IDENTIFICATION OF GEOTHERMAL RESOURCES IN HAWAI’I UTILIZING AQUEOUS GEOCHEMISTRY

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ABSTRACT

This study examines the use of aqueous geothermal indicators to assess the geothermal potential in the State of Hawai’i. These geochemical techniques are broadly applied to hot springs and fumaroles at other geothermal settings; however, in Hawai’i there are few such surface expressions, making Hawai’i geothermal resource largely blind. Thus, the focus shifted to existing well water analyses, and a database was populated with aqueous cation and anion data from over 800 wells. The active geothermal production area near Puna Geothermal Venture was used as training area, and four key geothermal indicators were found to be relevant to the Hawai’i situation. These indicators include silica concentration, Cl/Mg ratio, Na/K geothermometer, and SO_4/Cl ratio. These indicators were then applied to the database, and anomalous chemical analyses were identified across the state. On the Island of Hawai’i grouping of anomalies are located near Hualālai volcano and in the Kawaihae-Hawi area. For O’ahu, anomalies are located on the South-Shore of O’ahu and in the former caldera area of the Waianae Volcano. Kawailoa area on the North-Shore, Waimanalo and in central O’ahu are the locations of additional anomalies. Maui results include anomalies in the Northwest and East rift zones of the East Maui Volcano. Olowalo and near Lahaina are the locations of West Maui anomalies. Most of these anomalous areas outside the Puna training area indicates that potential geothermally altered water was mixed with fresh or meteoric water. Despite the mixing, anomalies are present. The process was also limited to available data, and collection of additional data in high potential areas should be considered. In conclusion, the application of geothermal indicators to well water data was found to be a useful tool for the identification of potential geothermal resources.

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1. Introduction

With active volcanism and some of the highest electricity costs in the United States, Hawai'i is an ideal location for the development and use of geothermal energy. Interest in geothermal development peaked in the late 70's and early 80's. In 1990 there was even consideration of an electrical transmission cable from the Island of Hawai'i to O'ahu, where most of the state's energy is consumed (Borg, 1990). Today, only about 3% of the states total electrical consumption comes from geothermal energy. A single geothermal power plant located in the Kīlauea East Rift Zone (KERZ) on the Island of Hawai'i produces electricity from geothermal energy. Ormat, Inc. operates the 38 MW hybrid binary plant called Puna Geothermal Venture (PGV). Despite the low percentage of geothermal electricity production as measured on a statewide basis, PGV provides 26% of the electrical energy for the Island of Hawai'i (Hawaiian Electric Company, Inc., 2014). PVG has uniquely demonstrated that production of geothermal energy can be remotely controlled (or dispatched) by the Hawai'i Electric Light Co., Inc.(HELCO); the 8 MW of power dispatched by HELCO supports both electrical system stability and reliability.

Recently, the Hawai'i Institute of Geophysics and Planetology at the University of Hawai'i has embarked on a statewide assessment of geothermal resources. The work aims to create a foundation for future exploration activity and reduce the cost and time for future resource development. This assessment utilizes the Play Fairway approach which is a multi-attribute decision making process that ranks potential plays by the confluence of three key qualities of a geothermal resource: sufficient heat, sufficient fluids, and the necessary permeability for production. These qualities are analyzed by incorporating numerous data sets into multiple layers of an ARC-GIS system and probability calculations are made. This study focuses on the application of aqueous geochemical techniques to identify location of geothermal heat.

Aqueous geochemistry is an especially important tool for addressing the characteristic challenge of geothermal exploration in Hawai'i. The few hot springs and fumaroles in Hawai'i make the potential resources largely blind. With the exception of the hot springs and steam vents in the active volcanoes of Hawai'i Volcanoes National Park and the Puna District of the Island of Hawai'i, the potential geothermal resources have few or no direct surface indicators. We must therefore take advantage of the indirect evidence provided by geochemistry techniques. Such techniques also offer more cost-effective measures than, for example, geophysical exploration and drilling.

The first step in this study was to analyze data from the test wells and production wells in the Puna district near PGV. Doing so established a group of geothermal indicators and geothermometers[1], and thresholds for anomalous data were established. Next, a database of well water analyses for the whole state was assembled from the University of Hawai'i, local water utilities, Hawai'i Department of Land and Natural Resources and United States Geological Service information. The established geo-indicators and geothermometers were applied to the database, and anomalies were identified. The study found that specific wells within the state demonstrated individual anomalies, and some evidenced multiple anomalies. Several areas had numerous wells with anomalies in close proximity. Areas like this occur on the Island of Hawai'i as might be anticipated given active volcanism, but there are also areas on the older island of Maui as well as O'ahu. These areas of concentrated anomalies included the Puna district near PGV, Hualālai volcano, Kawaihae/Hawi area, Northwest rift zone of the East Maui Volcano, South-Shore Koolau Volcano, and Waianae Volcano. These areas should be high priorities for further exploration.

[1] S. Arnorsson(Arnorsson, 2000) defines geothermometers as an estimate of sub-surface temperature using water and solute composition, gas composition, and isotopes. The term geothermal indicator refers to calculated values such as Chloride/Magnesium ratio used by D. Thomas (Cox and Thomas, 1979).

2. Geological Setting and Previous Studies

Hawaiian volcanoes form as the Pacific oceanic plate moves over a fixed (or slow moving) hot spot in the mantle (Tarduno, 2009). The evolution of the volcanoes begins with the growth of seamounts below the surface, continuing with the creation of massive volcanic structures, described as shield volcanoes that stand thousands of meters above the sea floor. The eruptions during shield building often originate in calderas or in rift zones, emanating out from the calderas. Then, after a period of decline and erosion, these volcanoes can undergo rejuvenation as seen in the Koolau range on O'ahu. Ultimately, the volcano can erode to atolls (Walker, 1990). The surface manifestations of shield building include fissures, vents, cones, pit craters, dike structures and faults. The resulting geology structures, discussed in this section, create the lithology, hydrological model, rock-water interactions, and hydrothermal alteration that define the geochemical environment discussed in this paper.

2.1 Lithology

The lithology of Hawai'i volcanos consists of thinly stratified layers of basaltic lava deposited in submarine and subaerial environments, as well as intrusions in the form of gabbro and dikes. The following are the characterizing rock groups found in the Scientific Observation Hole 1, Kīlauea Volcano, from the top of the core to the base (Trusdell et al., 1999):

1) 'A'a with dense core, low level of deformed vesicles and associated with rubble and clinkers
2) Pāhoehoe with medium to high levels of rounded to sub-rounded vesicles
3) Transition between 'a'a and pāhoehoe
4) Sub-aqueous lava including Hyaloclastite and pillow lava
5) Dikes consisting of dense material free of vesicles
6) Ash composed of sub-aerial pyroclastic material
7) Volcanoclastic material with fine grains deposited in a subaqueous eruption.

The basaltic lava flows along the Kīlauea East Rift Zone demonstrate how sustained lateral eruptions create the lithology described by Trusdell. The basalts are tholeiitic or picritic (Figure 2.1). Despite the generally mild eruptive style of shield volcanoes, phreatomagmatic eruption can create ash layers such as the 1790 eruption and the resulting Keanakakoi ash (ENLI, 1990). This lithology is generally very permeable and accommodates the flow of water in aquifers. At depth, compaction generally reduces permeability of all rock types (personal conversation with D. Thomas).

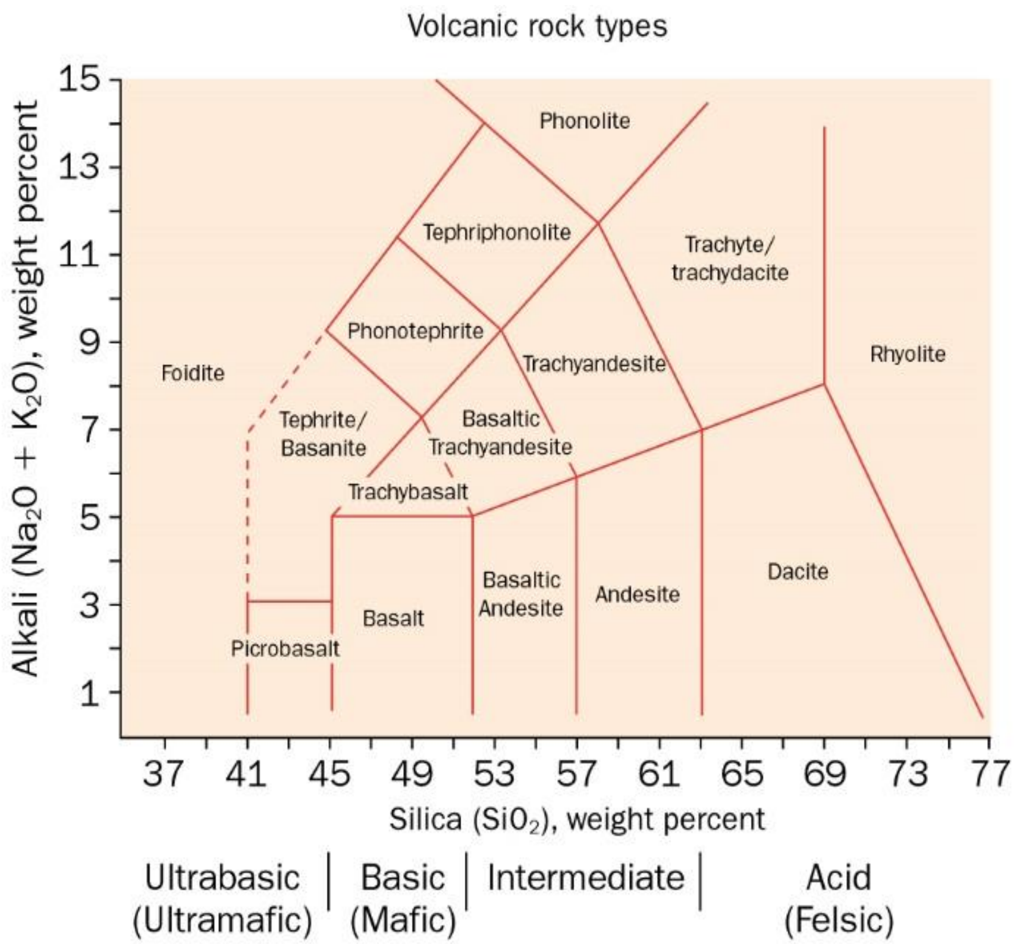

Figure 2.1. Silica vs sodium and potassium concentrations in various lava types [Fig. 3.3 of *Lockwood*, 2010]

2.2 Groundwater and Hydrology

Groundwater in the Hawai'ian Islands is grouped into dike-impounded water, sedimentary and alluvial water, and basal water (Cox, Thomas, 1979). Impermeable dikes can impound water at a wide variety of elevations, and the impounded water has been extracted using tunnels. Because impounded water is generally captured at a high elevation, impounded water has not resulted in a geothermal resource; however, it is not inconceivable that the configuration of dike swarms and fractures could allow impounded water to intersect a heat source. Sedimentary and alluvial water are found in the larger valleys where sedimentary formations are thick and permeable.

Basal water is located under most major Hawaiian Islands and resides above the deep saline water and the transition zones between the saline water and fresh basal water. Recharge of basal aquifers occurs across a wide variety of elevations and topographies. The water flow within these aquifers is generally down the topographic gradient toward the ocean, but impermeable layers and caprock make the flow more complex. Caprock[2] can reduce the flow of basal water into the ocean (e.g., South-shore O'ahu), but elsewhere water can flow directly into the ocean or enter the ocean as a submarine discharge. These flow characteristics can mask geothermal resources if fresh basal water mixed with geothermally heated water.

Several hydrological factors confound the search for geothermal resources. The first is the lack of a large number of surface indications such as fumaroles and hot springs. The lack of surface indications greatly limits the ability to collect spring samples and apply analytical tools to determine subsurface temperatures. The second factor is the fresh water aquifers do not always follow the Ghyben-Hertzberg model

[2] Caprock is less permeable material located on the peripheral edges of the island that constrains the flow of basal water into ocean(Visher and Mink, 1964)

(Macdonald et al., 1983).[3] This challenge is best understood by the drilling in the Humuulu saddle near located between Mauna Loa and Mauna Kea. At this location, a continuous layer of water was found at 1,000 meters above sea level (Willoughby, 2015). The geothermal gradient at this location was less than 18 °C per kilometer; however, at some 1,000 meters below the surface the geothermal gradient increased to 165 °C per kilometer (D. Thomas, personal comm.). At this location, the thick layer of water concealed a potential geothermal resource. Another problem is that ground water flow may carry geothermally altered water far away from the actual source of heat. Thus, a well sample that indicates heat alteration may be from a source miles up the topographic gradient.

3. Water-Rock Interactions and Geothermal Indicators in Hawai'i

The application of geothermal indicators in Hawai'i requires an understanding of the key conditions that make the indicators effective, the chemical species present in the country rock, the chemical species in groundwater, and the processes by which rocks and water interact. It is an important

[3] The Ghyben-Herzberg lens develops within oceanic island when rainwater floats on salt water and accumulates in a lens shaped area under the island. The lens thickness follows a concept that for every foot of fresh water above sea level there will be forty feet below sea level. The exception to this is the central area of an island, which may be an area of high rainfall. When limited by permeability, the aquifer recharge from high levels rainfall may result in water piling up, and the height of the water column does not strictly follow the Ghyben-Hertzberg principle.

condition that the dissolution of rock compounds into water must be temperature-dependent, and the re-equilibration rate after the water leaves the reservoir and cools must be slow or negligible. In addition, there must be adequate reactants to achieve equilibrium. Finally, interpretations of the final chemical analyses must account for mixing with other water (Fournier, 1977).

The principal components of basaltic lavas and water in the Hawaiian Islands make the use of indicators and geothermometers possible. These components include SiO_2, MgO, MnO, CaO, Na_2O, K_2O, H_2O and various iron compounds (Table 3.1). Relevant water types include seawater, fresh water, geothermal fluids, and rainwater. (Table 3.2).

Table 3.1 Average Composition of Hawaiian Rock Types (Wt. %)

	Alkalic basalt	Hawaiite	Trachyte	Oceanite	Tholeiitic basalt
SiO_2	46.5	48.6	61.7	46.4	49.4
TiO_2	3	3.2	0.5	2	2.5
Al_2O_3	14.6	16.5	18	8.5	13.9
Fe_2O_3	3.3	4.2	3.3	2.5	3
FeO	9.1	7.4	1.5	9.8	8.5
MnO	0.1	0.2	0.2	0.2	0.2
MgO	8.2	4.7	0.4	20.8	8.4
CaO	10.3	7.8	1.2	7.4	10.3
Na_2O	2.9	4.4	7.4	1.6	2.1
K_2O	0.8	1.6	4.2	0.3	0.4
P_2O_5	0.4	0.7	0.2	0.2	0.3

Source: Macdonald, 1983

Table 3.2 Reference and Typical Compositions of Different Water Types

	Sea Water (mg/l)	Fresh Groundwater (mg/l)	Geothermal Production Fluids (mg/l)	Rainwater (mg/l)
SiO2	4	45	561	0
Na	10,760	27	4,420	4.5
K	399	3	910	0.4
Ca	412	10	177	0.85
SO4	2,712	13	15.4	1.8
Mg	1,292	31	0.189	1.1
Cl	19,353	34	7,920	7.9

Sources: Seawater http://www.soest.hawaii.edu/oceanography/courses/OCN623/Spring%202015/Salinity2015web.pdf , Groundwater(County of Hawai'i, Department of Water Supply), Geothermal Production Fluids(State of Hawai'i, Department of Health UIC Report June 14, 2014), and Rainwater (Cox and Thomas, 1979).

Rock-water interaction in a geothermal environment involves several processes. When fresh water interacts with high temperature rock, the alkaline ions (Na, K, Ca, and Mg) and silica content increase in the freshwater phase. The interaction of high temperature rock and seawater will alter the composition of both seawater (e.g. depletion of Mg) and the rock. Seawater and freshwater can mix thus altering the composition of the mixture. Some chemical species (e.g. Cl) are non-reactive (conservative) when they interact with rock, freshwater or saltwater. Conservative species are used as a comparative tool to gauge how water-rock reaction have affected water composition (both seawater and groundwater). Finally, when phase changes occurs (boiling), some species (e.g. Na, Ca, and Cl) will remain in liquid phase, and some will vaporize.

These compositions and basic knowledge about the behavior of the reactants establish the framework of the geothermal indicators in this study.

- With the country rock being the source of silica, a higher solubility of silica at elevated temperatures causes geothermal production fluids to be more concentrated in silica than cool seawater or freshwater (Fournier and Rowe, 1966).
- Magnesium from seawater (smaller amounts in groundwater) is depleted by geothermal reaction. When saline water is geothermally heated, the magnesium is substantially depleted by the formation of hydrothermal clays (Cox and Thomas, 1979). With Cl being conservative, geothermal production water typically have very high Cl/Mg.
- The sodium/potassium ratio is lower for the heat-altered water such as geothermal fluids due to breakdown of parent minerals (feldspars) to secondary minerals (albite) (Fournier and Truesdell, 1973).

- Sulfate concentration diminishes in the geothermal water due to decreasing solubility of gypsum ($CaSO_4 \cdot 2H_20$) when temperature is increased (Libes, 2009).[4] Steam loss (or boiling) can ultimately increase the concentration of sulfate in certain circumstances.

Out of this framework arises the four geothermal indicators for the Hawai'i situation: silica content, chloride/magnesium ratio (Cl/Mg), sodium/potassium ratio (Na/K) and sulfate/chloride ratio (SO_4/Cl) which are described later in this section.

3.1 Silica

Quartz geothermometers are used to estimate the subsurface temperatures for hot springs. The solubility reaction for silica and water is expressed as (Walther and Helgeson, 1977)

$$SiO_{2,\ solid} + 2\ H_2O \ = \ H_4SiO_4^0.$$

A number of polymorphs such as alpha-quartz, beta-cristobalite and chalcedony complicates the water chemistry of silica. For lower temperatures, amorphous and chalcedony geothermometers were developed.

One question arises when considering silicate concentration and heat alteration. Does the silica concentration re-

[4] The decreasing solubility of gypsum and anhydrite with increasing temperature will deplete SO_4 in geothermal water. This should not be confused with low concentration of sulfate in meteoric water.

equilibrated, as temperature falls such that surface or near surface silica concentrations do not reflect heat alteration? When considering silica content, water may be cooled by adiabatic expansion (boiling), by conductive cooling to adjacent rock and water, and by mixing. Fournier (1977) argues that conductively cooled, ascending water retains its silica concentration due to the slowing of the silica solubility reaction with decreasing temperature. For adiabatic expansion, Fournier suggests a steam correction (Fournier, 1977). In both situations, silica can remain in solution for a longer period than the time for the water to ascend from depth, thus making it likely that silica is an effective marker of geothermal alteration. Mixing with fluids having low silica content, will, however, diminish the silica concentration and obscure deeper thermal water/rock reactions.

Silica concentrations in Hawai'i aquifers can be impacted by other processes. For example, Visher and Mink (1964) noted that silica levels in central O'ahu were unusually high. They attributed the elevated levels to the mobilization of silica into groundwater during irrigation and the associated the soil weathering processes (Visher and Mink, 1964). Given that silica values are influenced by both natural and anthropogenic activities, the selection of anomalous wells based on silica concentrations requires caution. For the purposes of this paper, the groundwater wells were divided into aquifers, and anomalies were selected by identifying groundwater wells that had elevated levels relative to other wells in the same aquifer (see methodology described in section 4).

3.2 Chloride/Magnesium

The relationship between chloride and magnesium in coastal areas with geothermal activity can be a valuable tool. The heating of water in the presence of feldspar and Mg^{+2} accelerates the following reaction involving K-feldspar, biotite, and chlorite,

$$2.8\ KalSi_3O_8 + 1.6\ H_2O + Mg^{+2} =$$
$$0.8(K,Mg,Fe)_3AlSi_3O_{10}(OH)_2 + 0.2(Mg_5Al)(AlSi_3)O_{10}(OH)_8$$
$$+ 5.4(SiO_2) + 2K^+.$$

This process results in very low Mg levels when compared to chloride, and so the Cl/Mg ratio is used as a geothermal indicator. Given that seawater typically is associated with CL/Mg ratios greater than 15, a Cl/Mg greater than 15 is considered anomalous (Thomas, 1979). Outside Hawai'i, diminished levels of Mg were also noted in a New Zealand geothermal field (Mahon, 1970).

3.3 Sodium/Potassium

The sodium/potassium ratio (Na/K) is one of the most commonly used indicators of geothermal activity. The ratio reflects the equilibrium between albite and K-spar, and the reaction is expressed as follows:

$$NaAlSi_3O_8 + K^+ = KALSi_3O_8 + Na^+.$$

As the activity of the two feldspars approaches 1, the equilibrium equation becomes the following (Arnorsson, 2000),

$$K_{eq} = [KAlSi_3]\ [Na^+]/[NaAlSi_3O_8]\ [K^+]$$

$$K_{eq} = [Na^+]/[K^+]$$

K_{eq} is the equilibrium constant for the reaction, and […] are activity coefficients. The following van't Hoff equation relates the K_{eq} to the temperature,

$$d(\mathrm{Log}\ K_{eq})/d(1/T) = \mathrm{delta}\ H/4.5758.$$

This equation results in a linear relationship between log (Na/K) and 1/T, and so the Na/K ratio is used as a geothermometer (Fournier and Truesdell, 1973).

Jacobus H. van't Hoff's work was based on the empirical measurement of organic chemical reaction. van't Hoff was awarded the first Nobel Prize of Chemistry for the discovery of this relationship and his subsequent work with osmotic pressure.

Several forms of the Na/K geothermometers have been derived (Table 3.3).

Table 3.3 Na/K Geothermometers

(1)	**Na/K (Fournier,1979)**	**T = 1217/(log(Na/K)+1.483) - 273.15**
(2)	Na/K (Truesdale,1976)	T = 856/(log (Na/K) + 0.857) - 273.15
(3)	Na/K (Arnorssen,1983) (25-250 C)	T = 993/(log (Na/K) + 0.993)- 273.15

3.4 Sulfate/Chloride Ratio

The sulfate/chlorite ratio provides an indication of geothermal heat in two ways. The first is the precipitation of gypsum and corresponding depletion of SO_4 from geothermal fluids. Unlike many chemical species, gypsum (or anhydrite) precipitates in aqueous solution when temperature increases. In hydrothermal systems, the precipitation begins at about 200°C (Libes, 2009). An example of the sulfate depletion is seen in Table 3.2 where the sulfate/chloride ratio for geothermal fluids is 0.002, which is much lower than that of the other water types.

An elevated SO_4/Cl ratio is a second way geothermal activity can be identified. Aided by a drilling program in Yellowstone National Park, the interaction of sulfates, water and geothermal heat was studied (Truesdell et al., 1973). They found that steam loss (or boiling) could occur as geothermally heated water ascends. As steam is formed, hydrogen sulfide (H_2S) separates from the liquid water and ascends with the steam. When this steam-H_2S mixture subsequently contacts new water (e.g. meteoric water), the H_2S is then oxidized to H_2SO_4 (Rye and Truesdell, 2007). Finally, sulfate forms by the following the reactions,

$H_2S + 2\ O_2 = 2\ H^+ + SO_4^{2-}$, and remaining liquid has an anomalously high SO_4/Cl ratio.

