mud and fluids) will be discharged into a sump at each drilling site. Solids will be settled out and fluids will be recycled. Residual solids will be left in the sump and buried, or in the case of drill cuttings, used as sand within the drill site if needed. Similarly, geothermal brine brought to the surface during well testing will be piped to a rock muffler and then discharged into a sump for percolation. In
the unlikely event that fresh ground water is found to exist in the rift zone at the project site and it is determined that the limited amount of brine produced from the well would contaminate the fresh water a lined sump will be used for collecting of the brine for settling out of solids. Trash will be collected daily on site and periodically transferred to the nearest county disposal site. Portable toilets will be positioned on site.

9. **Narrative Statement Describing the Proposed Measures to be Taken for the Protection of the Environment**

As described in Section 6 in the Revised Environmental Impact Statement for Kahauale'a, June 1982, Section III in the Final Supplemental EIS to Revised EIS for Kahauale'a, February 1986, and in the environmental monitoring plans and programs submitted separately to DLNR for ministerial approval.

10. **Geologist's Preliminary Report on Surface and Sub-Surface Geology, Nature and Occurrence of the Known or Potential Geothermal Resources, Surface Water Resources and Ground Water Resources.**

a. **Geothermal resources in the Kilauea Middle East Rift Zone (KMERZ)**

   The resource potential of the Kilauea East Rift Zone has been recognized for many years and studied by many investigators. The combination of a prolific heat source, abundant water, and permeable rocks at drillable depths makes the East Rift Zone a highly valued resource area.
There is no fundamental change in surface geology along the 30 mile extent of the East Rift Zone. The proposed development will occur in the area of the Middle East Rift Zone as shown on Figure 5. Variations in surface geology are determined by the number and density of surface vents and faults, the age of the lava flows, and the variations between a'a-a'a and Pahoehoe flows.

Stratigraphy of the KMERZ is simple in that all the rocks are basaltic lavas. Seismicity caused by magma movement and thermal contraction after intrusion is believed to induce the fracturing that is necessary for creating a geothermal reservoir. Approach of the drill bit into a reservoir will be indicated by marked increases in temperature.

Temperatures and pressures are expected to be similar to that encountered at H.G.P.A. It is also expected that a liquid dominated reservoir will be encountered.

The HGP-A Project proved that the Kilauea east rift was a commercial geothermal province. Moreover, it demonstrated that wells could be drilled, tested, and produced with existing technology. Six additional deep geothermal wells have been drilled in the lower east rift zone. Of the seven total wells, two are producers, two produced geothermal fluids but had mechanical failures, and three wells did not encounter sufficient fracture permeability to produce
geothermal fluids. Based on this result, it is apparent that success or failure hinges on the existence of fractured rocks at the target depths. Temperatures are not an overriding concern. In fact, an aeromagnetic survey reported by Godson (1981) suggests that temperatures under the Middle East Rift Zone are quite adequate for geothermal development. The apparent negative magnetism suggests subsurface rock temperatures that are above the Curie temperature of 500 degrees C.

Thus, to determine favorable areas to encounter permeability, several techniques are feasible including evidence of micro earthquakes, surface geology, radon surveys, and exploratory drilling. The latter is the most definitive. Surface geology was meaningful in the siting of the Kapoho State Wells (Iovenitti, 1985). An apparent offset in the rift zone was one of the primary justifications for the well sites. Geothermal exploration in other magmatic environments such as the Phillipines, Alaska, and Long Valley Caldera utilizes surface geological features in drill site selection, and considerable reliance will be placed on surface geology in the KMERZ.

Radon is a naturally occurring radioactive gas that emanates from geothermal systems. Thus, if radon is detected at the surface and particularly near faults or vents, this suggests a geothermal fluid may be close by or may have been close by. Cox (1980) did a passive radon survey from Kaohe Homesteads to Cape Kumakahi. This survey
delineated a radon anomaly that was elongated along the axis of the rift zone but with a very irregular shape. Interestingly, all three wells that failed to encounter geothermal fluids were drilled outside the radon anomaly. All four productive wells were drilled within the anomaly. The radon anomaly comes up to the boundary between Kaohe Homesteads and the Puna Forest Reserve suggesting a high degree of probability that a geothermal resource extends into the proposed development area. At the boundary, the radon anomaly is 3 Km wide and stretches across the rift zone from about Iilewa Crater to the northwest corner of Kaohe Homesteads.

Recently, reports in the literature (Iovenitti, 1985) have indicated that the Kapoho State Wells #1 and #2 have produced dry steam. If true, the resource description may have to be altered to take this into account. Although the reservoir is liquid-dominated, there may be areas dry steam is present. If in fact the produced fluid is dry steam, it will be a much easier task to produce, transport, utilize, and dispose of the geothermal fluids. However, plans for drilling and development anticipate a two-phase resource.

A Statewide Geothermal Resource Assessment (DLNR, 1984) concluded that the proposed development area has high geothermal potential. In fact half of the development area has a probability of 90% or greater of encountering a resource with temperatures above 125 degrees C. The other half has a 25% to 90% probability of encountering the same type of resource.
Within the proposed development area, recent lava flows have occurred in 1961, 1963, 1977, and 1985. Steaming ground at Heiheiahulu has also been reported indicating that a heat source is in the vicinity.

Information about the proposed development area indicates that there is a high probability that a resource will be discovered which is sufficient evidence to justify exploratory drilling. See Appendix D to Revised Environmental Impact Statement for Kahauale'a (June 1982) and DLNR Report 1985.

b. **Surface & Ground Water Resources**

There are no known surface streams or natural water storage features in the project area. There are pockets of standing water in areas underlain by Pahoehoe lava in the North eastern portion of the project area which includes the access road to the first drill site.

Ground water along the Kilauea east rift may occur as dike impounded, perched and basal water. According to the State's report on Geothermal Resource Subzones (DPED, June 1986) "the only known perched water exists north of Mountain View", and "Basal water underlies all of the Kilauea east rift zone except where dikes occur."
It is expected that all basal water in this area will be at elevated temperatures with saline content varying from low (north side of rift zone) to high (south side of rift zone) and therefore the water will not be potable. This condition is evidenced in the lower portions of the rift zone by samples of well water on the North and South sides of the rift zone and within the rift zone. Analysis of water samples taken before injection of production well effluent will be used to verify that the basal water in the middle rift zone is non-potable as has been observed in the lower rift zone.

11. Environmental Monitoring Plans and Programs

The D & O prescribed environmental monitoring plans and programs are submitted separately to DLNR for ministerial approval.

12. Development Plans

(Plans for the development of a discovered resource will be submitted to DLNR for approval when it has been determined that such resources are suitable for production and a demand for the energy at a specified level has been established.)