3.5 Calcium Geothermometers

Calcium is one of the major components of basaltic lava, and it has been used in geothermometers. When Ca based geothermometers were applied to data from Puna exploration wells, the equation performed erratically (See Appendix I Geothermometer Calculation for Selected Areas). The challenges with these geothermometers have been attributed to the impact of CO_2 and acidity on the solubility of calcium. The following reactions show the interaction of CO_2 and acidity,

$$CO_2 + H_2 = CO_3^{2-} + H^+,$$

$$CaCO_3 = Ca^{+2} + CO_3^{2-},$$

which sum to

$$CO_2 + H_2 + CaCO_3 = 2\ CO_3^{2-} + 2\ H^+ + Ca^{2+}.$$

Because the presence of CO_2 and acidity were not known, the Ca geothermometers were not used in this study.

Nonetheless, the concentration of calcium can be useful in understanding mixing that occurs in aquifers. The first step in this process is to plot each well on a log10(Na/K) and log10(Ca/Mg) vs.log10(Cl) graph. Next, representative water types are selected as end members. In this study, end members include geothermal fluids from the PGV plant, seawater, rainwater and groundwater. These types of water are plotted on this same graph. By examining the position of each well on the graph relative to the end members, it can be determined if the well sample is similar to one water type or if it is a mixture of two or more water types. For example, if the well analysis plot between seawater and geothermal fluids, the water may geothermally heated seawater. These mixing charts will be used later in the paper to understand the impact of mixing.

An ion exchange process can influence these plots as well as the calculation of certain geothermometers such as Na-K-Ca. This ion exchange between ocean water and fresh water results in the depletion of sodium and potassium and increasing level of calcium and magnesium in the aquifer water (Visher and Mink, 1964). A sample calculation showing the impact of the ion exchange on a calcium-based geothermometer is provided in Appendix I.

4. Methodology and Results

Applying geothermal indicators and geothermometers to an updated, expanded data set provides an opportunity to produce a more complete picture of the potential locations of geothermal heat sources in Hawaii. The workflow for this project has the following four steps: research the foundational work on geological setting and solute chemistry; compile the water well chemistry data into a database; characterize the observations from the Puna area as a training set, and identify anomalies around the state. Section 2 and 3 contain results of the first task, and the methodology and results for second, third and fourth tasks are found in this section of the report.

4.1 Database Development

A database of some 800 wells was assembled using information from United States Geological Service (USGS), local water utilities, Hawai'i Department of Land and Natural Resources, Hawai'i Department of Health, and reports from Hawai'i Institute of Geophysics and Planetology. The database includes analyses for cations (sodium, potassium, calcium and magnesium), anions (chloride, sulfate and carbonate), silicates and other chemical characteristics (total dissolved solid and pH). The charge balance was computed for each analysis, where a full complement of cations and anions was available in the database. A master data table is in Appendix IV.

4.2 Puna Test Area

The presence of steam vents and hot springs, decades of geological study and the active production of geothermal energy makes the Puna district a potential test area from which the distinctive characteristics, or signature, of the geothermal resources can be defined. The Geothermal Collection[5] included extensive chemical and temperature data from the geothermal exploration wells. The Hawai'i State Department of Health provided the underground injection wells associated with the Puna Geothermal Venture geothermal plant. The purpose of examining the Puna test area is to establish the key geothermal indicators that will be applied to the other data from elsewhere in the state of Hawaii.

A group of 10 wells group located in the production area and adjacent to the production area (Figure 4.1) were used to analyzed geothermal indicators. These wells had downhole temperature measurements from drilling records that allowed for a comparison of temperature and chemistry. Four key geothermal

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[5] This website can be accessed at (http://scholarspace.manoa.Hawai'i.edu/handle/10125/21320)

indicators (silica composition, Cl/Mg ratio, Na/K geothermometers, and SO4/CL ratio) were applied to the analyses (Table 4.1). The geothermometer calculations for Puna and other selected areas are provided in Appendix I, and the weighting and attributes of each geothermal indicator are summarized in Appendix III.

Table 4.1 Puna Geothermal Indicators, Well Depths and Well Temperatures

	Depth, m	**Max. Temp. °C**	**Cl/Mg Ratio**	**Silica**	**Na/K (Arnorsson,2000)**	**SO_4/CL Ratio**
Anomaly Threshold			Cl/Mg>15	Z>3	Geotherm. >200	Z>3 or Z<3
HGP-A	1956	360	1150	9	303	
Lanipuna 6	1500	168	1040	4	134	-4
KS-1 A	1970	354	10500		324	
KS-2	2425	354	80	12	305	
KS-3	2244	351	822		301	
KS-8	1056	332	n.a.		338	
Geo. Test 3	160	92	38		238	
Malama-Ki	96	52	18		155	
Kapoho Crater	10	22	5		213	
Kapoho Airstrip	113	36	13		211	

Source of well depth, temperature and well analysis: GeothermEx, 1994 and GeothermEx, 1992.

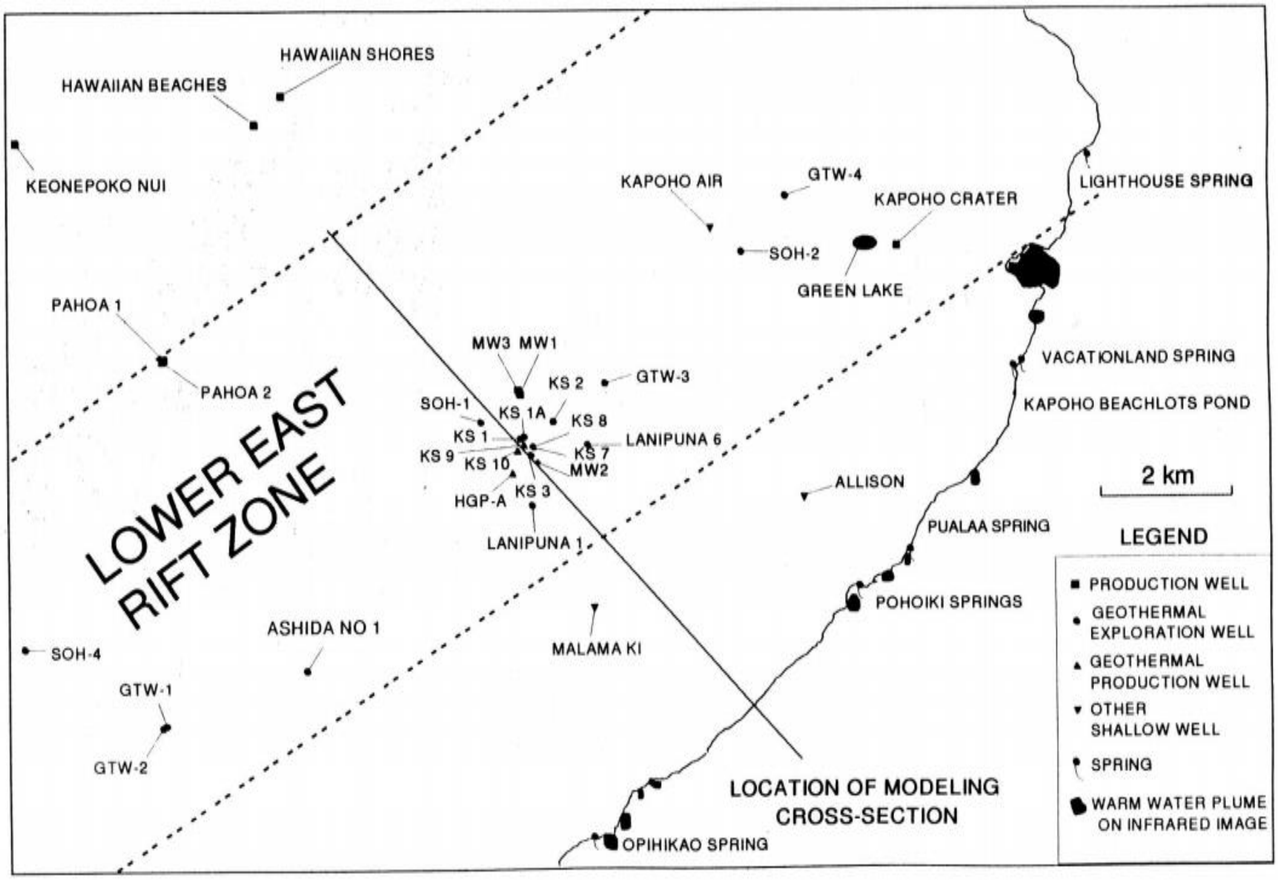


Figure 4.1 Wells in the Puna Area (reproduced from Gingrich, 1985)

One method of interpreting the data are to plot them in the Giggenbach chart shown (Figure 4.2). This chart relates water composition to various aspects, the first of which is the maturity of the water. If the water has been exposed to geothermal heat and has reached the equilibrium temperature, it is considered mature water. The immature zone of the chart indicates mixing with meteoric water, lack of exposure to heat and/or limited residence time for reactions to proceed. The partial equilibrium zone is between the immature area and full equilibrium area. A maturity index (MI) is calculated by the following equation:

$$MI = 0.315(L_{km}) - L_{kn}, \text{ where}$$

$$L_{kn} = \log 10\ (C_{k+}/C_{Na+}),$$

$$L_{km} = \log 10(C_{k+}{}^{2}/C_{Mg2+}),$$

and where C (with subscripts) denotes concentration in mg/Kg. Giggenbach concluded through judgement that an MI below 2.0 was immature, and temperature lines in the partial equilibrium sector of the graph should not be applied to samples designed immature. The area above the upper curved line represents the full equilibrium (Giggenbach, 1988).

To estimate temperature lines across the partial equilibrium part of the graph in Figure 4.2 represent geothermometer developed by Giggenbach. In Figure 4.2, a K/Na geothermometer (T_{kn}) is used. For lower temperatures, K/Mg geothermometer (T_{km}) is used [6](Giggenbach, undated).

When the data from these wells are graphed on a Giggenbach ternary diagram (Giggenbach, 2010), they fall into three groups (Figure 4.2). The first group (Kapoho State 1(KS 1), Kapoho State 2(KS 2), Kapoho State 3 (KS 3) and Hawaii Geothermal Project Well A (HGP-A) consists of high-temperature wells with

[6] $T_{kn} = 1390/(1.75 - L_{kn}) - 273$ and $T_{km} = 4410/(14.0 - L_{km}) - 273$

relatively high Na-K geothermometer and high Cl/Mg ratio. The second group Lanipuna 6, Geothermal Test Well 3(GT3) and Malama Ki are medium-temperature wells. The remaining wells are in the immature area and have lower actual temperatures, but calculated geothermometer temperatures were relatively high.

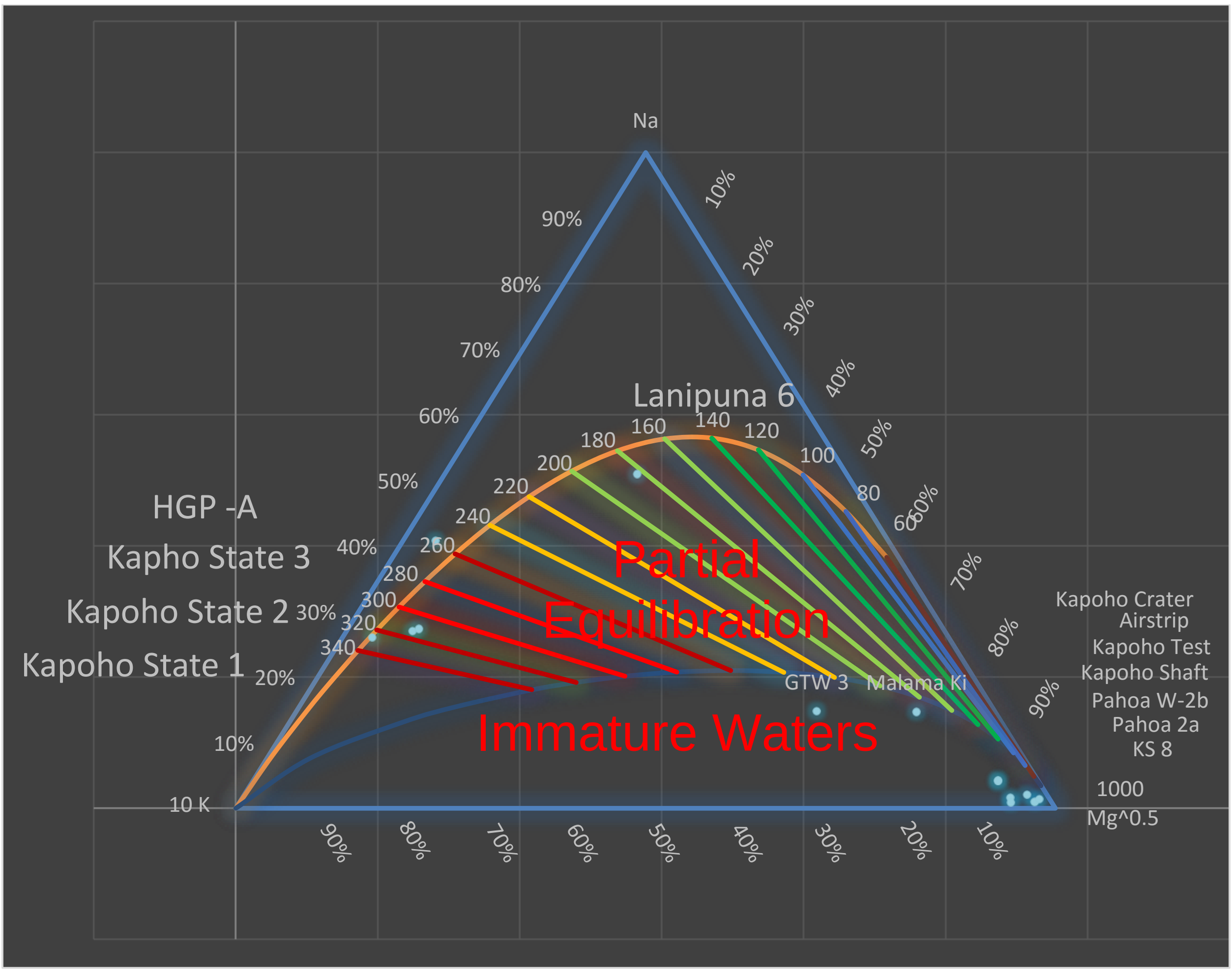


Figure 4.2 Ternary Diagram for Puna Area Wells with Mg, K, and Na apexes. Blue circles indicate wells. Area of immature water and partial equilibrium are shown. Temperatures lines are located in the partial equilibrium area (Powell and Cumming, 2010)

Figure 4.3 provides a ternary diagram of actual temperature, and temperature contours are extrapolated and interpolated. The apexes are Mg, Na, and K which are the same as for Figure 4.2. The temperature contours are generally consistent with the temperatures predicted in the partial equilibrium zone of Figure 4.2. The temperatures contours and actual temperatures increase as Mg content descreases over a range that is broadly consistent with the measured temperatures. Consistent with the Na/K geothermometer predictions in Table 4.1, the wells close to the Mg apex (e.g. Kapoho Crater, Kapoho Airstrip) have lower measured temperatures. The wells that plot away from the Mg apex (Malama Ki and GT3) have higher measured temperatures (52°C and 92°C respective) and predicted temperatures. HGP-A, Kapoho State 1, Kapoho State 2 and Kapoho State 3 plot near the line joining the Na-K apexes and are among the highest measured and predicted temperatures of the wells in the Puna test area. These results confirm that Na, K, and Mg ternary diagrams are useful in understanding the relationship of cation composition and temperature.

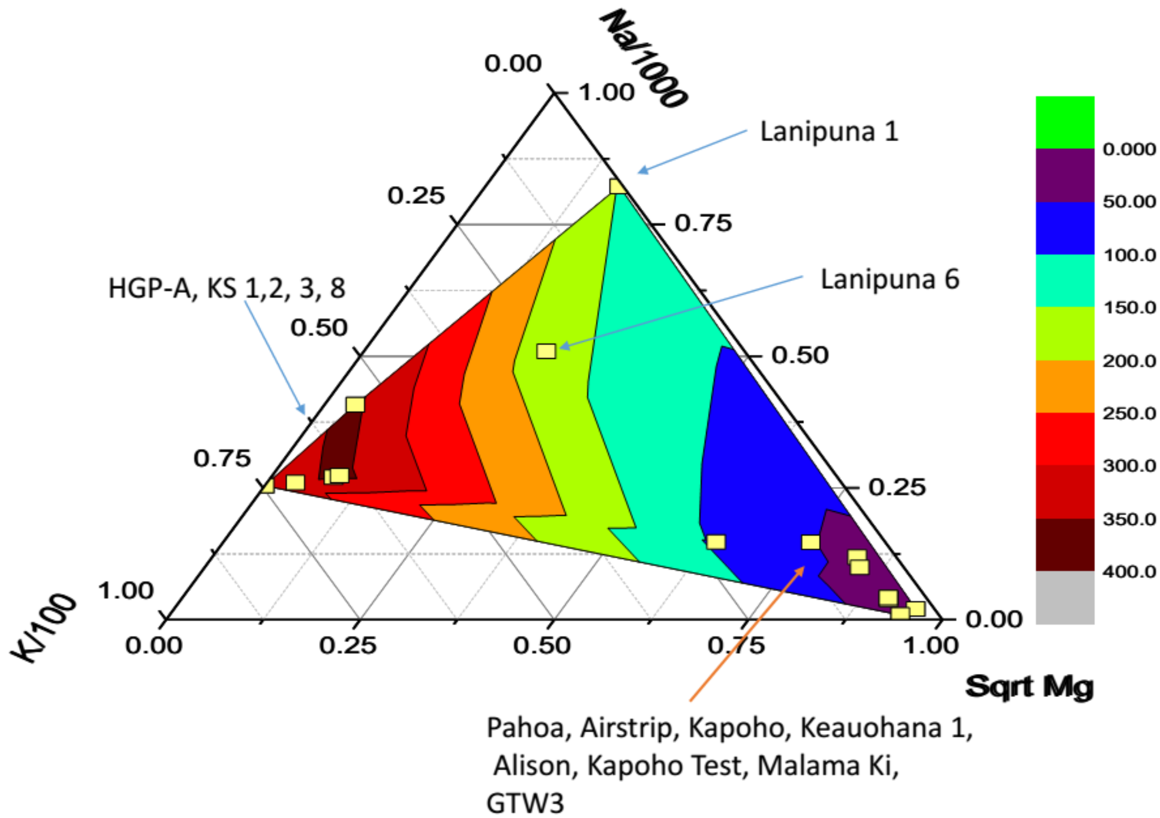


Figure 4.3. Compositions of 15 wells from the Puna area are shown in this Mg, Na, K Ternary Plot. Colors show interpolated and extrapolate temperatures contours(°C), measured for each well (see Table 4.1).

The next step was to examine evidence in the Puna well data for the mixing (Figure 4.4). Four types of waters were designated as end members. The first end member is geothermally altered fluids. For this end member, the injection well data from the Puna Geothermal Plant was used(Puna Geothermal Venture,2014). The second end member is groundwater from the

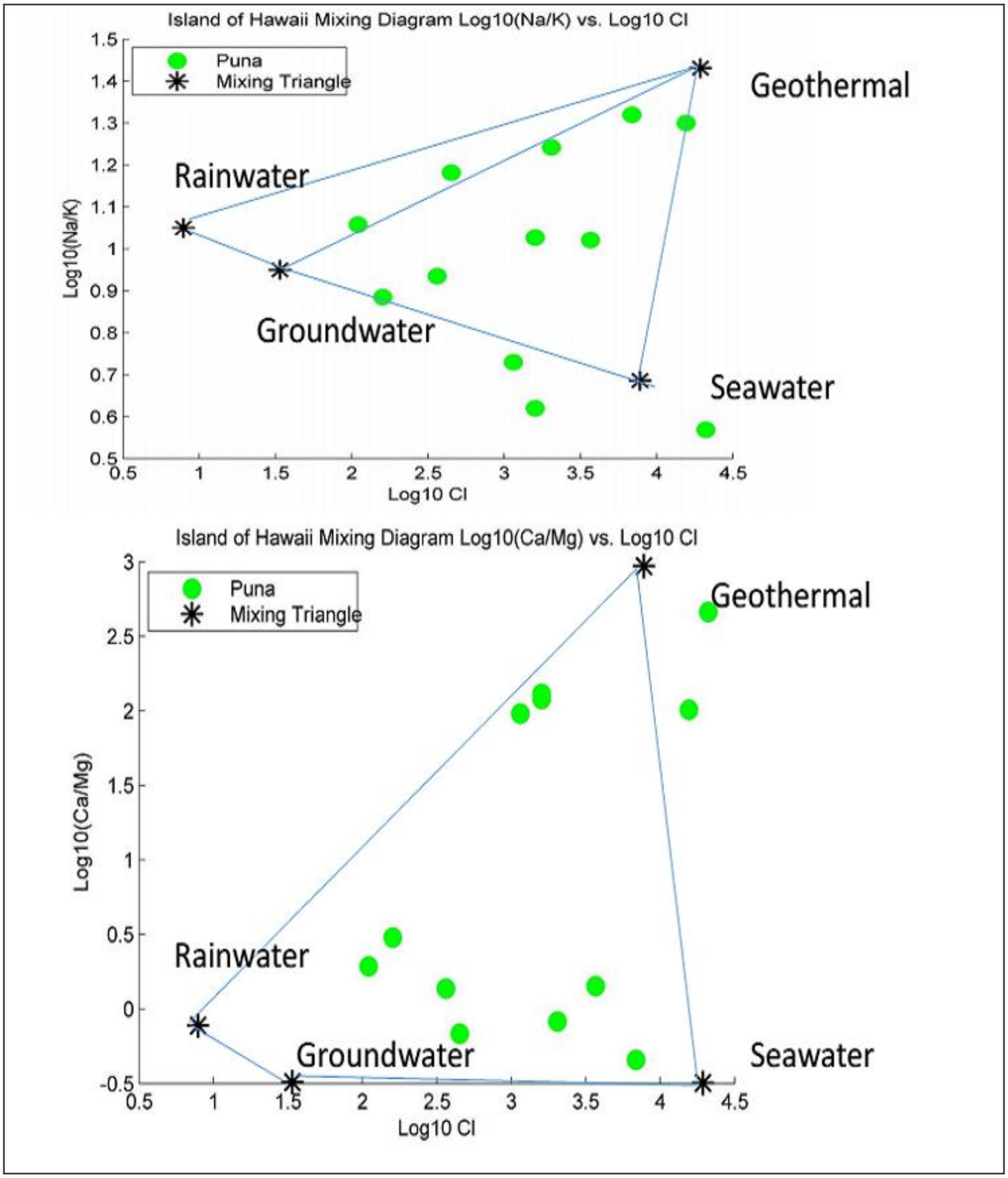


Figure 4.4 Puna Mixing Chart. Green circles show data from the Puna District. Asterisks show end-member compositions of the four-labeled sources.

Hawai'i County Department of Water supply data (Appendix IV), and the third end and fourth members are typical seawater and rainwater. The $\log_{10}$(Na/K) and $\log_{10}$(Ca/Mg) are plotted verses the $\log_{10}$(Cl) ratio(Cox et al.1979). Most of the points lie within or near the envelope bounded by the four endmembers. This finding indicates that the compositions of each sample can be explained by mixing between the end-members fluids.

The findings of the analysis of Puna Data are as follows:

1. Anomalous single or multiple geothermometers and geothermal indicators were found for 8 wells in or near the production area.
2. A match between measured water temperatures and predictions of geothermometers shows that wells with high geothermal potential plot near the Na/K axis in the Na-K-MG Ternary diagram, whereas wells with lower geothermal potential plot closer to the Mg apex.
3. The Na, K, and Mg compositions can generally be explained by mixing between groundwater, rainwater, seawater, and geothermal fluids.

4.3 Indications of Geothermal Influence Across the State

Given the findings from the Puna test area and development of database of well water analyses, it is possible to identify water well locations with anomalous characteristics across the state. When these locations are mapped, some wells with anomalies were found to be in close proximity to each other. In this section of the report, details on these areas are provided. For these areas, the types of anomalies, ternary diagrams and mixing analyses are discussed. Additionally, areas with potential for geothermal resource, but lacking ground water data are identified. These results provide an insight into what is known, what is possible and what is not known. These results also provide a foundation for future work.

For silica, the threshold for anomalies were set in a two-step process. First, silica analyses were placed in aquifers using State of Hawai'i Department of Health aquifer designation. (Mink and Lau, 1987) Then, Z values were calculated for each silica analysis. The Z value is the difference between the silica analysis and median of the aquifer silica analyses divided by the standard deviation. Those analyses with Z-values greater than 3 were designated anomalous. This process for determining silica anomalies selects values that are different from the median value for that area, and this mitigates the impact of anthropogenic activities that might elevate the general level of silica analyses in the area.

A second anomaly designation is the CL/Mg ratio. As explained in Section 3.2, Mg levels are depleted by the heat-alteration processes, and since Cl is unreactive in these environments, an elevated Cl/Mg ratio results. Given that seawater has a Cl/Mg ratio of 15, well analyses that exceed 15 were considered as anomalous.

Geothermometers using the Na/K ratio provide an indication of heat alteration, and the resulting temperature is used as a threshold for anomalies. The geothermometer developed by Arnorsson was used (Table 3.2). The level of 200°C was used the threshold. This temperature was choose by examining various thresholds. A higher threshold resulted in a small number of anomalies on Maui and Kauai; lower threshold resulted in a greater number of anomalies on Hawaii and O’ahu.

The thresholds for the SO_4/Cl were established by again using a Z value. Since both high and low ratios reflect heat alteration, the thresholds for anomalies were set at Z greater 3 and Z less than 3.

4.3.1 Island of Hawai'i

Puna test area as previously discussed has many geochemical anomalies; however, other areas of the Island of Hawai'i have anomalies of interest (Figure 4.5). In Hawai'i Volcanoes National Park, two anomalous wells were identified, and a group of wells is found in Kau District, where the Kīlauea Southwest rift zone is location. Based on other studies, geothermal potential is expected in the Mauna Loa's Southwest Rift Zone (Lautze et al. 2015), but only two wells, both having anomalies, are located near this rift zone.

In the Kona area of the Island of Hawai'i, groups of anomalies are located near Hualālai Volcano and in the Kawaihae-Hawi area. Down slope of Hualālai Volcano, 29 wells have two anomalies. In the Kawaihae and Hawi area, eleven wells

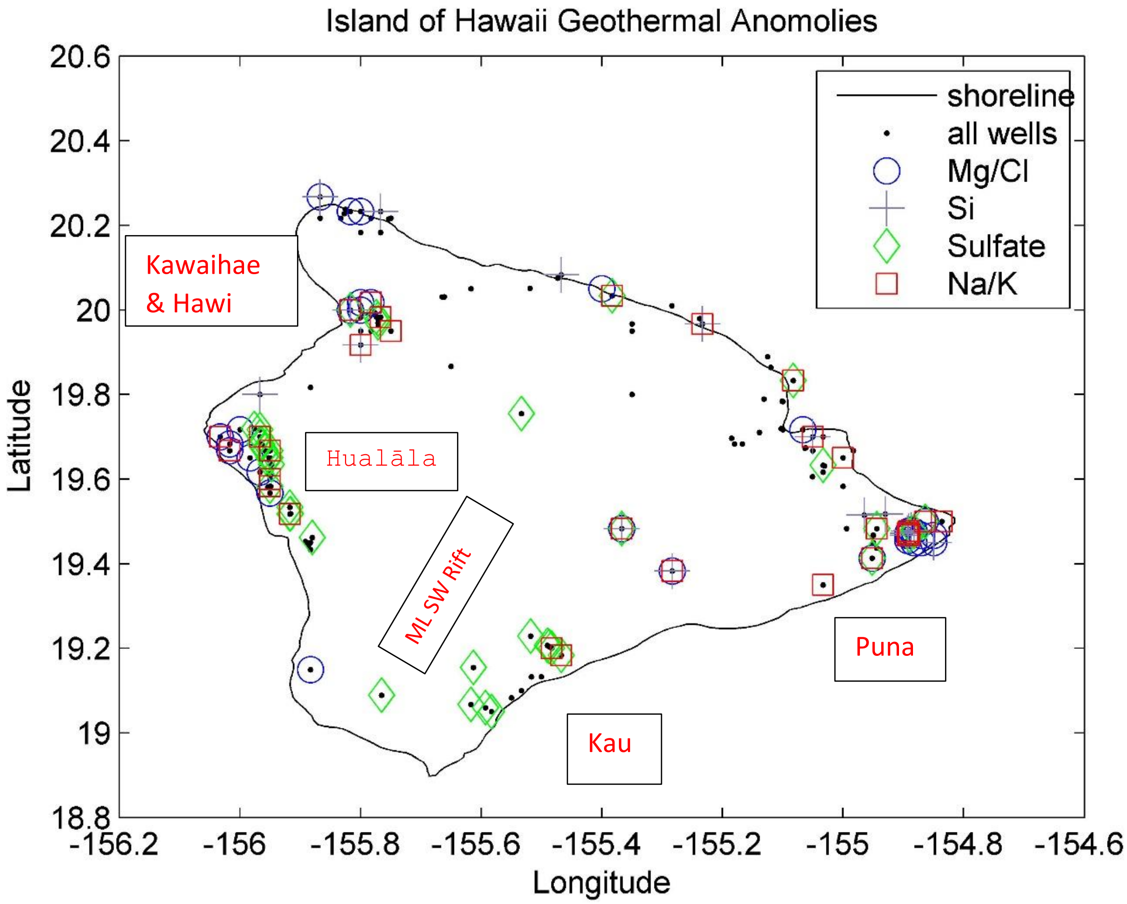


Figure 4.5 Anomalies in geothermal indicators for the Island of Hawai'i. Dots show locations of all of the wells. Different symbols indicate which indicator is anomalous.

have anomalies. The Kawaihae 3 (well no. 8-6147-001) had one of the highest well temperatures in the state outside the Puna district (Epp and Halunen, 1979).

The area north of Mauna Kea has been identified as having geothermal potential (Lautze et al., 2015). Six wells with anomalies were identified in this area (Table 4.2).

Table 4.2 Anomalies North of Mauna Kea

Name	CL/MG >15	Si Z>3	Na/K Geotherm.> 200	SO4/Cl ZC>3
Haina Well			209	7.9
Laupahoehoe			213	7.1
Paauilo			353	
Maaki				40.8
Puukapu Shallow Well		0.4	249	
Paauilo Shaft	22.9			

As with the Puna area, mixing diagrams and ternary diagrams were constructed for the wells in the Hualālai and the Kawaihae-Hawi areas. For these two area, most wells plotted outside of the mixing envelope of groundwater, rainwater, seawater and geothermal fluids. As explained in section 3.1, the mixing of heat-altered water with fresher water (e.g. meteoric water) during the ascent of the heat-altered water can impact the effectiveness of the geothermometers calculation. Therefore, the use of geothermometers results require caution.

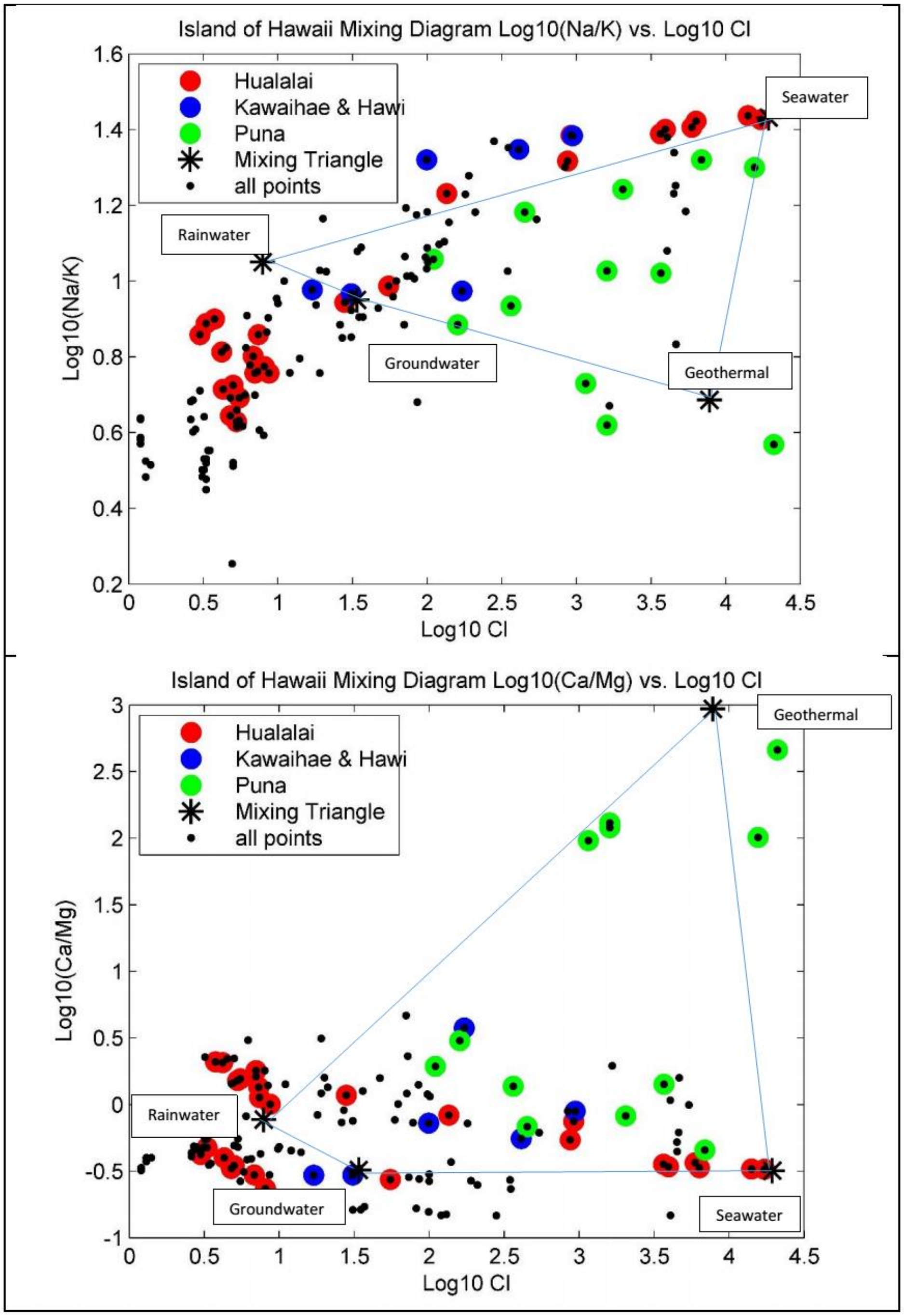


Figure 4.6 Mixing Diagram for Hualālai, Kawaihae-Hawi, and Puna Wells Demonstrating Anomalies With the Green Circles Denoting Anomalous Wells in Puna, the Red Circles Denoting Anomalous Wells in the Hualālai Area, and Blue Circles Denoting Wells in the Kawaihae-Hawi Area of the Island of Hawai'i.

Conversely, wells that plot inside the end member envelope may have exposure to geothermal resource that should be considered. Ternary plots of the analyses of these wells indicate immature water using the same format as Figure 4.2. A ternary diagram for the Pohakaloa Training Area well show water analyses in the partial equilibrium and some analyses in the immature area.

4.3.2 Results For O’ahu

The database had some O’ahu 330 wells that were analyzed for geothermal anomalies. When these wells and the associated anomalies were mapped, two areas, Waianae Volcano caldera and South-Shore near the Koolau Volcano, showed a number of anomalies in well-defined groupings. (Figure 4.7)

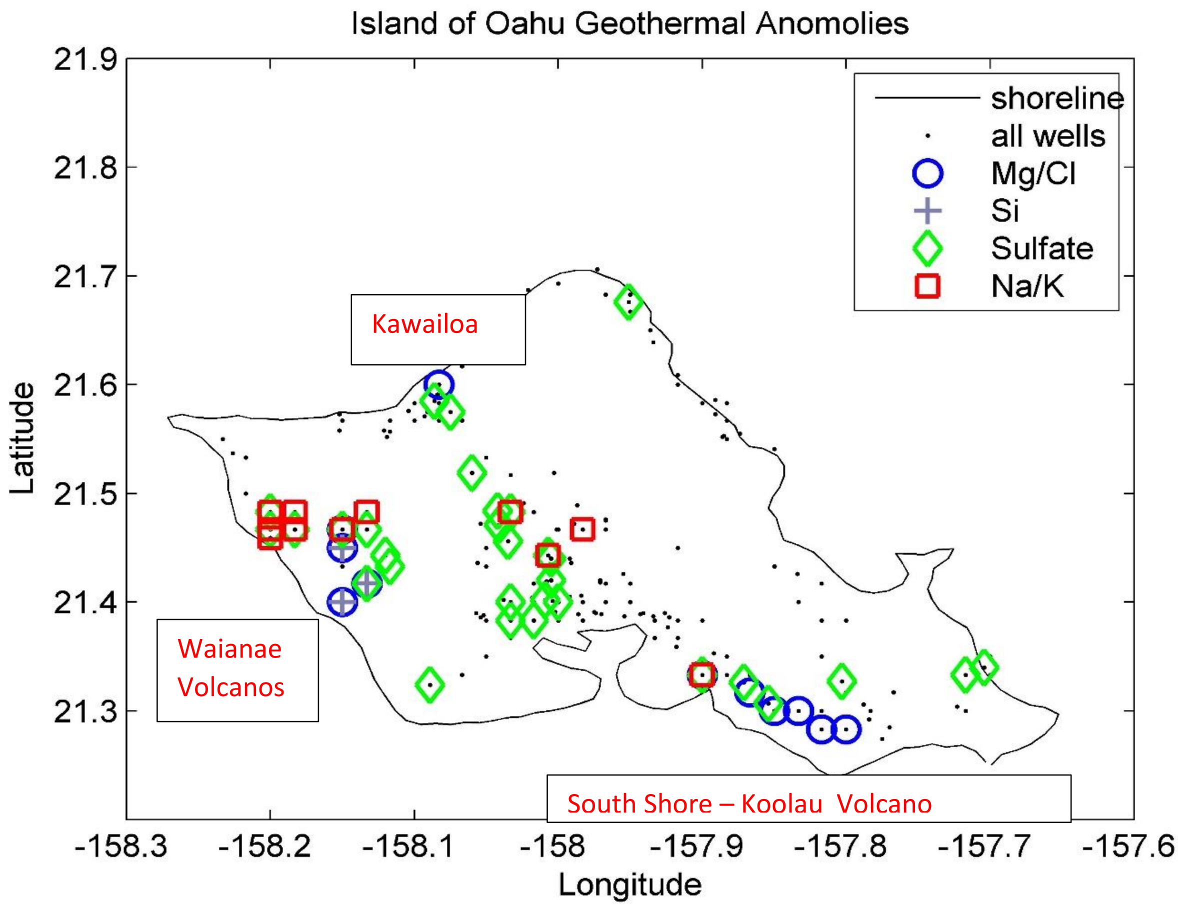


Figure 4.7 O'ahu Geothermal Anomalies. Dots show locations of all of the wells. Different symbols indicate which indicator is anomalous.

Between the two areas, thirty-four wells were found to be anomalous (Table 4.3).

Table 4.3 O'ahu Anomalies

Location	Cl/Mg > 15	Silica Z>3	Na/K Geothemometer	SO_4/CL Z>3	No. of Anomalous Wells
Koolau Volcano South-shore	9	-	6	1	15
Waianae Volcano	5	4	11	11	19
Kawailoa	4			2	6

The South-Shore of O'ahu anomalies are located in or near caprock areas on the south-shore of O'ahu. Despite having a number of anomalies, these South-Shore locations exhibit immature waters characteristics (Figure 4.8). Since this area only exhibit part of the characteristics (meets the thresholds for anomalies) of the Puna test area, the confidence in the geothermal potential of the South-Shore is not as high as Puna. However, the presents of potential mixing may mask geothermal resources that are located at greater depths than the wells.

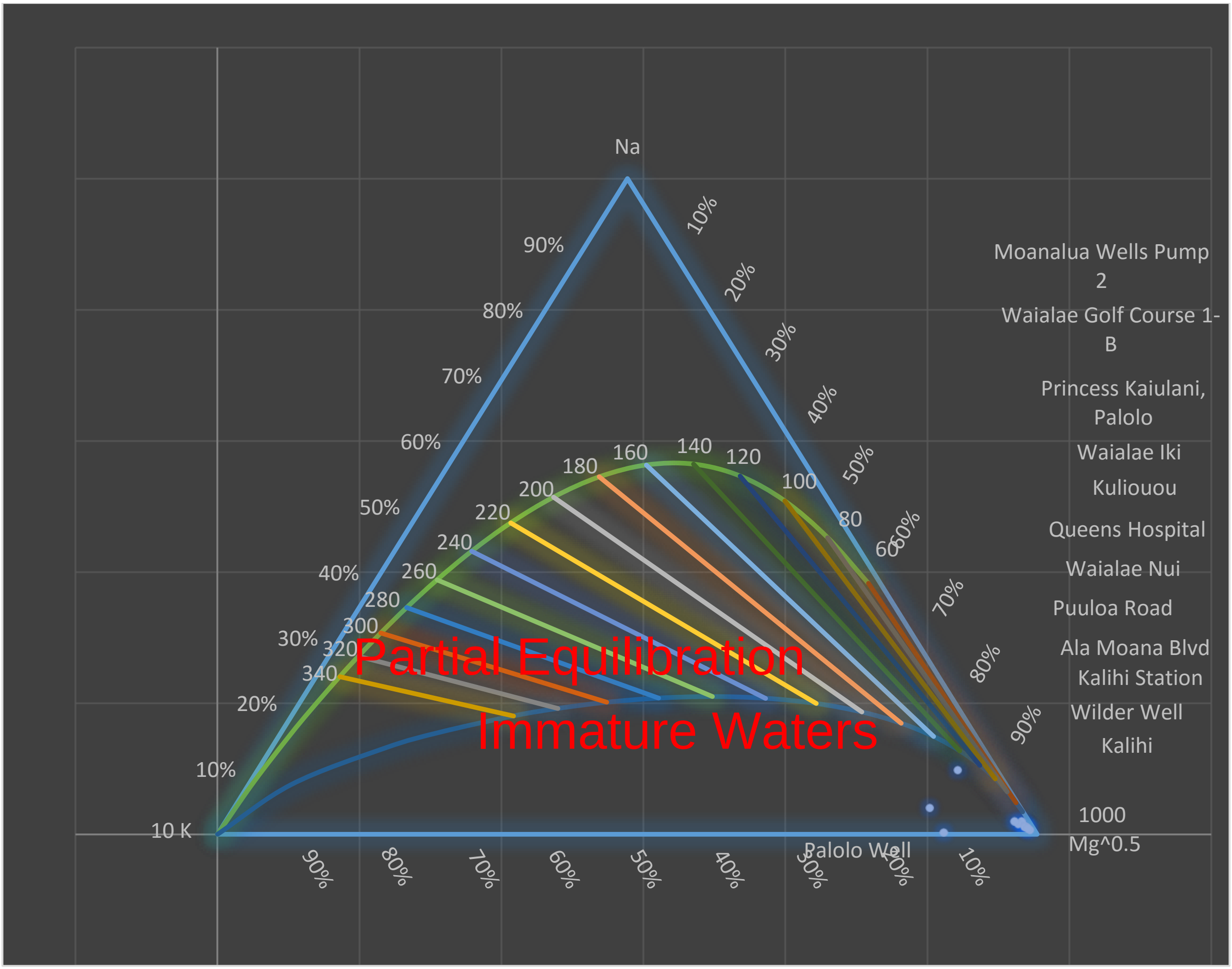


Figure 4.8 Ternary Diagram for anomalous South-Shore area wells with Mg, K, and Na apexes. Blue circles indicate wells. Area of immature water and partial equilibrium water are shown. Temperature lines are located in the partial equilibrium area. (Powell and Cumming, 2010)

The caldera area of the Waianae Volcano is a second area of interest. Thirty-one anomalies were identified in a group of 19 Waianae Volcano wells. As with the South-shore, the analyses for the Waianae Volcano area were in the immature waters area of the Giggenbach plots (Appendix II). Waianae wells do not have the same exposure to heat-alteration as the Puna test area and may have been exposed to mixing with meteoric (or other similar) water. Again, this situation would reduce the confidence in the presence of a geothermal resource, but a geothermal resource is possible at greater depths.

Anomalies are also present in other areas of O’ahu. On the north shore of O’ahu, the Kawailoa area has four wells with anomalous Cl/Mg ratios and two other wells have SO_4 /Cl anomalies. Waimanalo on the windward side of O’ahu had two wells (8-2042-13 and 8-2043-02) have SO_4/CL anomalies. A number of SO_4/Cl and Na/K geothermometer anomalies are located in central O’ahu.

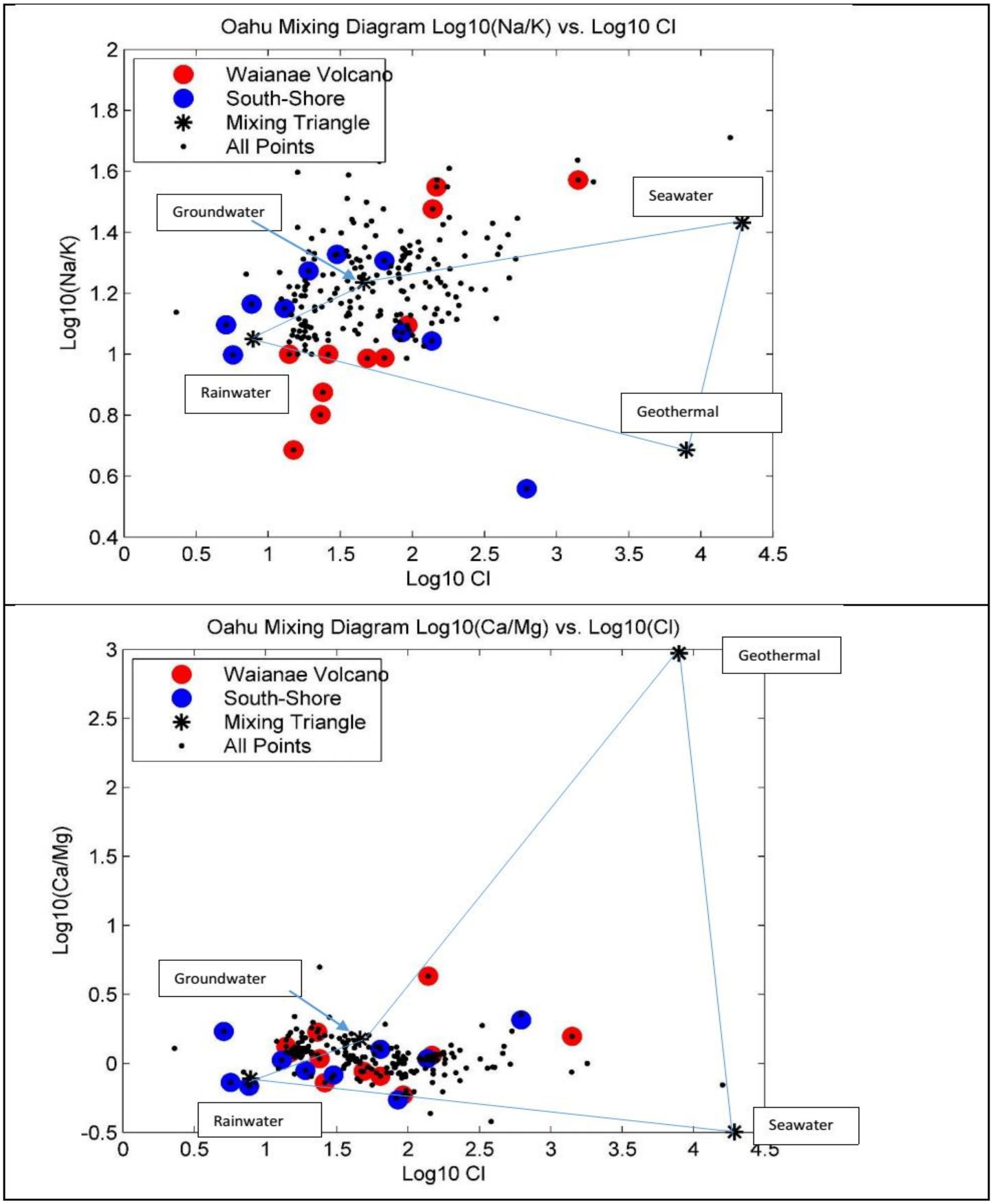


Figure 4.9 Mixing Diagram for O'ahu Demonstrating Anomalies With the Red Circles Denoting Anomalous Wells in the Waianae Volcano Area, and Blue Circles Denoting Anomalous Wells in the South-Shore of O'ahu.

As with ternary diagrams for Oahu, the mixing diagrams indicate that few points plot near the geothermal fluid end member, and the opportunity for heat-alteration is limited. The South-Shore wells plot away from the seawater end member. The most likely explanation for the lack of seawater influence is the reduce permeability the cap rock on the South-Shore. Given the results of the mixing plots for O’ahu, it is unlikely that the water from these wells experienced substantial contact with geothermal fluids and seawater. Several Waianae points have elevated log10(Ca/Mg) levels along with higher log10(Cl) concentration. These points may demonstrate the ion exchange between Ca-Mg and Na-K in which Ca-Mg displace Na-K in the aqueous phase in areas where seawater extends beyond the shoreline.

4.3.3 Results for Maui

The analysis of geochemical traits on Maui produced a number of anomalies. The database contained 132 wells, and 49 anomalies are present (Figure 4.10). The two key geological features on Maui are East Maui and West Maui Volcanoes. Unlike O’ahu and the Island of Hawai’i, Maui anomalies were more geographically disperse.

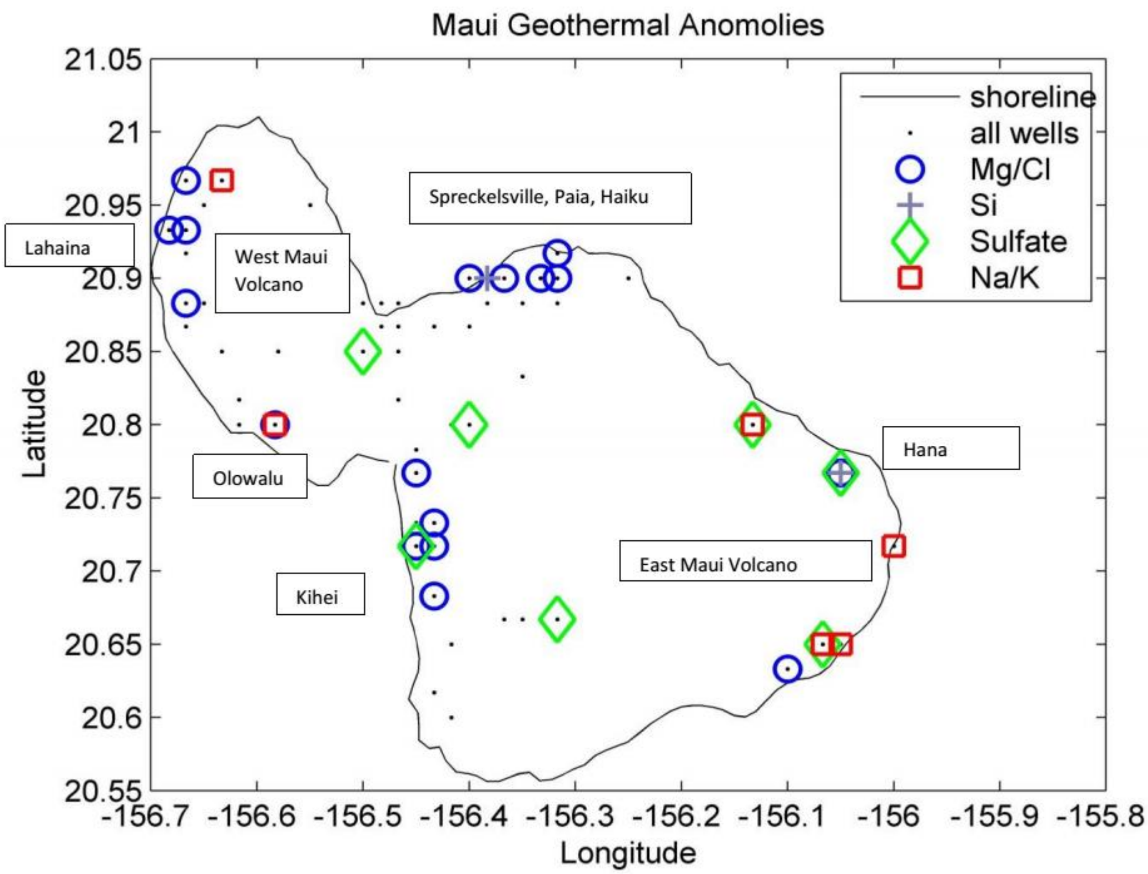


Figure 4.10 Maui Geothermal Anomalies with Dots show locations of all of the wells. Different symbols indicate which indicator is anomalous.

Interest in the geothermal potential of East Maui Volcano has focused on the three rift zone. Two of these rift zones, the East Rift Zone and Southwest Rift Zone lacked an adequate number of groundwater analyses, and areas of concentrated anomalies were not found. A number of anomalies in the North Rift Zone in the areas near Spreckelsville, Paia, and Haiku. (Table 4.6) In the general area of the East Rift of East Maui Volcano, each well in the database demonstrated anomalies.

Table 4.4 Anomalies in Northwest Rift of the East Maui Volcano

	CL/MG >15	Si Z>3
Kailua Gulch Country Club		3.0
Low Paia 16D		3.2
Spreckelsville	17.3	
Kuau Pump 12	17.7	
Kuau Pump 12	16.4	
Maui High	21.3	
Haiku (Behnke)	21.0	
Maliko Tunnel	58.0	

Table 4.5 Anomalies in East Rift of East Maui Volcano

	CL/MG >15	Si Z>3	SO_4/Cl Z>3	Na/K Geothermometer >200°
Maui County A	29.5			
Maui County B	20.0		4.5	
Hana Ranch			174.6	
Helaulani		4.3		
Hamoa W1				303
Kipahulu			198.6	
Mahina 1			3.4	302
National Park Service				381
Punahou Springs	16.0			

The wells in the Olowalu area have elevated water temperatures, and an anomaly was identified at Ukumehame (GeothermEx, 2000). Several anomalies were noted in the Lahaina area.

4.3.4 Results for Kauai

For Kauai, analyses for 106 wells are in the database with fourteen wells showing anomalies. The majority of the anomalies were SO_4/Cl ratio, and no well demonstrate multiple anomalies (Table 4.6). The Lihue Basin has several well with elevated temperature, but analyses were not found in the data base search (GeothermEx, 2000).

Table 4.6 Kauai Anomalies

	CL/MG >15	Si Z>3	SO_4/Cl Z>3	Na/K Geothermometer >200°
S8 Makawel			9.7	
Kalepa Ridge		3.5		
Kalaheo 24	41.8			
Hanapepe Valley W-B			6.1	
Lawai W-1			3.1	
Hanapepe Valley W-B			5.6	
Puhi W-1				233
Lihue Tunnel			5.6	
Kilohana W-A				237
Kilohana W-G			7.4	
Kalepa Ridge W-10			10.0	
W-5 Kapaa			8.5	
Kapaa Homestead W-1				236
Kapaa Homestead W-2				265
Anahola W-A			11.1	

4. Conclusions

In this study, an approach of using geothermal indicators and geothermometers was taken as part of an effort to assess the geothermal potential in the State of Hawaii. Given the lack of hot springs and fumaroles outside of the Kīlauea area, the focus was shifted to existing well water analyses. A database was populated with aqueous cation and anion data from over 800 wells, and the active geothermal production area near Puna Geothermal Venture was used as training area. Four key geothermal indicators and geothermometers, silicate content, Cl/Mg ratio, Na/K geothermometer, and the SO_4/Cl ratio were found to be relevant to the Hawai'i situation.

This process revealed anomalous compositions suggesting the presence of geothermally altered water on each of the four most populated Hawaiian Islands. On the Island of Hawai'i grouping of anomalies were noted near the Hualālai Volcano and in the Kawaihae-Hawi area. For O'ahu, anomalies were grouped on the South-Shore of O'ahu and in the former caldera area of the Waianae Volcano. Anomalies were also found in Kawailoa area on the North-Shore, Waimanalo and in central O'ahu. Maui results included anomalies in the North and East rift zones of East Maui

Volcano. Due to a very limited number of wells, anomalies were not identified in the Southwest rift zone of the East Maui Volcano. In West Maui, anomalies were found in the Olowalo area and near Lahaina.

Several limitations were encountered in the study. With exception of Puna area, mixing analyses indicate that mixing with fresh or meteoric water had occurred. Despite the mixing, anomalies were found and geothermometers indicated elevated temperatures. The process was also limited to available data, and collection of additional data in high potential areas should be considered.

In conclusion, the application of geothermal indicators and geothermometers to well water data was found to be a useful tool for the in identification of potential geothermal resources.

Appendix I

Geothermometer Calculation for Selected Areas

Geothermometers Waianae Volcano
Temperatures in degrees C

Sample Name	Amorphous Silica	Alpha Cristobalite	Beta Cristobalite	Chalcedony conductive	Quartz conductive	Quartz adiabatic	Na-K-Ca	Na-K-Ca Mg corr	Na/K Fournier 1979	Na/K Truesdell 1976	Na/K Giggenbach 1988	Na/K Tonani 1980	Na/K Nieva & Nieva	Na/K Arnorsson 1983	K/Mg Giggenbach 1986
Maili 7	47	120	70	147	170	160	127	22	125	79	145	102	114	91	61
Maili 23	41	114	64	141	164	155			130	84	150	108	119	96	63
Lualualei 2508	52	125	75	153	176	164			139	94	158	119	127	105	50
Lualualei 2607	15	84	36	108	135	131			186	150	204	181	174	159	39
Lualualei 2709	44	117	68	144	168	158	67	32	128	82	148	106	117	94	40
Lualualei 2808	7	75	27	98	126	123	38	38	138	93	158	118	127	105	38
Lualualei Tunnel	-8	58	11	79	109	109	56	51	260	243	272	285	245	247	46
Waianae Valley	-5	62	14	83	112	111			33	-18	54	-4	24	-6	4
Waianae Tunnel (Ent .)	2	70	22	92	121	118	44	29	217	188	232	223	204	195	30
Waianae Tunnel(Ov.fl.)	-13	52	6	73	103	103	55	39	288	281	298	329	273	283	44
Makaha	7	75	27	98	126	123	53	30	219	191	235	226	206	198	36
Makaha Shaft	10	78	30	101	129	126	59	21	199	165	216	198	186	174	34
Waianae Tunnel	-32	31	-14	49	81	84	35	35	217	188	232	223	204	195	30
Makaha Tunnel	2	70	22	92	121	118	52	37	243	221	256	260	229	226	39
Makaha									211	180	227	215	198	188	38
Makaha Well	-9	57	10	78	108	107	47	36	219	191	235	226	206	198	34
Makaha Well	-9	57	10	78	108	107	47	36	219	191	235	226	206	198	34
Makaha VI	-23	42	-5	61	92	94	61	26	219	190	234	226	206	198	39

Geothermometers Hualalai
Temperatures in degrees C

Sample Name	Amorphous Silica	Alpha Cristobalite	Beta Cristobalite	Chalcedony conductive	Quartz conductive	Quartz adiabatic	Na-K-Ca	Na-K-Ca Mg corr	Na/K Fournier 1979	Na/K Truesdell 1976	Na/K Giggenbach 1988	Na/K Tonani 1980	Na/K Nieva & Nieva 1987	Na/K Arnorsson 1983	K/Mg Giggenbach 1986
KEOPU PUU HONIU	-11	55	8	76	106	106	65	15	299	297	307	347	284	297	37
WAIAHA	-11	55	8	76	106	106	59	18	281	271	291	318	266	273	35
KEAHUOLU	-11	55	8	76	106	106	64	15	278	267	288	313	263	270	36
HONOKOHAU WELL	-7	59	12	80	110	109	73	13	259	242	271	285	245	247	37
KALAOA WELL	-6	61	13	82	112	111	80	10	266	251	277	295	251	254	39
KEEI C WELL	-9	58	10	79	108	108	66	13	219	191	235	226	206	198	32
HALEKII WELL PUMPHEAD	-11	55	8	76	106	106	58	19	240	217	254	256	226	223	34
KEEI D	-13	52	6	73	103	103	51	20	247	225	260	266	233	231	30
Okoe W-1	-26	37	-9	56	88	90	148	6	151	108	170	135	139	119	65
Keei W-C	-15	50	4	71	101	102	64	36	228	202	243	239	215	208	45
Keei W-B	-14	51	5	72	102	103	87	20	175	137	193	166	163	146	49
Halekii	-19	46	-1	65	96	97	54	54	238	214	251	253	224	220	46
Kainaliu Test Well	-16	50	3	70	100	101	53	53	257	239	269	281	243	243	47
Kahaluu W-A	-15	50	4	71	101	102	49	49	270	257	281	301	256	260	44
Keahuola QLT 1, HI	-18	46	0	66	97	98	62	47	286	279	296	327	272	281	50
Keopu Mauka, HI	-20	44	-2	64	95	96	66	45	303	302	311	354	288	302	52
Kamakana, HI	-56	2	-41	18	50	57	173	2	145	102	165	127	134	113	96
KAHO Well 1,	-35	27	-18	46	78	81	165	2	146	102	165	128	134	113	83
Honokohau Well	-16	49	2	69	99	100	72	38	269	255	280	300	255	259	53
KAHO Well 2	-28	36	-10	55	86	89	160	2	151	108	170	134	139	118	74
KAHO Well 3	-29	34	-12	52	84	87	161	2	149	106	168	132	137	117	76
Kohanaiki MW401	-51	9	-35	25	58	64	170	2	144	100	163	125	132	111	92
Kohanaiki 2	-29	35	-11	54	85	88	162	2	148	105	167	131	136	116	79
Hualalai Exp Well	-15	50	4	71	101	102	69	33	247	225	260	266	233	231	48

Appendix I

Pohakaloa Training Area

Geothermometers

Temperatures in degrees C

Sample Name	Amorphous Silica	Alpha Cristobalite	Beta Cristobalite	Chalcedony conductive	Quartz conductive	Quartz adiabatic	Na-K-Ca	Na-K-Ca Mg corr	Na/K Fournier 1979	Na/K Truesdell 1976	Na/K Giggenbach 1988	Na/K Tonani 1980	Na/K Nieva & Nieva 1987	Na/K Arnorsson 1983	K/Mg Giggenbach 1986
PTA 2/16/15	18	88	39	112	138	134	200	62	250	230	263	271	236	235	87
PTA 2/17/15	17	87	38	111	138	133	201	61	251	231	263	272	237	236	86
PTA 2/18/15	19	89	40	113	140	135	193	56	231	206	246	243	218	212	85
PTA 2/19/15	18	87	39	111	138	133	200	59	248	228	261	268	234	233	86
M-210	-67	-11	-53	4	35	45	51	51	341	358	345	418	326	353	54
T-201	-58	0	-42	16	48	56	51	51	223	195	238	231	209	202	44
PTA1/13/2015 4000	22	92	43	116	143	137	226	226	249	229	262	270	235	234	161
PTA1/13/2015 4500	61	135	85	165	186	172	159	159	166	125	184	153	154	135	116
PTA1/27/2015 2100	19	89	41	113	140	135	237	231	266	252	278	295	252	255	144
PTA1/27/2015 3500	54	127	77	155	178	166	236	229	268	254	279	298	254	257	143
PTA1/27/2015 4000	65	139	89	169	190	175	231	231	251	232	264	273	237	237	163
PTA 1/27/2015 4500'															

.

Geothermometers Kawaihae-Hawi

Temperatures in degrees C

Sample Name	Amorphous Silica	Alpha Cristobalite	Beta Cristobalite	Chalcedony conductive	Quartz conductive	Quartz adiabatic	Na-K-Ca	Na-K-Ca Mg corr	Na/K Fournier 1979	Na/K Truesdell 1976	Na/K Giggenbach 1988	Na/K Tonani 1980	Na/K Nieva & Nieva	Na/K Arnorsson 1983	K/Mg Giggenbach 1986
Kea Bch.	-13	52	6	73	103	103									
Kawaihae 3	-13	52	6	73	103	103	175	65	222	194	237	230	209	201	77
Kawaihae 4	-12	53	6	74	104	104									
Waikane Shaft	-11	55	8	76	106	106									
HAWI WELL 1	-9	57	10	78	108	107	51	17	222	193	237	230	208	201	26
HAWI WELL 2	-9	57	10	78	108	107	59	15	224	196	239	232	210	203	29
S4 KOHALA	120	199	150	236	249	220	143	8	151	109	170	135	140	119	60
Hawi W-H	-26	38	-8	57	89	91	146	9	161	120	180	147	149	130	55
S1 WAIKANE	39	111	61	137	161	153	151	4	157	115	175	142	145	125	62

Geothermometers South-shore Koolau

Temperatures in degrees C

Sample Name	Amorphous Silica	Alpha Cristobalite	Beta Cristobalite	Chalcedony conductive	Quartz conductive	Quartz adiabatic	Na-K-Ca	Na-K-Ca Mg corr	Na/K Fournier 1979	Na/K Truesdell 1976	Na/K Giggenbach 1988	Na/K Tonani 1980	Na/K Nieva & Nieva 1987	Na/K Arnorsson 1983	K/Mg Giggenbach 198
Waialae Golf Course 1-B	-23	42	-5	61	92	94	74	22	160	118	178	146	148	129	42
Princess Kaiulani, Palolo	-30	33	-12	52	84	87	69	22	186	150	204	181	174	159	40
Waialae Iki	-23	42	-5	61	92	94	71	24	168	128	187	157	156	139	42
Waialae Nui	-28	35	-10	54	86	88	90	19	217	188	233	224	204	195	52
Kuliouou	-10	56	9	77	107	106	61	32	189	153	206	184	176	162	40
Palolo Well	-23	42	-5	61	92	94	34	34	199	165	215	197	186	173	31
Queens Hospital	-23	41	-5	61	92	94	92	92	1117	3150	943	4841	1092	2146	102
Kalihi Station	-24	40	-6	60	91	93	55	31	184	147	201	177	171	156	36
Puuloa Road	-35	27	-18	45	77	81	240	116	323	331	329	386	307	328	103
Kalihi	-29	34	-12	53	85	87	64	31	208	177	224	211	195	185	43
Moanalua Wells Pump 2	-31	32	-13	51	83	85	50	40	203	170	220	204	190	179	37
Wilder Well	-29	35	-11	54	85	88	167	7	208	177	224	211	195	185	55

Appendix I

Geothermometers Waianae Volcano
Temperatures in degrees C

Sample Name	Amorphous Silica	Alpha Cristobalite	Beta Cristobalite	Chalcedony conductive	Quartz conductive	Quartz adiabatic	Na-K-Ca	Na-K-Ca Mg corr	Na/K Fournier 1979	Na/K Truesdell 1976	Na/K Giggenbach 1988	Na/K Tonani 1980	Na/K Nieva & Nieva	Na/K Arnorsson 1983	K/Mg Giggenbach 1986
Maili 7	47	120	70	147	170	160	127	22	125	79	145	102	114	91	61
Maili 23	41	114	64	141	164	155			130	84	150	108	119	96	63
Lualualei 2508	52	125	75	153	176	164			139	94	158	119	127	105	50
Lualualei 2607	15	84	36	108	135	131			186	150	204	181	174	159	39
Lualualei 2709	44	117	68	144	168	158	67	32	128	82	148	106	117	94	40
Lualualei 2808	7	75	27	98	126	123	38	38	138	93	158	118	127	105	38
Lualualei Tunnel	-8	58	11	79	109	109	56	51	260	243	272	285	245	247	46
Waianae Valley	-5	62	14	83	112	111			33	-18	54	-4	24	-6	4
Waianae Tunnel (Ent .)	2	70	22	92	121	118	44	29	217	188	232	223	204	195	30
Waianae Tunnel(Ov.fl.)	-13	52	6	73	103	103	55	39	288	281	298	329	273	283	44
Makaha	7	75	27	98	126	123	53	30	219	191	235	226	206	198	36
Makaha Shaft	10	78	30	101	129	126	59	21	199	165	216	198	186	174	34
Waianae Tunnel	-32	31	-14	49	81	84	35	35	217	188	232	223	204	195	30
Makaha Tunnel	2	70	22	92	121	118	52	37	243	221	256	260	229	226	39
Makaha									211	180	227	215	198	188	38
Makaha Well	-9	57	10	78	108	107	47	36	219	191	235	226	206	198	34
Makaha Well	-9	57	10	78	108	107	47	36	219	191	235	226	206	198	34
Makaha VI	-23	42	-5	61	92	94	61	26	219	190	234	226	206	198	39

Na-K-Ca Sensitivity Calculation

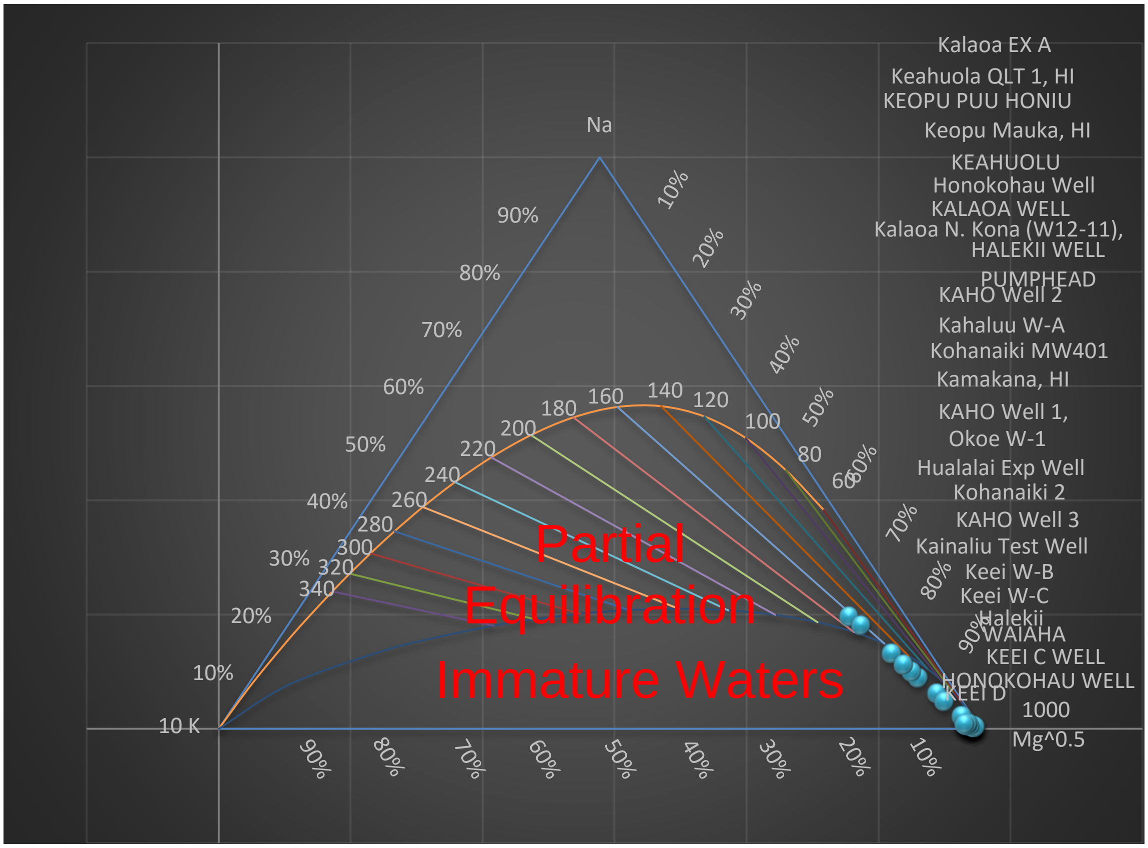
Background: In coastal environment, an ion exchange process between ocean water and fresh water has been identified. This process can increase Ca-Mg concentrations and decrease and Na-K concentrations. (Visher and Mink, 1964) Below is a sensitivity calculation using the Na-K-Ca(Fournier and Truesdell, 1973)and Na-K (Fournier, 1979) geothermometers. This calculation assumes the ion-exchange process increased Ca-Mg by 10 % (and ionic equivalent decrease of Na and K). The concentrations were based on the Pualoa(O'ahu) well analysis, which is an area where this might occur.

	Na-K Geothermometer °C	Na-K-Ca Geothermometer °C
Before Ion Exchange	323	240
After Ion Exchange	320	237

Appendix II

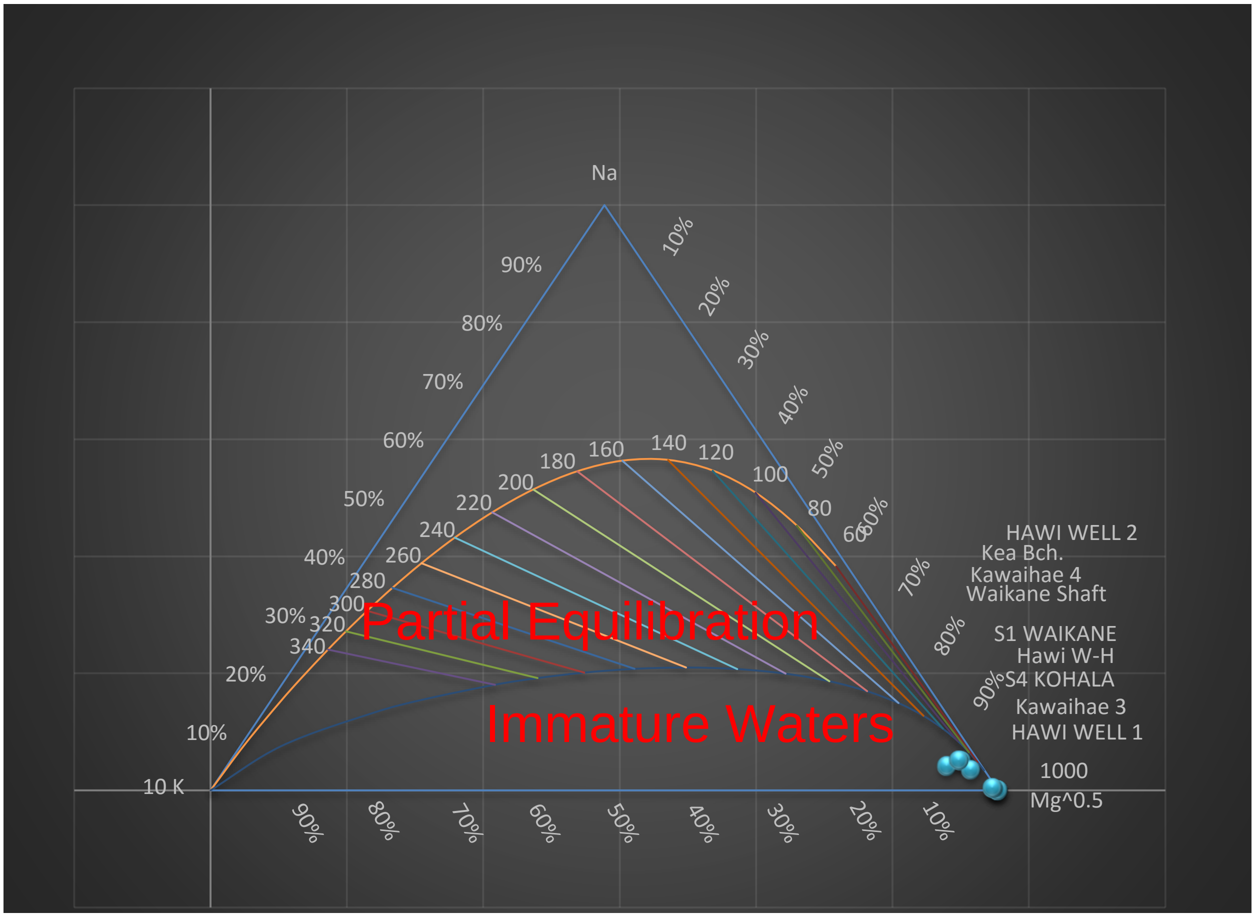
Ternary Diagrams

Hualālai Giggenbach Diagram



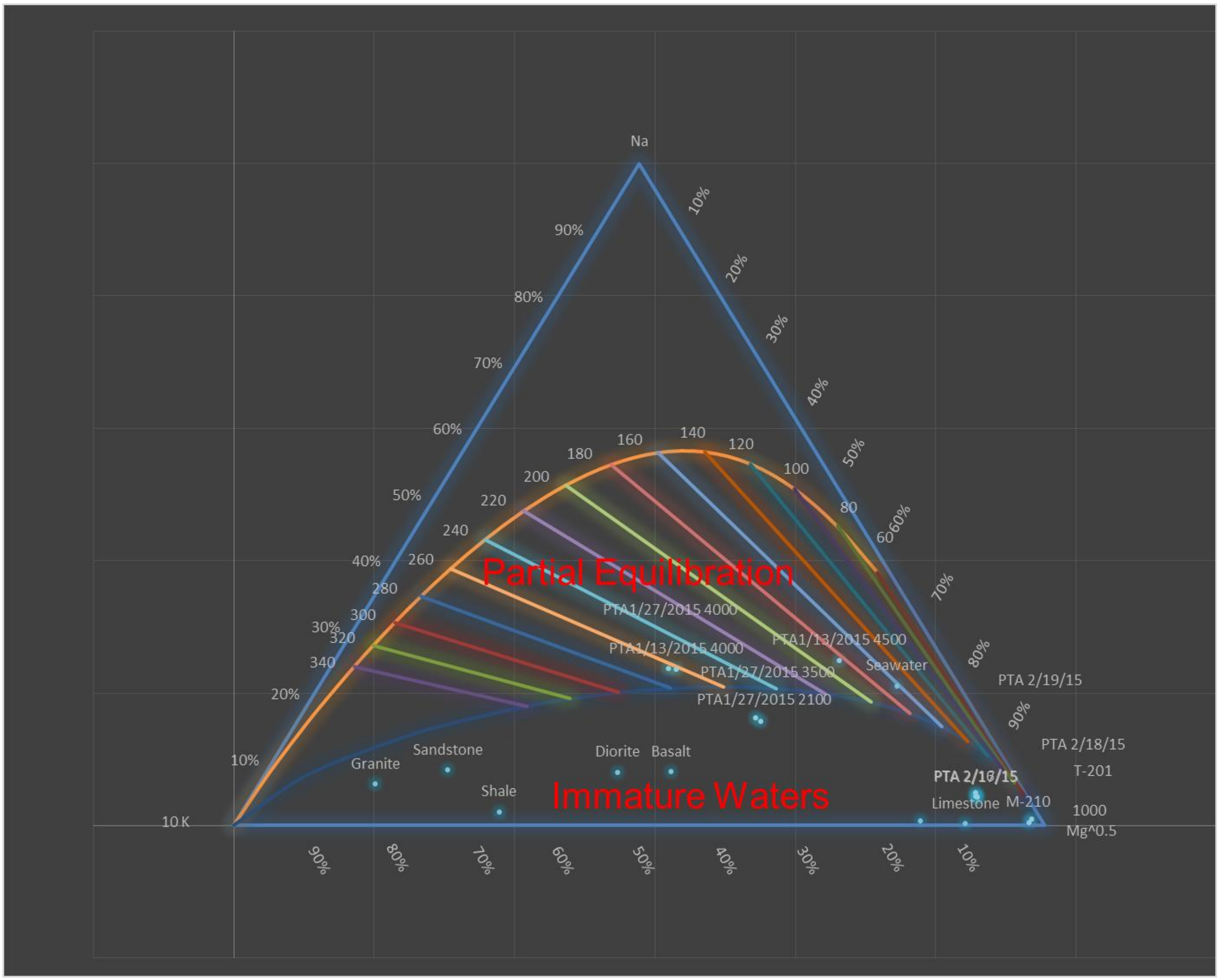
Appendix II

Kawaihae - Hawi Area Giggenbach Diagram



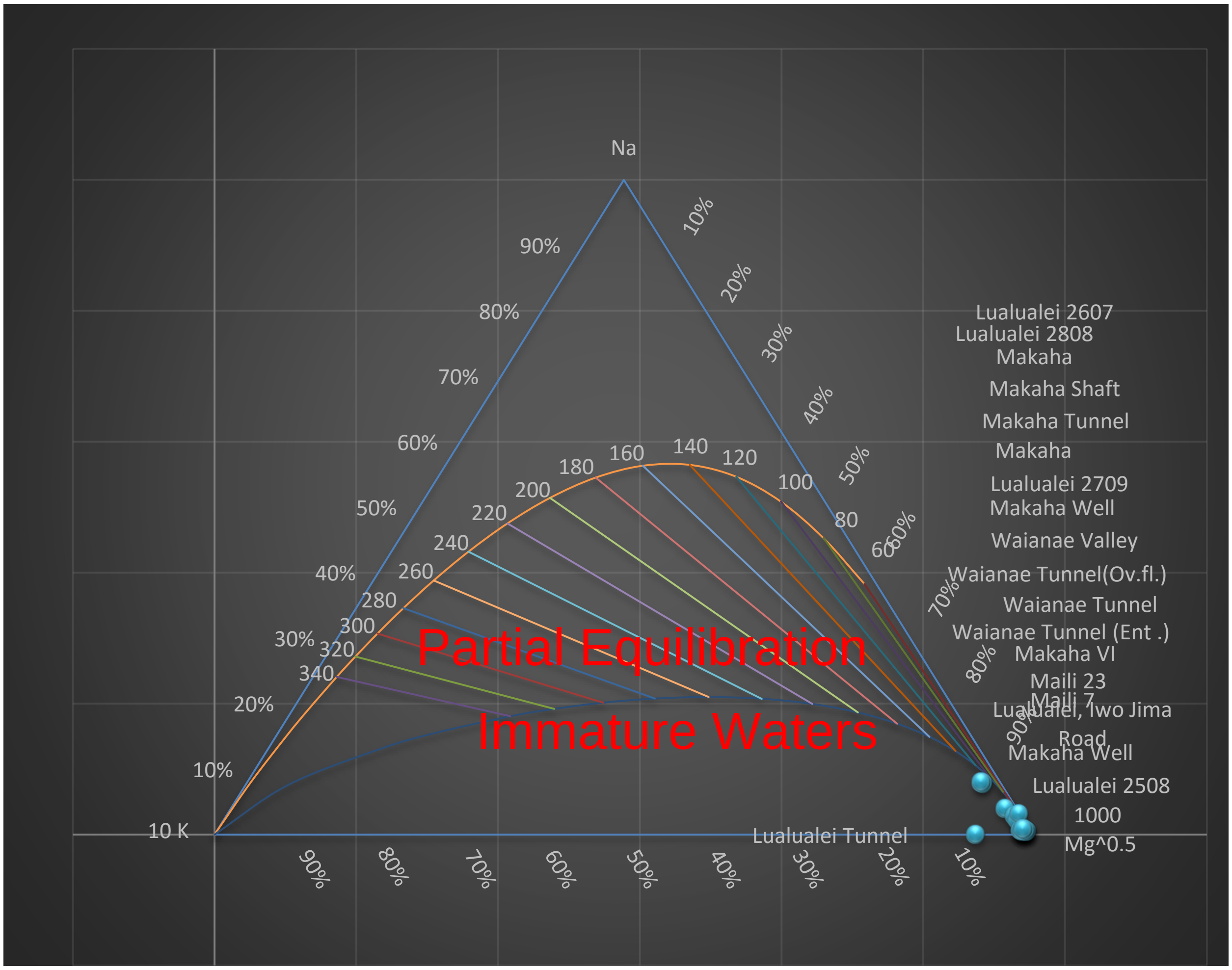
Appendix II

Pohakaloa Training Area Giggenbach plot



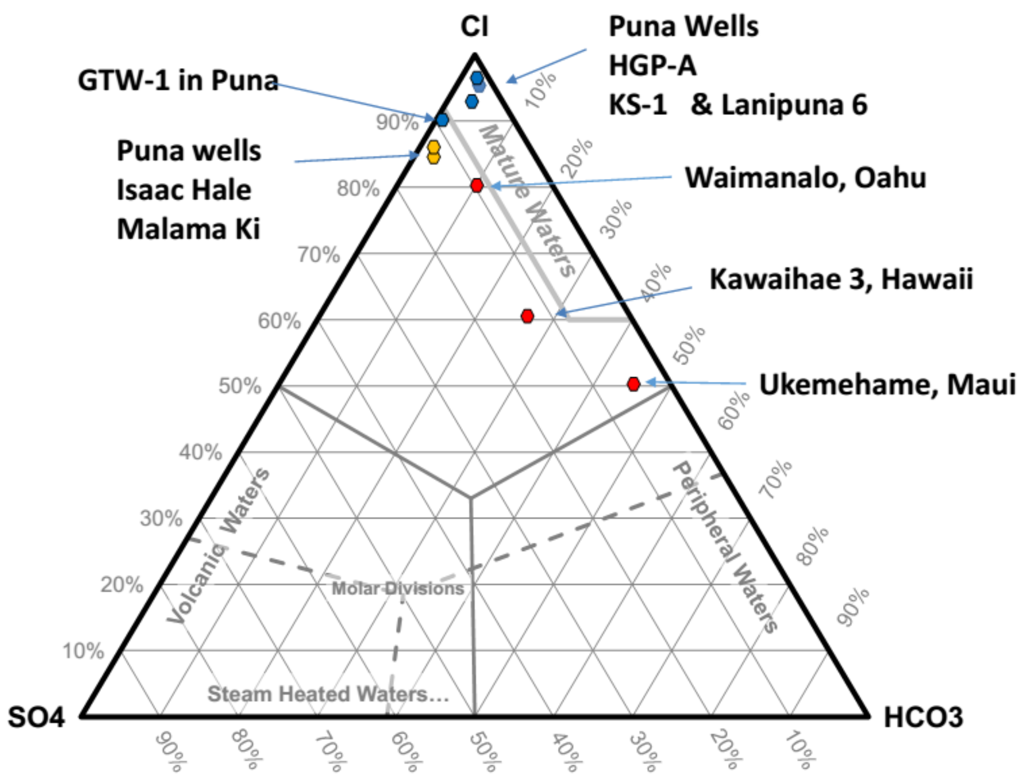
Appendix II

Waianae Volcano Giggenbach Diagram



Appendix II

$CL-SO_4 - HCO_3$ Diagram



Appendix III Weighting and Attributes

Cl/Mg Attributes and Qualitative Weighting

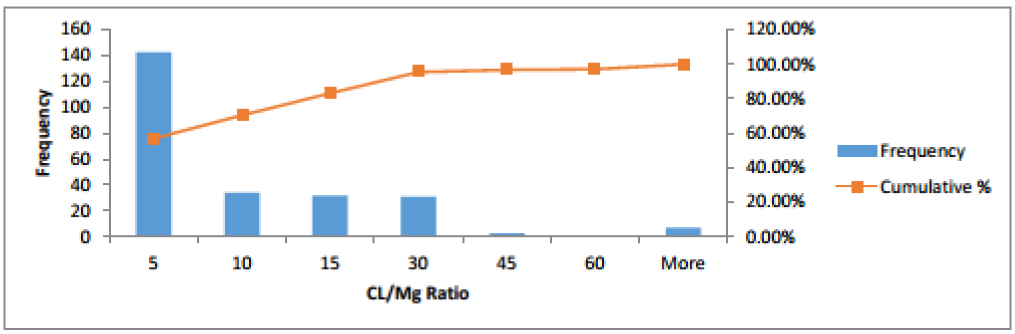
Cl/Mg Ratios in Well Data – Island of Hawaii

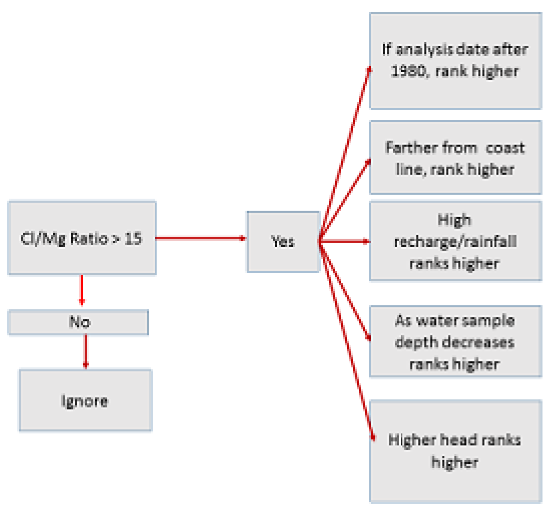
CL/Mg Ratio	*Frequency*	*Cumulative %*
0–5	143	57.0%
5–10	34	70.5%
10–15	32	83.3%
15–30	31	95.6%
30–45	3	96.8%
45–60	1	97.2%
>60	7	100.00%

Median Ratio = 2.86

Ratio Percentile

5%	0.11
10%	0.22
25%	0.97
50%	2.86
75%	11.10
90%	17.40
95%	21.21





Appendix III

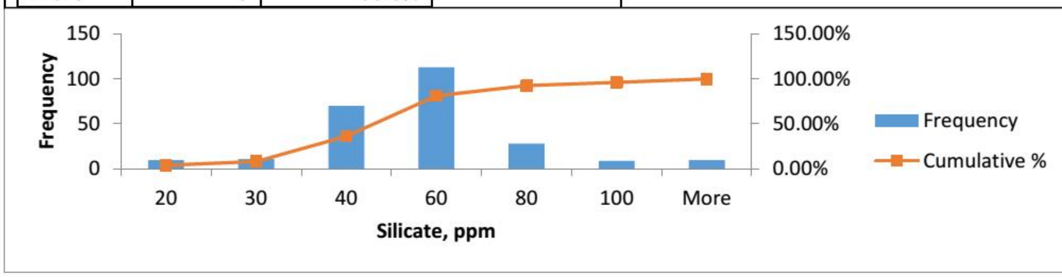
Silicate Attributes and Qualitative Weighting

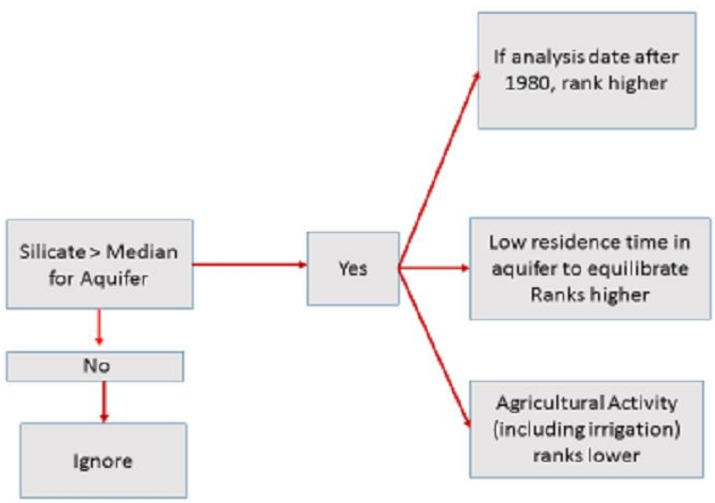
Silicate, ppm from Well Data – Island of Hawaii

SiO2, ppm	*Frequency*	Cumulative %
20	10	4.0%
30	11	8.4%
40	70	36.3%
60	113	81.3%
80	28	92.4%
100	9	96.0%
More	10	100.0%

Percentiles

5%	21.0
10%	31.2
25%	37.0
Median 50%	43.1
75%	55.0
90%	71.0
95%	93.0





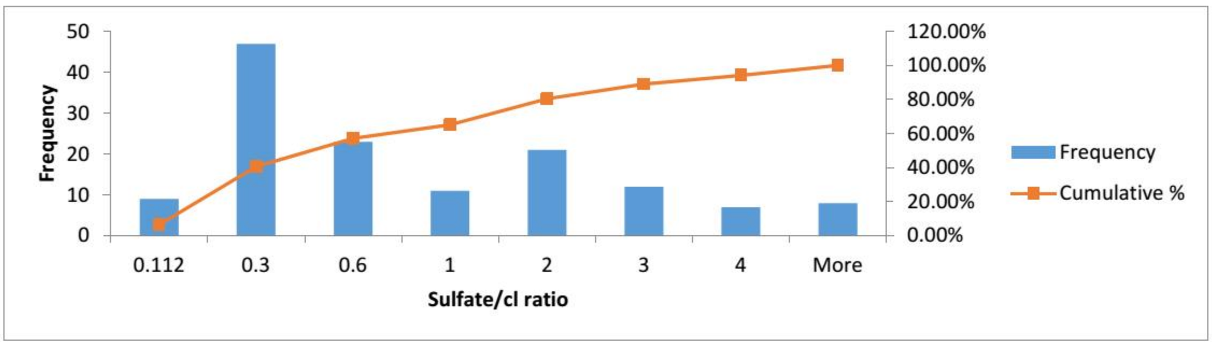
Appendix III

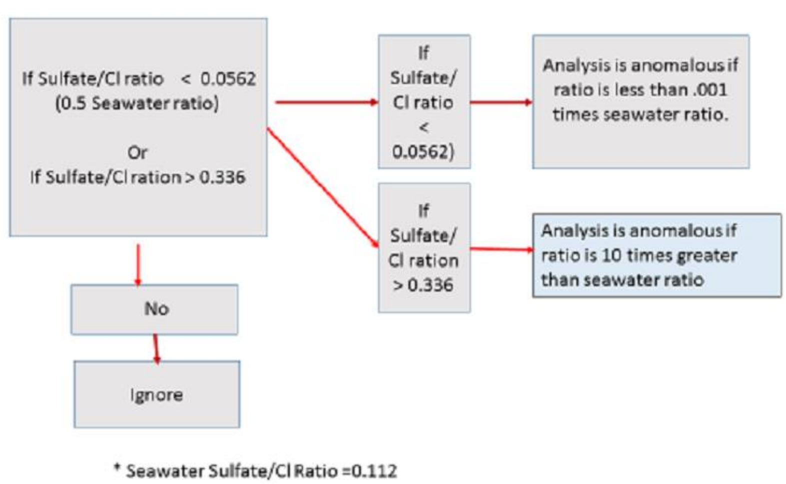
Sulfate/Chloride Ratio Attributes and Qualitative Weighting (Lower is better)

Sulfate/CL	*Frequency*	*Cumulative %*
0.112	9	6.52%
0.3	47	40.58%
0.6	23	57.25%
1	11	65.22%
2	21	80.43%
3	12	89.13%
4	7	94.20%
More	8	100.00%

Percentile
n= 138

5%	0.095
10%	0.131
25%	0.188
Median 50%	0.467
75%	0.161
90%	3.043
95%	4.240



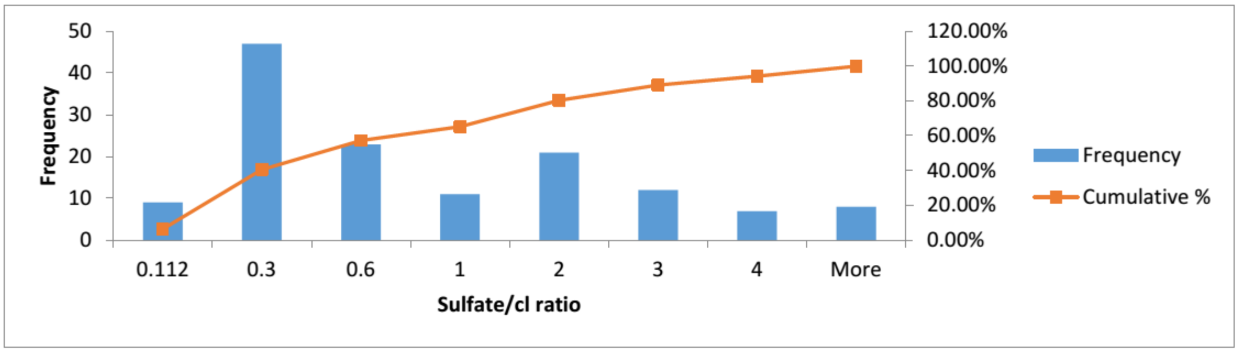


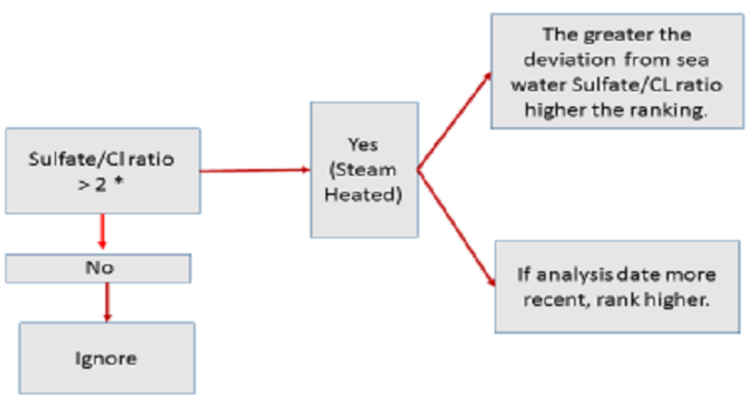
Sulfate/Chloride Ratio Attributes and Qualitative Weighting for High Sulfate levels

Sulfate/CL	*Frequency*	*Cumulative %*
0.112	9	6.52%
0.3	47	40.58%
0.6	23	57.25%
1	11	65.22%
2	21	80.43%
3	12	89.13%
4	7	94.20%
More	8	100.00%

Percentile
n= 138

5%	0.095
10%	0.131
25%	0.188
Median 50%	0.467
75%	0.161
90%	3.043
95%	4.240





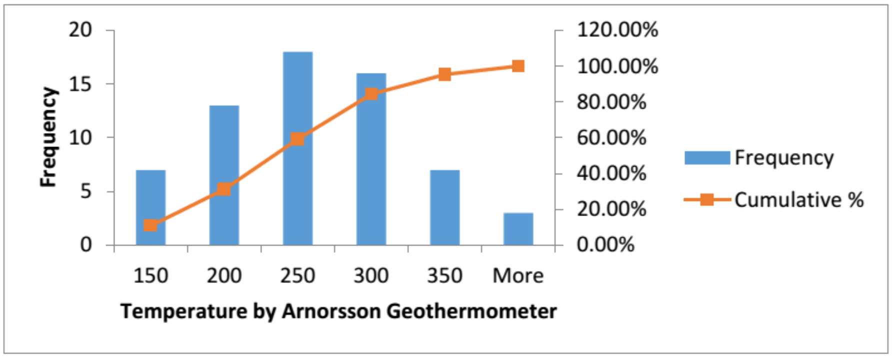
* Seawater Sulfate/Cl Ratio =0.112

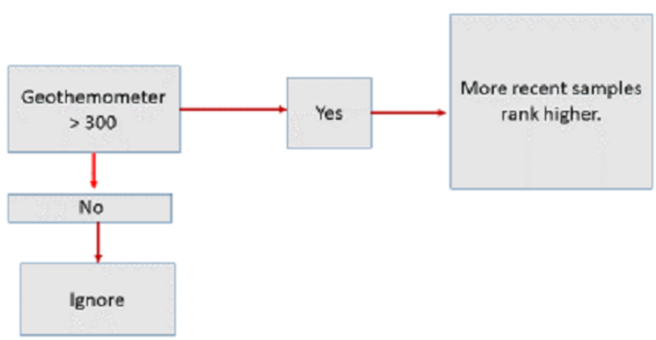
Na-K Temperature as predicted by Arnorsson Geothermometer n = 66 (Big Island only)

$$T = 993/(\log (Na/K) + 0.993) - 273.15$$

	Frequency	*Cumulative %*
150	7	10.94%
200	13	31.25%
250	18	59.38%
300	16	84.38%
350	7	95.31%
More	3	100.00%

Percentile	
5%	138
10%	144
25%	173
Median 50%	225
75%	266
90%	314
95%	339





Appendix IV – Master Database

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	SiO2	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Silica)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
2-0044-003	21	-159.733	22.000	Kaunalewa 2	23.5	65	3500	610.0								1	<1979	0.00	5.7			
2-0044-004	21	-159.733	22.000	Kaunalewa 3	28	31	350	82.0								1	<1979	-4.88	4.3			
2-0044-010	21	-159.733	22.000	Kaunalewa 12	23.5	50	1200	220.0								1	<1979	-1.73	5.5			
2-0044-012	21	-159.733	22.000	Kaunalewa 11	22.5	72	2000	360.0								1	<1979	0.67	5.6			
2-0044-013	21	-159.750	22.000	Kaunalewa 7	22	70	1180	228.0								1	<1979	0.49	5.2			
2-0045-001	21	-159.750	22.000	Camp 2 KS19	22.5	67	290	76.0								1	<1979	0.20	3.8			
2-0045-003	21	-159.750	22.000	Camp 2 KS5	21.4	71	145	47.0								1	<1979	0.58	3.1			
2-0145-008	21	-159.750	22.017	Mana 4	22.5	67	122	44.0								1	<1979	0.20	2.8			
2-0145-009	21	-159.750	22.017	Mana 5	22.5	66	152	46.0								1	<1979	0.10	3.3			
2-0145-010	21	-159.750	22.017	Mana 6	22.5	65	350	38.0								1	<1979	0.00	9.2			
2-0145-011	21	-159.750	22.017	Mana 7	22.5	59	175	52.0								1	<1979	-0.64	3.4			
2-0145-012	21	-159.750	22.017	Mana 8	22	64	165	50.0								1	<1979	-0.10	3.3			
2-0145-013	21	-159.750	22.017	Mana 9	22	62	72	35.0								1	<1979	-0.31	2.1			
2-0145-016	21	-159.750	22.017	Mana 12	22	65	65	34.0								1	<1979	0.00	1.9			
2-0245-002	21	-159.750	22.033	Mana Shaft	23	66	70	36.0								1	<1979	0.10	1.9			
2-0345-004	21	-159.750	22.050	Saki Mana	23	72	460	65.0								1	<1979	0.67	7.1			
2-0545-001	21	-159.750	22.083	Kaulaula W59	25	57	170	42.0								1	<1979	-0.87	4.1			
2-5638-001	21	-159.633	21.933	Mahinauli	23	52	20	15.0								1	<1979	-1.47	1.3			
2-5840-002	21	-159.667	21.967	Waimea 26	24.5	73	120	12.0								1	<1979	0.77	10.0			
2-5842-002	21	-159.700	21.967	Kekaha PLS 11	24.5	40	140	26.0								1	<1979	-3.17	5.4			
2-5842-003	21	-159.700	21.967	Huluhulunui	25		310									1	<1979					
2-5843-001	21	-159.717	21.967	Kekaha Shaft	24	56	67	19.0								1	<1979	-0.97	3.5			
2-5939-001	21	-159.650	21.983	Waimea 9	24.5	36	74	20.0								1	<1979	-3.88	3.7			
2-5942-001	21	-159.700	21.983	Paua Valley	24	48	41	17.0								1	<1979	-2.00	2.4			
2-5943-001	21	-159.720	21.980	Waiawa Shaft	24.5	77	340	43.0										1.12	7.9			
2-5638-01	21	-159.635	21.935	S8 MAKAWEL		52	20	15.0	48	3.3	14.0	86			9.8	3	1972	-1.47	1.3	14.5	187.5	0.700
2-5840-01	21	-159.669	21.967	Waimea W-A		70	102	13.0	84	3.5	18.0	72			7.5	3	1972	0.49	7.8	24.0	145.3	0.176
2-5840-02	21	-159.670	21.967	Waimea W-B		70	43	11.0	62	2.8	9.6	63	7.8		7.2	3	1983	0.49	3.9	22.1	151.5	0.223
2-5923-02	21	-159.392	21.984	Kilohana W-B		33	24	9.3	18	1.3	6.6	57			7.4	3	1977	-4.47	2.6	13.8	192.1	0.275
2-5939-01	21	-159.659	21.984	Waimea Shaft (S9		51	170	39.0	69	4.2	23.0	230	7.4		26.0	3	1982	-1.60	4.4	16.4	176.5	0.135
2-5943-02	21	-159.717	21.987	Kekaha W-B		72	75	24.0	60	2.1	18.0	140			16.0	3	1978	0.67	3.1	28.6	132.3	0.240
2-5943-01	21	-159.724	22.001	S13 KEKAHA		77	180	43.0	98	5.2	33.0	240			25.0	3	1975	1.12	4.2	18.8	164.6	0.183
2-0044-12	21	-159.741	22.001	W30 KEKAHA		72	2000	360.0	600	1.0	280.0	2100			240.0	3	1977	0.67	5.6	600.0	-9.8	0.140
2-0044-14	21	-159.741	22.023	Kaunalewa		25	290	66.0	79	2.1	38.0	390			46.0	3	1977	-6.30	4.4	37.6	113.5	0.131
2-0044-03	21	-159.740	22.025	W32B KEKAH		65	3500	610.0	910	14.0	380.0	3500			400.0	3	1977	0.00	5.7	65.0	80.7	0.109
2-0145-10	21	-159.756	22.057	W45F MANA		65	90	38.0	31	1.4	16.0	220			25.0	3	1972	0.00	2.4	22.1	151.5	0.178

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Silica.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
2-0145-11	21	-159.756	22.059	W45G MANA		59	175	52.0	51	1.7	27.0	300			36.0	3	1972	-0.64	3.4	30.0	128.9	0.154
2-0345-04	21	-159.757	22.059	S16 SAKIMA		72	300	65.0	120	3.9	46.0	370			39.0	3	1975	0.67	4.6	30.8	127.1	0.153
2-0545-01	21	-159.751	22.103	Kaulaula		57	145	42.0	76	1.6	17.0	240			27.0	3	1975	-0.87	3.5	47.5	98.8	0.117
2-0021-001	23	-159.350	22.000	Kalepa Ridge	25.3	66	29	8.4								1	<1979	3.47	3.5			
2-0120-001	23	-159.333	22.017	Kalepa Ridge	25.5	77	160	33.0								1	<1979	2.00	3.4			
2-0120-002	23	-159.333	22.017	Kalepa Ridge	27.5	73	110	23.0								1	<1979	1.84	4.8			
2-0320-001	23	-159.333	22.050	Nonou A	23	63	45	15.0								1	<1979	1.43	3.0			
2-0320-002	23	-159.333	22.050	Wailua		59	25	12.0								1	<1979	1.22	2.1			
2-0320-003	23	-159.333	22.050	Nonou 9-1B	24.5	51	48	8.4								1	<1979	0.79	5.7			
2-0321-001	23	-159.350	22.050	Wailua 3	24.2	68	64	20.0								1	<1979	1.63	3.2			
2-0421-001	23	-159.350	22.067	Wailua	24.5	83	41	21.0								1	<1979	2.22	2.0			
2-0618-005	23	-159.300	22.100	Kealia 7	24.5	36	40	12.0								1	<1979	-0.24	3.3			
2-0620-001	23	-159.333	22.100	Kapaa Cannery	26.5	30	28	12.0								1	<1979	-0.77	2.3			
2-0622-001	23	-159.367	22.100	Akulikuli	19	34	15	7.4								1	<1979	-0.44	2.0			
2-0623-001	23	-159.383	22.100	Makaleha 6	19.1	32	14	7.0								1	<1979	-0.63	2.0			
2-0818-001	23	-159.300	22.133	Anahola A	23.5	36	25	16.0								1	<1979	-0.24	1.6			
2-0818-002	23	-159.300	22.133	Anahola B	23.5	30	24	11.0								1	<1979	-0.79	2.2			
2-1020-002	23	-159.333	22.167	Moloaa 1	22	36	15	11.0								1	<1979	-0.24	2.0			
2-1020-003	23	-159.333	22.167	Moloaa 2	22	36	15	11.0								1	<1979	-0.24	1.4			
2-1020-04	23	-159.333	22.017	Aliomanu	20.8	39	22	11.0								1	<1979	0.00	2.0			
2-1120-001	23	-159.333	22.183	Moloaa Tun. 3	25.5	13	25	7.0								1	<1979	-3.23	3.6			
2-1125-001	23	-159.417	22.183	Kilauea 1	24.5	39	13	6.8								1	<1979	0.00	1.9			
2-1125-001	23	-159.417	22.183	ECDC 1	22.8	33	17	2.5								1	<1979	-0.51	6.9			
2-1125-001	23	-159.417	22.183	ECDC 2 Hanale	23.5	47	17	8.7								1	<1979	0.55	2.0			
2-1125-001	23	-159.417	22.183	Maka Ridge	24	38	22	9.9								1	<1979	-0.08	2.2			
2-1327-001	23	-159.450	22.217	Anini Tunnel	23	36	23	7.7								1	<1979	-0.24	3.0			
2-1327-001	23	-159.450	22.217	Haena Deep	22.5	33	19	9.0								1	<1979	-0.49	2.1			
2-5426-004	23	-159.433	21.900	Koloa C	22.6	58	55	17.0								1	<1979	1.17	3.2			
2-5427-001	23	-159.450	21.900	Koloa A	23	59	27	10.0								1	<1979	1.22	2.7			
2-5427-002	23	-159.450	21.900	Koloa B	23	37	30	15.0								1	<1979	-0.17	2.0			
2-5530-002	23	-159.500	21.917	Lawai Cannery	22	52	26	8.9								1	<1979	0.85	2.9			
2-5530-003	23	-159.500	21.917	Lawai Deep	22.5	59	23	9.4								1	<1979	1.22	2.5			
2-5531-001	23	-159.517	21.917	Kalaheo 24	25	59	46	1.1								1	<1979	1.22	41.8			
2-5533-001	23	-159.550	21.917	Hanapepe	21.5	49	28	13.0								1	<1979	0.67	2.2			
2-5534-003	23	-159.567	21.917	Hanapepe Valley	22.5	50	37	5.1								1	<1979	0.73	7.3			
2-5631-001	23	-159.517	21.933	Kalaheo	20.7	42	22	9.0								1	<1979	0.22	2.4			
2-5635-001	23	-159.583	21.933	Manienieula	22.5	43	140	16.0								1	<1979	0.31	8.8			
2-5725-001	23	-159.417	21.950	Kokolau Tun.	21.5	37	19	11.0								1	<1979	-0.19	1.7			
2-5823-001	23	-159.383	21.967	Garlinghouse	22	32	22	8.6								1	<1979	-0.58	2.6			
2-5921-001	23	-159.350	21.983	Kalapa Ridge	23	32	23	12.8								1	<1979	-0.58	1.8			
2-5923-002	23	-159.383	21.983	Kilohana	23.3	33	24	9.3								1	<1979	-0.49	2.6			
2-5426-04	23	-159.434	21.903	Koloa W-C		58	55	17.0	36	1.4	12.0	100			13.0	3	1977	1.17	3.2	25.7	140.1	0.218
2-5427-01	23	-159.457	21.909	Koloa W		57	23	11.0	20	1.2	5.0	70	8.0		9.8	3	1982	1.12	2.1	16.7	175.2	0.217
2-5534-03	23	-159.571	21.920	Hanapepe Town		50	46	5.1	93	2.4	24.0	30			3.7	3	1975	0.73	9.0	38.8	111.5	0.522
2-5530-03	23	-159.504	21.923	Lawai W-1		59	23	9.4	19	1.4	8.7	61			8.9	3	1975	1.22	2.4	13.6	194.0	0.378
2-5530-04	23	-159.504	21.924	Lawai W-2		54	19	9.7	18	1.1	5.7	58	8.0		7.3	3	1985	0.96	2.0	16.4	176.8	0.300
2-5533-01	23	-159.558	21.924	Hanapepe Valley		49	28	13.0	22	1.4	9.3	84			12.0	3	1974	0.67	2.2	15.7	180.4	0.332
2-5533-02	23	-159.558	21.925	Hanapepe Valley W-B		52	32	12.0	28	1.6	16.0	74	6.6		10.0	3	1990	0.85	2.7	17.5	170.9	0.500
2-5631-01	23	-159.524	21.938	Kalaheo DW		42	22	9.0	15	1.0	3.7	60			9.2	3	1974	0.22	2.4	15.0	184.6	0.168

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date		Z value for ln(Silica)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
2-5631-02	23	-159.523	21.938	Kalaheo DW2		44	21	11.0	16	1.1	4.0	70	8.1		10.0	3	1985		0.35	1.9	14.5	187.5	0.190
2-5635-01	23	-159.592	21.939	S7 Hanapepe		63	146	20.0	110	6.5	39.0	100			7.2	3	1972		1.41	7.3	16.9	173.8	0.267
2-5824-01	23	-159.401	21.971	Puhi W-1		23	17	12.0	42	4.5	4.0	77			11.0	3	1975		-1.55	1.4	9.3	232.7	0.235
2-5823-01	23	-159.387	21.974	Lihue Tunnel (TU8)		32	22	8.6	16	1.2	11.0	52			6.7	3	1977		-0.58	2.6	13.3	195.7	0.500
2-5923-01	23	-159.392	21.984	Kilohana W-A		23	16	11.0	34	3.8	2.8	68			9.0	3	1975		-1.55	1.5	8.9	237.5	0.175
2-5923-05	23	-159.390	21.985	Kilohana W-G		27	17	5.4	17	1.3	10.0	37	8.3		5.8	3	1981		-1.08	3.1	13.1	197.6	0.588
2-5923-03	23	-159.391	21.985	Kilohana W-C		25	18	8.1	17	1.0	6.2	49			6.3	3	1978		-1.31	2.2	17.0	173.5	0.344
2-5921-01	23	-159.357	22.003	Kalepa Ridge W-10		72	67	20.0	54	1.3	48.0	130	8.0		19.0	3	1991		1.80	3.4	41.5	107.1	0.716
2-0120-01	23	-159.343	22.025	Kalepa Ridge W-7		70	148	35.0	90	1.7	32.0	200			22.0	3	1972		1.72	4.2	52.9	92.4	0.216
2-0320-01	23	-159.343	22.088	Nonou W-A		67	40	15.0	36	1.9	13.0	97			14.0	3	1972		1.59	2.7	18.9	164.2	0.325
2-0320-03	23	-159.343	22.101	Nonou W-B		73	53	18.0	44	2.2	14.0	110	7.6		15.0	3	1982		1.84	2.9	20.0	159.7	0.264
2-0620-01	23	-159.336	22.104	W5 KAPAA		30	28	12.0	26	1.8	18.0	79			12.0	3	1972		-0.77	2.3	14.4	188.1	0.643
2-0618-05	23	-159.306	22.105	W2A KEALIA		36	40	12.0	21	0.9	6.3	82			13.0	3	1972		-0.24	3.3	23.3	147.4	0.158
2-0623-04	23	-159.387	22.138	Kapaa Homesteads W-1		31	12	6.1	10	1.1	2.5	50	7.9		10.0	3	1983		-0.67	2.0	9.1	235.7	0.208
2-0622-02	23	-159.374	22.151	Kapaa Homesteads W-2		36	11	4.6	10	1.4	2.0	34	8.3		6.0	3	1989		-0.24	2.4	7.1	264.5	0.182
2-0818-01	23	-159.309	22.168	Anahola W-A		28	26	11.0	26	1.6	20.0	70			10.0	3	1972		-0.97	2.4	16.3	177.4	0.769
2-0919-03	23	-159.322	22.173	Anahola Well		49	47	17.0	34	1.3	10.0	100			14.0	3	1979		0.67	2.8	26.2	138.8	0.213
2-1020-04	23	-159.334	22.192	Anahole		39	22	11.0	14	0.7	4.3	73			11.0	3	1974		0.00	2.0	20.0	159.7	0.195
2-1020-03	23	-159.340	22.200	Moloaa		36	19	11.0	14	0.7	3.4	73			11.0	3	1972		-0.24	1.7	20.0	159.7	0.179
2-1126-02	23	-159.442	22.220	Princeville W-2		32	15	7.2	12	1.0	2.6	62			13.0	3	1972		-0.58	2.1	12.0	206.1	0.173
2-1229-03	23	-159.489	22.200	Maka Ridge (W73)		38	20	9.9	14	0.9	4.1	76			14.0	3	1975		-0.08	2.0	15.6	181.3	0.205
2-1333-01	23	-159.560	22.220	Haena W-66		33	21	9.0	18	1.1	3.2	650			11.0	3	1975		-0.49	2.3	16.4	176.8	0.152
3-1748-05Z	31	-157.800	21.283	Kaimuki Pump Station		16	56	2.4								1	<1979		-2.63	23.3			
3-1749-001	31	-157.817	21.283	Kapahulu		35	70	5.5								1	<1979		0.10	12.7			
3-1749-008	31	-157.817	21.283	Kapahulu	22	55	208	4.4								1	<1979		1.68	47.3			
3-1749-016	31	-157.817	21.283	Kapahulu		33	102	5.1								1	<1979		-0.10	20.0			
3-1749-018	31	-157.817	21.283	Kapahulu		67	50	1.4								1	<1979		2.37	35.7			
3-1849-010	31	-157.817	21.300	Manoa Valley	25	30	18	6.5								1	<1979		-0.47	2.8			
3-1850-027	31	-157.833	21.300	Makiki		26	85	4.8								1	<1979		-0.94	17.7			
3-1851-009	31	-157.850	21.300	Kawaiahao Church	21	77	80	8.0								1	<1979		2.86	10.0			
3-1851-030	31	-157.850	21.300	Kawaiahao Church		29	63	3.2								1	<1979		-0.56	19.7			
3-1952-004	31	-157.867	21.317	Kapalama	26	10	118	5.5								1	<1979		-4.28	21.5			
3-1952-011	31	-157.867	21.317	Kapalama		28	99	8.0								1	<1979		-0.68	12.4			
3-2052-007	31	-157.867	21.333	Kapalama Avenue	26	20	130	36.0								1	<1979		-1.82	3.6			
3-2053-005	31	-157.883	21.333	Kalihi	30	34	136	21.9	52	4.7	22.9	62	7.4		23.7	1			-0.05	6.2	11.1	214.4	0.168
3-2053-005	31	-157.883	21.333	Kalihi	30	42	60	11.0								1	<1979		0.70	5.5			
3-2054-003	31	-157.900	21.333	Puuloa Road	32	28	620	1.5	58	16.0	28.4				3.4	1	<1979		-0.63	413.3	3.6	366.5	0.046
3-2153-002	31	-157.883	21.350	Moanalua	21.5	63	74	12.0								1	<1979		2.16	6.2			
3-2153-007	31	-157.883	21.350	Moanalua	25.6	44	76	12.0								1	<1979		0.90	6.3			
3-2153-009	31	-157.883	21.350	Moanalua	25.0		1050	203.0								1	<1979			5.2			
	31			Alewa Heights Spring		11	20	7.6	14	0.6	7	51	6.2	118	6.3	4			-3.94	2.6	23.3	147.4	0.350
	31			Beretania High Service		30	70	12.0	39	3.1	9.5	68	8.1	247	12.0	4			-0.44	5.8	12.6	201.4	0.136
	31			Beretania Low Service		36	70	13.0	41	3.6	11	78	8.2	267	12.0	4			0.20	5.4	11.4	211.4	0.157
3-1843-01	31	-157.717	21.300	Kuliouou Well		49	94	16.0	47	3.9	12	81	7.7	321	16.0	4			1.28	5.9	12.1	205.6	0.128

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
3-1948-01	31	-157.800	21.317	Manoa Well II		21	14	5.7	10	0.6	2.3	49	8.0	111	6.9	4		-1.68	2.5	16.7	175.2	0.164
3-2153-10	31	-157.883	21.350	Moanalua Wells Pump 1		34	92	16.0	44	2.9	16	76	7.9	302	18.0	4		0.00	5.8	15.2	183.6	0.174
3-2153-11	31	-157.883	21.350	Moanalua Wells Pump 2		32	85	15.0	33	2.8	15	54	7.8	258	18.0	4		-0.21	5.7	11.8	207.9	0.176
3-2153-12	31	-157.883	21.350	Moanalua Wells Pump 3		33	136	23.0	43	3.4	19	55	7.8	340	26.0	4		-0.10	5.9	12.6	200.8	0.140
3-2149-03	31	-157.817	21.350	Nuuanu Aerator Well		21	16	10.0	17	0.4	3.9	88	7.6	166	8.4	4		-1.68	1.6	39.5	110.3	0.244
3-1946-01	31	-157.767	21.317	Palolo Tunnel		16	12	4.7	13	0.7	4	54	n.a.	99	6.8	4		-2.63	2.6	18.6	165.9	0.333
3-1847-01	31	-157.783	21.300	Palolo Well		34	23	9.5	21	1.3	4.4	90	8.2	197	11.0	4		0.00	2.4	16.2	178.0	0.191
3-1849-15	31	-157.817	21.300	Wilder Well		34	56	6.3	51	4.6	9.2	78	8.5	246	4.4	4		0.00	8.9	11.1	214.1	0.164
3-1646-01	31	-157.775	21.274	Waialae Golf Course 1		40	30	23.0	98	4.6	180	140			19.0	3		0.57	1.3	21.3	154.6	6.000
3-1749-19	31	-157.817	21.283	Princess Kaiulani, Pa		33	8	8.7	36	2.5	51	51	8.0		5.9	3		-0.10	0.9	14.6	187.0	6.610
3-1746-02	31	-157.770	21.285	Waialae Iki		40	19	18.0	75	4.0	140	110			16.0	3		0.57	1.1	18.8	165.1	7.368
3-1747-03	31	-157.784	21.292	Waialae Nui		34	6	6.6	40	4.0	41	39	8.3		4.8	3		0.04	0.9	10.0	225.6	7.175
3-1843-01	31	-157.723	21.304	Kuliouou		55	13	17.0	51	3.6	100	120	7.9		18.0	3		1.68	0.8	14.2	189.9	7.692
3-1851-22	31	-157.860	21.305	Ala Moana Blvd		1	64	150.0	1400	69.0	2800	1100	9.3		190.0	3		-12.32	0.4	20.3	158.5	43.750
3-1847-01	31	-157.788	21.306	Palolo Well		40	5	8.8	20	1.6	24	74			15.0	3		0.57	0.6	12.5	202.0	4.706
3-1851-54	31	-157.854	21.307	Queens Hospital		40	7	8.2	9	36.4			8.2		57.6	3		0.55	0.9	0.2	2301.7	0.000
3-1952-06-08	31	-157.871	21.326	Kalihi Station		39	12	15.2	40	2.7	81	97	7.5		13.9	3		0.48	0.8	15.2	183.6	6.577
3-1948-01	31	-157.803	21.327	Manoa II		27	2	5.6	11	0.8	12	41	7.7		7.2	3		-0.81	0.4	13.8	192.8	5.217
3-2153-12	31	-157.892	21.353	Moanalua W-3		41	123	20.7	45	2.6	16	140	7.7		22.0	3	2000	0.67	5.9	17.2	172.3	0.128
3-2153-11	31	-157.892	21.353	Moanalua W-2		43	100	16.0	44	2.6	15	110			19.0	3	1973	0.82	6.3	16.7	174.9	0.150
3-2255-35	31	-157.924	21.377	Aiea Refinery (W189-3		49	182	27.0	80	4.2	33	180			29.0	3	1975	1.28	6.7	19.0	163.7	0.181
3-2103-002	32	-158.050	21.350	Puu Makakilo	25.5		251									1	<1979					
3-2202-003	32	-158.033	21.367	Honouliuli	22.2	63	145	27.4								1	<1979	0.53	5.3			
3-2202-009	32	-158.033	21.367	Honouliuli		83	145	27.4								1	<1979	1.37	5.3			
3-2202-015	32	-158.033	21.367	Mill Pump 7A	25.5	82	840	59.0								1	<1979	1.33	14.2			
3-2255-007	32	-157.917	21.367	Halawa	21.7	64	96	14.0								1	<1979	0.58	6.9			
3-2256-012	32	-157.933	21.367	Aiea	27		160	21.0								1	<1979		7.6			
3-2300-002	32	-158.000	21.383	Waipahu	23	66	135	20.0								1	<1979	0.67	6.8			
3-2300-007	32	-158.000	21.383	Waipahu P6A	30	45	89	6.4								1	<1979	-0.53	14.0			
3-2300-007	32	-158.000	21.383	Waipahu P6A	30	38	131	13.1	100	0.2	30.5	51.7	7.6		35.7	1	<1979	-1.01	10.0	500.0	-4.2	0.233
3-2300-011	32	-158.000	21.383	Waipahu	22.5	60	180	19.0								1	<1979	0.38	9.5			
3-2300-018	32	-158.000	21.383	Waipahu	22	60	96	13.0								1	<1979	0.38	7.4			
3-2301-001	32	-158.017	21.383	Waikele P81A	22	67	51	10.7								1	<1979	0.72	4.8			
3-2301-011Z	32	-158.017	21.383	Waikele	21	74	113	11.0								1	<1979	1.02	10.3			
3-2301-034	32	-158.017	21.383	Hoeaea 1	22.5	71	120	15.7								1	<1979	0.89	7.6			
3-2302-001	32	-158.033	21.383	Kunia 1	22	73	103	16.2								1	<1979	0.98	6.4			
3-2302-002	32	-158.033	21.383	Kunia 1	22.4	75	135	17.0								1	<1979	1.06	7.9			
3-2359-004	32	-157.983	21.383	Waipahu	22.5	68	395	71.0								1	<1979	0.76	5.6			
3-2359-005	32	-157.983	21.383	Waipahu	22.5	59	340	80.0								1	<1979	0.33	4.3			
3-2359-006	32	-157.983	21.383	Waipahu	22.5	66	280	38.0								1	<1979	0.67	7.4			
3-2359-014	32	-157.983	21.383	Waipahu	21.6	66	840	130.0								1	<1979	0.67	6.5			
3-2359-015	32	-157.983	21.383	Waipahu	22	64	1050	150.0								1	<1979	0.58	7.0			
3-2359-016	32	-157.983	21.383	Waipahu	22	62	1650	240.0								1	<1979	0.48	6.9			
3-2359-017	32	-157.983	21.383	Waipahu	22	65	1110	175.0								1	<1979	0.62	6.3			
3-2400-001	32	-158.000	21.400	Waipahu		57	80	7.9								1	<1979	0.22	10.1			

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
3-2402-001	32	-158.033	21.400	Kunia II		71	105	18.0								1	<1979	0.89	5.8			
3-2458-001	32	-157.967	21.400	Pearl City	21.5	62	172	14.5								1	<1979	0.46	11.9			
3-2459-001	32	-157.983	21.400	Waipio Heights 1		60	82	11.0								1	<1979	0.38	7.5			
3-2459-062	32	-157.983	21.400	Waipio Heights		33	519	43.0								1	<1979	-1.44	12.1			
3-2501-001	32	-158.017	21.417	Waipahu	21.9	57	121	31.0								1	<1979	0.20	3.9			
3-2558-010	32	-157.967	21.417	Waiawa	22	58	160	14.0								1	<1979	0.27	11.4			
3-2600-002	32	-158.000	21.433	Kipapa Gulch	25	61	35	12.0								1	<1979	0.43	2.9			
3-2603-001	32	-158.050	21.433	Waikele	22	74	46	15.0								1	<1979	1.02	3.8			
3-2703-001	32	-158.050	21.450	Kunia	23	65	37	8.4	90		7.8				95.0			0.64	4.4			0.211
3-2800-001	32	-158.000	21.467	Mililani	22	63	18	6.3								1	<1979	0.53	2.9			
3-2800-003	32	-158.000	21.467	Mililani	20.5	64	18	5.6								1	<1979	0.58	3.2			
3-2755-06	32	-157.917	21.450	Aiea Wells		33	84	15.0	42	2.6	16	73	7.8	287	17.0	4		-1.44	5.6	16.2	178.0	0.190
3-2355-07	32	-157.917	21.383	Aiea Wells		31	80	15.0	48	2.5	16	96	7.5	310	17.0	4		-1.64	5.3	19.2	163.1	0.200
3-2355-03	32	-157.917	21.383	Aiea Gulch		29	58	12.0	28	2.1	9.4	66	7.8	221	14.0	4		-1.84	4.8	13.3	195.7	0.162
3-2354-01	32	-157.900	21.383	Halawa Shaft		28	82	16.0	33	2.6	14	66	7.8	262	18.0	4		-1.95	5.1	12.7	200.5	0.171
3-2255-39	32	-157.917	21.367	Halawa Wells Pump 1		37	157	24.0	62	3.6	26	68	7.4	410	28.0	4		-1.10	6.5	17.2	172.3	0.166
3-2255-37	32	-157.917	21.367	Halawa Wells Pump 2		45	150	21.0	77	3.9	31	82	7.6	440	23.0	4		-0.50	7.1	19.7	160.8	0.207
3-2255-38	32	-157.917	21.367	Halawa Wells Pump 3		47	142	19.0	82	4.0	32	85	7.4	440	20.0	4		-0.37	7.5	20.5	157.7	0.225
3-2301-34	32	-158.017	21.383	Hoaeae Wells Pump 1		46	86	13.0	80	3.8	29	112	7.0	401	11.0	4		-0.43	6.6	21.1	155.5	0.337
3-2301-35	32	-158.017	21.383	Hoaeae Wells Pump 2		35	87	14.0	77	3.7	32	112	7.1	390	12.0	4		-1.27	6.2	20.8	156.5	0.368
3-2301-37	32	-158.017	21.383	Hoaeae Wells Pump 3		41	90	14.0	81	3.8	29	117	7.0	400	11.0	4		-0.78	6.4	21.3	154.6	0.322
3-2301-36	32	-158.017	21.383	Hoaeae Wells Pump 4		42	96	13.0	91	4.0	35	122	7.0	436	14.0	4		-0.71	7.4	22.8	149.4	0.365
3-2301-38	32	-158.017	21.383	Hoaeae Wells Pump 5		40	84	13.0	4	3.6	30	110	7.0	386	11.0	4		-0.86	6.5	1.0	726.9	0.357
3-2301-39	32	-158.017	21.383	Hoaeae Wells Pump 6		42	86	13.0	78	3.5	30	110	7.0	390	11.0	4		-0.71	6.6	22.3	151.0	0.349
3-2303-01	32	-158.050	21.383	Honouliuli I Pump 1		37	168	24.0	77	4.6	26	88	7.1	458	28.0	4		-1.10	7.0	16.7	174.8	0.155
3-2303-02	32	-158.050	21.383	Honouliuli I Pump 2		66	216	35.0	89	5.2	32	95	7.1	573	30.0	4		0.67	6.2	17.1	172.9	0.148
3-2303-03	32	-158.050	21.383	Honouliuli II Pump 1		50	148	25.0	69	4.9	24	105	7.0	458	26.0	4		-0.18	5.9	14.1	190.5	0.162
3-2303-04	32	-158.050	21.383	Honouliuli II Pump 2		53	178	30.0	75	5.5	27	117	6.8	527	35.0	4		0.00	5.9	13.6	193.6	0.152
3-2303-05	32	-158.050	21.383	Honouliuli II Pump 3		53	122	20.0	64	4.5	18	105	6.9	413	22.0	4		0.00	6.1	14.2	189.6	0.148
3-2303-06	32	-158.050	21.383	Honouliuli II Pump 4		48	105	25.0	49	4.4	17	120	6.9	398	22.0	4		-0.30	4.2	11.1	213.7	0.162
3-2302-02	32	-158.033	21.383	Pump I		42	88	13.0	86	3.9	33	117	7.0	418	11.0	4		-0.71	6.8	22.1	151.9	0.375
3-2302-01	32	-158.033	21.383	Kunia Wells I		51	96	15.0	84	3.9	32	112	7.0	428	12.0	4		-0.12	6.4	21.5	153.7	0.333
3-2302-03	32	-158.033	21.383	Pump 3		51	114	17.0	88	4.0	34	110	7.1	453	15.0	4		-0.12	6.7	22.0	152.0	0.298
3-2302-04	32	-158.033	21.383	Kunia Wells I		55	93	15.0	84	3.9	32	115	7.1	432	12.0	4		0.11	6.2	21.5	153.7	0.344
3-2402-02	32	-158.033	21.400	Kunia Wells II		60	71	14.0	72	3.7	30	120	7.3	410	13.0	4		0.38	5.1	19.5	162.0	0.423
3-2402-03	32	-158.033	21.400	Kunia Wells II		52	7	15.0	66	3.6	32	110	13.0	385	13.0	4		-0.06	0.5	18.3	167.0	4.558
3-2301-41	32	-158.017	21.383	Kunia Wells		58	78	14.0	66	4.9	31	109	7.2	387	14.0	4		0.27	5.6	13.5	194.7	0.397
3-2301-42	32	-158.017	21.383	Kunia Wells		65	76	14.0	62	4.8	30	98	6.9	374	12.0	4		0.62	5.4	12.9	198.8	0.395
3-2400-08	32	-158.000	21.400	Waipahu II		58	46	12.0	51	2.9	20	113	7.3	333	12.0	4		0.27	3.8	17.6	170.5	0.435
3-2355-09	32	-157.917	21.383	Kalauao Wells -		29	71	14.0	38	2.2	11	73	7.5	252	12.0	4		-1.84	5.1	17.3	172.1	0.155
3-2355-12	32	-157.917	21.383	Kalauao Wells - Pump 3		29	60	14.0	27	2.0	9	66	7.9	221	12.0	4		-1.84	4.3	13.5	194.5	0.150
3-2355-10	32	-157.917	21.383	Kalauao Wells - Pump 4		28	44	11.0	27	1.9	7	68	7.9	197	8.5	4		-1.95	4.0	14.2	189.7	0.159
3-2355-13	32	-157.917	21.383	Kalauao Wells - Pump 5		36	150	29.0	48	2.7	21	68	7.7	381	26.0	4		-1.18	5.2	17.8	169.6	0.140

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
3-2355-14	32	-157.917	21.383	Kalauao Wells -		31	132	25.0	45	2.7	18	68	7.9	347	23.0	4		-1.64	5.3	16.7	175.2	0.136
3-2356-55	32	-157.933	21.383	Kaonohi Well I		31	60	12.0	25	1.8	9.3	62	7.8	219	16.0	4		-1.64	5.0	13.9	191.8	0.155
3-2004-04	32	-158.067	21.333	Makakilo Well		72	256	41.0	121	7.4	46	139	7.1	737	38.0	4		0.93	6.2	16.4	176.9	0.180
3-2800-01	32	-158.000	21.467	Mililani I		64	18	6.6	15	1.4	6.9	56	7.3	177	7.6	4		0.58	2.7	10.7	217.7	0.383
3-2800-04	32	-158.000	21.467	Mililani Wells I 4		60	19	5.7	17	1.5	8.1	49	7.0	171	6.9	4		0.38	3.3	11.3	211.9	0.426
3-2859-01	32	-157.983	21.467	Mililani Wells II 1		54	16	7.1	16	1.4	9.1	57	7.4	174	7.9	4		0.06	2.3	11.4	211.0	0.569
3-2859-02	32	-157.983	21.467	Mililani Wells II 2		54	16	7.0	12	1.2	5.4	55	7.4	162	8.2	4		0.06	2.3	10.0	225.1	0.338
3-2600-04	32	-158.000	21.433	Mililani III Pump 2		30	20	5.1	24	1.0	6.8	59	7.1	162	6.8	4		-1.74	3.9	24.0	145.3	0.340
3-2558-01	32	-157.967	21.417	Mililani Wells IV Pump 1		44	18	8.0	13	0.8	4.3	67	7.4	168	10.0	4		-0.57	2.3	16.3	177.4	0.239
3-2858-02	32	-157.967	21.467	Mililani Wells IV Pump 2		35	18	8.5	14	0.8	3.9	71	7.9	163	9.7	4		-1.27	2.1	17.5	170.9	0.217
3-2858-03	32	-157.967	21.467	Mililani Wells IV Pump 3		40	17	7.3	10	0.8	3.7	57	7.8	147	9.2	4		-0.86	2.3	12.5	202.0	0.218
3-2458-03	32	-157.967	21.400	Pearl City Wells I Pump 1		36	40	5.6	44	2.3	14	76	7.0	228	6.0	4		-1.18	7.1	19.1	163.4	0.350
3-2458-04	32	-157.967	21.400	Pearl City Wells I Pump 2		41	41	5.8	41	2.0	13	70	7.1	230	6.6	4		-0.78	7.1	20.5	157.7	0.317
3-2457-01	32	-157.950	21.400	Pearl City Wells Ii Pump 1		31	42	8.8	21	1.8	8.3	56	7.7	184	13.0	4		-1.64	4.8	11.7	208.9	0.198
3-2457-02	32	-157.950	21.400	Pearl City Wells Ii Pump 2		31	32	7.4	25	1.7	5.9	68	7.6	182	8.9	4		-1.64	4.3	14.7	186.5	0.184
3-2557-03	32	-157.950	21.417	Pearl City Well III		33	18	6.3	15	0.9	4.3	63	7.9	151	9.1	4		-1.44	2.9	16.7	175.2	0.239
3-2458-01	32	-157.967	21.400	Pearl City Shaft		36	53	7.4	45	2.8	16	73	7.3	247	9.7	4		-1.18	7.2	16.1	178.4	0.302
3-2457-06	32	-157.950	21.400	Punanani Wells Pump 1		26	150	25.0	53	3.0	21	49	7.9	349	21.0	4		-2.17	6.0	17.7	170.1	0.140
3-2457-09	32	-157.950	21.400	Punanani Wells Pump 2		25	76	14.0	25	2.1	12	46	7.9	220	18.0	4		-2.29	5.4	11.9	206.9	0.158
3-2457-11	32	-157.950	21.400	Punanani Wells Pump 3		35	44	7.9	29	1.5	8.2	63	7.6	202	11.0	4		-1.27	5.6	19.3	162.5	0.186
3-2457-10	32	-157.950	21.400	Punanani Wells Pump 4		30	36	7.7	26	1.9	7.4	66	7.7	187	10.0	4		-1.74	4.7	13.7	193.2	0.206
3-2457-12	32	-157.950	21.400	Punanani Wells Pump 5		31	37	7.3	27	1.9	6.6	66	7.7	189	10.0	4		-1.64	5.1	14.2	189.7	0.178
3-2457-05	32	-157.950	21.400	Punanani Wells Pump 6		31	35	7.0	24	1.8	7.2	59	7.8	177	10.0	4		-1.64	5.0	13.3	195.7	0.206
3-2400-02	32	-158.000	21.400	Waipahu Wells Pump 1		37	48	5.4	60	1.9	15	93	7.3	278	6.0	4		-1.10	8.9	31.6	125.3	0.313
3-2400-01	32	-158.000	21.400	Waipahu Wells Pump 2		46	52	6.8	52	1.9	14	79	7.3	268	6.4	4		-0.43	7.6	27.4	135.4	0.269
3-2400-03	32	-158.000	21.400	Waipahu Wells Pump 3		41	38	5.3	50	1.8	15	83	7.3	250	5.7	4		-0.78	7.2	27.7	134.7	0.395
3-2400-04	32	-158.000	21.400	Waipahu Wells Pump 4		51	39	5.9	46	1.7	14	81	7.4	254	6.7	4		-0.12	6.6	27.1	136.3	0.359
3-1905-04	32	-158.089	21.324	EWA DESALT PLANT		19	91	73.0	180	9.4	430	488	7.5		75.0	3		-3.13	1.2	19.1	163.3	4.725
3-1905-05	32	-158.089	21.324	EWA DESALT PLANT		41	210	90.0	520	36.0	970	620	7.5		100.0	3		-0.78	2.3	14.4	188.1	4.619
3-2155-04	32	-157.918	21.359	Makalapa (W160)		45	130	18.0	57	3.0	19	120			19.0	3	1972	-0.50	7.2	19.0	164.0	0.146
3-2255-35	32	-157.924	21.377	Aiea Refinery (W189-3A)		49	182	27.0	80	4.2	33	180			29.0	3	1975	-0.24	6.7	19.0	163.7	0.181
3-2355-07	32	-157.923	21.386	Aiea W2		48	87	15.5	41	2.6	14	105	7.7		16.4	3	2000	-0.31	5.6	16.1	178.5	0.157
3-2303-07	32	-158.054	21.386	Honouliuli Deep Monitor Well		25	18	8.1	14	0.9	5	58	7.4		9.7	3	1984	-2.29	2.2	15.6	181.3	0.294
3-2356-59	32	-157.934	21.387	Kaamilo P2		52	94	18.0	57	3.0	19	120			19.0	3	1973	-0.06	5.2	19.0	164.0	0.202
3-2357-19	32	-157.954	21.387	W197-2		45	320	53.0	62	3.8	27	360			57.0	3	1973	-0.50	6.0	16.3	177.1	0.084
3-2303-02	32	-158.052	21.388	Honouliuli I-2		69	460	43.0	190	7.7	63	300	7.4		51.0	3	1986	0.80	10.7	24.7	143.2	0.137
3-2358-48	32	-157.970	21.389	W201-1		38	390	68.0	100	4.7	53	440			64.0	3	1975	-1.01	5.7	21.3	154.7	0.136
3-2358-02	32	-157.970	21.389	Pearl City		36	1800	190.0	700	19.0	230	1300			190.0	3	1975	-1.18	9.5	36.8	114.8	0.128
3-2356-60	32	-157.943	21.389	Waimalu II-1		43	120	22.0	33	3.1	15	150			24.0	3	1975	-0.64	5.5	10.6	218.4	0.125
3-2359-05	32	-157.986	21.389	Waiawa Road		59	520	80.0	150	7.3	63	530			79.0	3	1975	0.33	6.5	20.5	157.5	0.121
3-2355-10	32	-157.926	21.390	Kalauao P2		43	37	9.4	21	1.6	5	68	7.9		11.4	3	2007	-0.67	3.9	13.5	194.5	0.147
3-2300-18	32	-158.003	21.390	Waipahu Deep Monitor Well		39	16000	1200.0	7200	140.0	2200	7040	7.0		840.0	3	1985	-0.94	13.3	51.4	94.1	0.138
3-2303-03	32	-158.057	21.390	Honouliuli II-I 2000		70	176	26.4	71	4.5	25	189	7.5		31.9	3	2000	0.86	6.7	15.7	180.3	0.144
3-2356-50	32	-157.941	21.390	Waimalu I P2 2000		43	203	37.2	35	2.7	24	263	7.7		44.1	3	2000	-0.67	5.5	13.0	197.9	0.117
3-2358-22	32	-157.974	21.390	Taba Farm, Waiawa (204-4 2000)		43	154	22.0	64	2.7	23	150			24.0	3	2000	-0.64	7.0	23.7	146.2	0.149
3-2358-29	32	-157.975	21.391	Taba Farm, Waiawa (204-9),1975		41	405	65.0	110	4.9	50	420			61.0	3	1975	-0.78	6.2	22.4	150.4	0.123

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
3-2300-11	32	-158.002	21.391	Watanabe well 2		60	163	19.0	96	3.6	31	130			22.0	3	1975	0.38	8.6	26.7	137.4	0.190
3-2400-03	32	-158.004	21.401	Waipahu I P4 (W241-1C) 1984		64	48	6.9	53	2.0	17	43			6.0	3	1984	0.58	7.0	26.5	137.8	0.354
3-2401-03	32	-158.017	21.400	Royal Kunia Golf Course A-2 2001		77	174	15.2	142	4.0	46	86	7.5		9.5	3	2001	1.14	11.4	35.4	117.5	0.264
3-2400-05	32	-158.009	21.402	Waipahu II 2000		71	47	12.7	49	2.2	20	80	8.0		11.1	3	2000	0.89	3.7	22.5	150.4	0.422
3-2459-20	32	-157.992	21.405	Waipio Heights P1 2000		61	55	7.6	54	2.2	14	49	7.5		6.9	3	2000	0.41	7.3	24.5	143.7	0.245
3-2459-01-05	32	-157.984	21.406	WP6A 1981		55	1400	150.0	520	12.0	170	940	5.8		130.0	3	1981	0.11	9.3	43.3	104.4	0.121
3-2558-10	32	-157.971	21.418	Waiawa Shaft 1983		59	180	19.0	90	3.2	22	126	7.0		19.0	3	1983	0.33	9.5	28.1	133.5	0.122
3-2500-03	32	-158.008	21.419	Waiola Deep Monitor Well 2001		62	57	11.5	36	2.0	12	78	7.8		12.2	3	2001	0.49	4.9	18.2	167.6	0.212
3-2558-09	32	-157.971	21.420	T40 1981			470	45.0	160	9.0	84	340	6.5		60.0	3	1981		10.4	17.8	169.6	0.179
3-2500-01	32	-158.005	21.420	Waipio Heights II P1 2000		69	29	7.9	32	1.5	12	48	7.7		6.1	3	2000	0.81	3.7	21.1	155.3	0.414
3-2659-01	32	-157.991	21.436	Waipio-Mauka Deep Monitor Well 2001		76	44	13.4	26	2.1	16	91	7.2		14.5	3	2001	1.11	3.2	12.6	201.4	0.375
3-2600-08	32	-158.005	21.440	Kipapa ST01MW07 2001		54	21	11.0	19	0.9	9	68	7.1		8.9	3	2001	0.08	1.9	21.4	154.1	0.420
3-2659-02	32	-157.992	21.440	Waipio Hts Wells III, no. 1 2001		57	16	6.3	18	1.4	5		7.6		7.1	3	2001	0.20	2.6	13.1	197.7	0.330
3-2402-03	32	-158.038	21.402	Kunia II P3 2000		76	50	12.2		2.8	24	736	7.3		9.4	3	2000	1.11	4.1	0.0		0.484
3-2400-05	32	-158.009	21.402	Waipahu II W1 2002		71	47	12.7	49	2.2	20	80	8.0		11.1	3	2002	0.89	3.7	22.5	150.4	0.422
3-2401-01	32	-158.018	21.404	W251-1 1982		62	110	32.0	48	2.3	37	180	7.1		20.0	3	1982	0.48	3.4	20.9	156.3	0.336
3-2459-20	32	-157.992	21.405	Waipio Heights P1 2000		60	55	7.6	54	2.2	14	49	7.5		6.9	3	2000	0.38	7.3	24.5	143.7	0.245
3-2459-01-5	32	-157.984	21.406	WP6A 1981		6	1400	150.0	520	12.0	170	940	5.8		130.0	3	1981	-6.64	9.3	43.3	104.4	0.121
3-2558-10	32	-157.971	21.418	Waiawa Shaft 1981		57	230	36.0	95	3.8	36	170	8.1		27.0	3	1981	0.22	6.4	25.0	142.2	0.157
3-2500-03	32	-158.008	21.419	Waiola Deep Monitor Well, 3 2001			470	45.0	160	9.0	84	340	6.5		60.0	3	2001		10.4	17.8	169.6	0.179
3-2500-01	32	-158.005	21.420	Waipio Heights II P1 2000		69	29	7.9	32	1.5	12	48	7.7		6.1	3	2000	0.81	3.7	21.1	155.3	0.414
3-2557-03	32	-157.955	21.426	Pearl City III 2000		43	15	6.9	13	0.9	3	49	7.9		8.1	3	2000	-0.66	2.2	15.0	184.6	0.178
3-2603-01	32	-158.056	21.436	Hawaii Country Club 1975		76	44	13.4	26	2.1	16	91	7.2		14.5	3	1975	1.11	3.2	12.6	201.4	0.375
3-2600-08	32	-158.005	21.440	Kipapa ST01MW07 2001		55	21	11.0	19	0.9	9	68	7.1		8.9	3	2001	0.09	1.9	20.5	157.6	0.420
3-2659-02	32	-157.992	21.440	Waipio Hts Wells III, no. 1 2001		57	16	6.3	18	1.4	5	44	7.6		7.1	3	2001	0.20	2.6	13.1	197.7	0.330
3-2600-03	32	-158.007	21.443	Mililani Wells III, no. 1		70	17	5.6	17	1.5	7	40	7.5		6.8	3	2000	0.83	3.0	11.3	212.4	0.392
3-2702-05	32	-158.035	21.456	Waikakalaua, Air Force ST12MW04		75	36	13.3	36	2.1	20	87	7.2		12.7	3	2001	1.05	2.7	17.4	171.3	0.558
3-2800-01	32	-158.001	21.467	Mililani I P1		65	16	6.1	13	1.3	5	44	6.6		7.4	3	1983	0.62	2.6	10.0	225.1	0.325
3-2859-02	32	-157.989	21.472	Mililani II P6		62	15	5.8	12	1.1	3	41	7.4		6.9	3	1999	0.48	2.6	11.5	210.2	0.226
3-2803-07	32	-158.054	21.472	Kunia Pump 4		70	17	7.0	17	1.4	6	50	7.4		8.3	3	2000	0.84	2.5	12.4	202.4	0.329
3-2858-03	32	-157.967	21.475	Mililani IV-11		45	18	7.6	14	0.9	4	56	8.2		9.8	3	1985	-0.50	2.4	15.6	181.3	0.206
3-2858-01	32	-157.967	21.475	Mililani IV-9		42	17	7.8	14	0.9	4	60	8.1		11.0	3	1984	-0.71	2.2	15.6	181.3	0.218
3-2858-02	32	-157.967	21.476	Mililani Mauka Wells IV		42	15	6.8	12	0.8	2	50	8.1		8.6	3	2000	-0.68	2.2	15.7	180.5	0.129
3-2409-007	33	-158.150	21.400	Maili	25.5	172	1410	61.0	680	18.2	232				96.0			3.48	23.1	37.4	113.9	0.165
3-2409-023	33	-158.150	21.400	Maili	25	157	1480	60.0	690	20.1	178					1	<1979	3.10	24.7	34.3	119.5	0.120
3-2508-001	33	-158.133	21.417	Lualualei	27	68	260	80.0								1	<1979	-0.35	3.3			
3-2508-002	33	-158.133	21.417	Lualualei	27.5	92	280	102.0								1	<1979	0.90	2.8			
3-2508-02	33	-158.133	21.417	Lualualei Shaft (bottom)	29	89	382	108.0	126	9.6	25		7.7		41.0	6		0.76	3.5	13.1	197.2	0.065
3-2508-007	33	-158.133	21.417	Lualualei	25.5	186	1330	81.0	380	12.8	59					6	<1979	3.80	16.4	29.7	129.6	0.044
3-2607-001	33	-158.117	21.433	Lualualei	24	96	41	12.0	41	2.8	58					6		1.07	3.4	14.6	186.9	1.415
3-2609-005	33	-158.150	21.433	Lualualei	24	41	141	50.0								1		-2.44	2.8			
3-2709-008	33	-158.150	21.450	Lualualei	26	165	147	9.6	92	2.6	22				11.0	6		3.31	15.3	35.4	117.5	0.150
3-2712-001	33	-158.200	21.450	Kamaile	24.5	94	143	39.0	50	3.7	14				17.0			0.99	3.7	13.5	194.4	0.098
3-2712-030	33	-158.200	21.450	Kamaile 1	25.5	75	97	34.0								1	<1979	0.06	2.9			

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
3-2808-001	33	-158.133	21.467	Lualualei	26.5	81	138	27.0	120	4.0	260				116.0	5		0.37	5.1	30.0	128.9	1.884
3-2808-002	33	-158.133	21.467	Lualualei Tunnel	19	58	23	6.5	19	3.0	33				11.0	6		-1.00	3.5	6.3	280.2	1.435
3-2809-005	33	-158.150	21.467	Waianae Valley		62	68	3.7	63	0.2	62					6		-0.73	18.3	315.0	11.3	0.916
3-2809-006	33	-158.150	21.467	Waianae Tunnel (Ent .)	22	73	26	29.0	27	2.7	34				21.0	6		-0.06	0.9	10.0	225.1	1.308
3-2809-006	33	-158.150	21.467	Waianae Tunnel(Ov.fl.)	20	51	15	10.0	16	3.3	28				12.0	6		-1.54	1.5	4.8	318.4	1.867
3-2811-002	33	-158.183	21.467	Makaha	25	81	49	24.0	34	3.5	3				21.0	6		0.37	2.0	9.7	228.3	0.062
3-2812-001	33	-158.200	21.467	Makaha Shaft	26.0	86	92	34.0	46	3.7	48				20.0	6		0.62	2.7	12.4	202.5	0.522
3-2908-002	33	-158.133	21.483	Waianae Tunnel	18.3	31	14	5.4	12	1.2	3.6		8.1		7.2	6		-3.59	2.6	10.0	225.1	0.257
3-2911-001	33	-158.183	21.483	Makaha Tunnel	20	73	24	12.0	21	2.8	3				13.0	6		-0.06	2.0	7.5	258.4	0.125
3-2912-001	33	-158.200	21.483	Makaha	25	66	92	30.0								1	<1979	-0.47	3.1			
3-2912-001	33	-158.200	21.483	Makaha			89	31.0	45	4.2	43					6			2.9	10.7	217.7	0.483
3-3013-009	33	-158.217	21.500	Ohikilolo	27	77	1900	170.0								1	<1979	0.16	11.2			
3-3213-006	33	-158.217	21.533	Makua	26.5	61	210	20.0								1	<1979	-0.80	10.5			
3-3314-001	33	-158.233	21.550	Keawaula		69	510	73.0								1	<1979	-0.29	7.0			
3-3314-002	33	-158.233	21.550	Keawaula	25.7	78	470	70.0								1	<1979	0.22	6.7			
3-3314-003	33	-158.233	21.550	Keawaula		68	290	44.0								1	<1979	-0.35	6.6			
3-2712-31	33	-158.200	21.450	Kamaile Well		74	83	30.0	50	3.7	14	171	7.4	451	17.0	4		0.00	2.8	13.5	194.4	0.169
3-2712-30	33	-158.200	21.450	Kamaile Well lookup		75	97	30.0	55	4.1	16	183	7.1	492	19.0	4		0.06	3.2	13.4	195.1	0.165
3-2912-01	33	-158.200	21.483	Makaha Well		56	91	30.0	34	3.5	15	153	7.2	420	30.0	4		-1.15	3.0	9.7	228.3	0.165
3-2812-01	33	-158.200	21.467	Makaha Shaft #1		71	100	33.2	46	4.0	14.3	157	7.2	452	19.4	4		-0.17	3.0	11.5	210.1	0.143
3-2911-03	33	-158.183	21.483	Makaha Well		56	91	30.0	34	3.5	15	153	7.2	420	30.0	4		-1.15	3.0	9.7	228.3	0.165
3-2911-04	33	-158.183	21.483	Makaha VI		40	64	21.0	37	3.8	11	129	7.2	330	17.0	4		-2.54	3.0	9.7	228.0	0.172
3-2607-01	33	-158.120	21.443	Lualualei, Iwo Jima Road			9	38.0	3	46.0	65	13	8.2		12.0	3	1975		0.2	0.1	-4734.1	7.647
3-2712-30	33	-158.200	21.459	Kamaile P1		80	82	30.0	48	4.3	14	170			17.0	3	1976	0.32	2.7	11.2	213.4	0.171
3-3213-07	33	-158.226	21.537	MAKUA		74	180	17.0	110	2.7	29	105	7.5		14.0	3	1987	0.00	10.6	40.7	108.3	0.161
3-3405-001	34	-158.083	21.567	Waialua	21.8	63	94	15.1								1	<1979	-0.17	6.2			
3-3404-002	34	-158.067	21.567	Waialua	21.1	62	25	5.3								1	<1979	-0.38	4.7			
3-3405-002	34	-158.083	21.567	Waialua	23	70	120	8.0								1	<1979	0.67	15.0			
3-3406-002	34	-158.100	21.567	Waialua	21.6	70	95	12.0								1	<1979	0.67	7.9			
3-3406-003	34	-158.100	21.567	Waialua	22.3	74	98	11.0								1	<1979	1.13	8.9			
3-3406-005	34	-158.100	21.567	Waialua	23.4	79	145	21.0								1	<1979	1.67	6.9			
3-3406-006	34	-158.100	21.567	Waialua	22.8	75	126	15.0								1	<1979	1.24	8.4			
3-3406-008	34	-158.100	21.567	Caprock 17		70	94	12.0								1	<1979	0.67	7.8			
3-3407-002	34	-158.117	21.567	Waialua	22.3	72	112	14.0								1	<1979	0.91	8.0			
3-3407-072	34	-158.117	21.567	Waialua II	22	60	135	20.0								1	<1979	-0.60	6.8			
3-3407-030	34	-158.117	21.567	Waialua	24.7	36	745	57.0								1	<1979	-4.81	13.1			
3-3409-013	34	-158.150	21.567	Mokuleia	22.4	56	205	32.0								1	<1979	-1.16	6.4			
3-3409-016	34	-158.150	21.567	Mokuleia	22.5	57	180	32.0								1	<1979	-1.02	5.6			
3-3505-001	34	-158.083	21.583	Opaeula P3	22	71	73	9.1								1	<1979	0.79	8.2			
3-3506-003	34	-158.100	21.583	Haleiwa	21.5	72	98	10.0								1	<1979	0.91	9.8			
3-3506-006	34	-158.100	21.583	Haleiwa	22.1	71	92	13.0								1	<1979	0.79	7.1			
3-3605-003	34	-158.083	21.600	Kawailoa 4	21	64	590	33.0								1	<1979	-0.06	17.9			
3-3605-015	34	-158.083	21.600	Kawailoa 4	21.6	64	370	24.0								1	<1979	-0.06	15.4			
3-3605-016	34	-158.083	21.600	Kawailoa 4	21.5	64	420	28.0								1	<1979	-0.06	15.0			
3-3605-021	34	-158.083	21.600	Kawailoa 4	21.5	65	390	22.0								1	<1979	0.06	17.7			

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
3-3605-023	34	-158.083	21.600	Kawailoa P4	21.6	65	335	22.0								1	<1979	0.06	15.2			
3-3704-001	34	-158.067	21.617	Meadow Gold	21.8	64	490	35.0								1	<1979	-0.06	14.0			
3-3405-03	34	-158.083	21.567	Haleiwa Wells Pump 1		51	46	8.2	53	2.9	17	89	7.2	288	6.1	4		-1.94	5.6	18.3	167.2	0.370
3-3405-04	34	-158.083	21.567	Haleiwa Wells Pump 2		49	46	8.3	49	2.8	16	88	7.1	283	8.6	4		-2.27	5.5	17.5	170.9	0.348
3-4002-04	34	-158.033	21.667	Sunset Beach Well		58	148	18.1	90	2.4	32.2	73	6.9	438	13.2	4		-0.88	8.2	37.3	114.0	0.218
3-3307-19	34	-158.119	21.552	WAIALUA		63	38	19.0	36	2.2	13	126	8.4		19.0	3	1985	-0.19	2.0	16.4	176.8	0.342
3-3307-21	34	-158.117	21.557	Thompson Corner Exp. Well II		69	35	7.0	61	1.9	13	45	7.8		6.4	3	2001	0.50	5.1	32.4	123.4	0.364
3-307- 01 6,8, 9,10	34	-158.121	21.558	Waialua Sugar Pump 2		66	110	16.9	79	3.4	23	106	7.4		14.5	3	2000	0.23	6.5	23.3	147.5	0.211
3-3309-02	34	-158.152	21.558	Mokuleia Ex. Well		62	200	31.0	77	5.0	25	233	7.3		42.0	3	1994	-0.33	6.5	15.4	182.2	0.125
3-3405-02	34	-158.093	21.571	Waialua P2		75	43	7.8	44	2.5	14	52	7.4		8.1	3	2014	1.22	5.5	17.9	168.9	0.326
3-3409-16	34	-158.152	21.573	Mokuleia		53	160	35.0	59	4.6	30	240			37.0	3	1975	-1.62	4.6	12.8	199.5	0.188
3-3404-02	34	-158.075	21.575	S17		15	21	6.1	25	1.8	10	53			11.0	3	1975	-12.02	3.4	13.9	191.8	0.476
3-3405-04	34	-158.091	21.575	Haleiwa P2		69	43	7.8	44	2.2	14	52	7.5		8.2	3	2014	0.58	5.6	20.3	158.4	0.317
3-3505-26	34	-158.086	21.585	Opaeula Exp. Well		68	37	7.3	40	2.7	1	48	7.5		7.2	3	2001	0.40	5.1	14.9	185.0	0.027
3-3505-25	34	-158.084	21.591	North Lower Anahulu Exp. Well		66	95	11.3	63	3.2	18	70	7.7		9.5	3	2001	0.21	8.4	19.7	161.1	0.188
3-4101-07	34	-158.021	21.687	Waialee I P1		48	50	9.0	29	1.4	8	64	7.9		10.0	3	2000	-2.50	5.5	20.9	156.3	0.153
3-2042-013	35	-157.700	21.333	Waimanalo	25	26	1500	110.0								1	<1979	-1.22	13.6			
3-2043-001	35	-157.717	21.333	Waimanlo	30	22	24	2.8	28	1.1	22	84	7.3	7.3	14.0	5		-1.79	8.6	25.5	140.8	0.917
3-2043-002	35	-157.717	21.333	Waimanalo	25	36	27	6.8								1	<1979	-0.13	4.0			
3-2142-003	35	-157.700	21.350	Bellows AFB	26.1		238									1	<1979					
3-4157-003	35	-157.950	21.683	Meadow Gold	26		208	17.0								1	<1979		12.2			
3-4158-012	35	-157.967	21.683	Kahuku Air Base	25	48	350	52.6								1	<1979	0.90	6.7			
3-3353-01	35	-157.883	21.550	Kahana Wells Pump1		31	26	8.8	21	1.8	6.9	90	7.9	201	14.0	4		-0.61	3.0	11.7	208.9	0.265
	35			Haiku Tunnel		21	15	3.9	11	0.8	2.5	39.5	8.3	100	6.2	4			3.7	13.5	194.5	0.172
3-2450-02	35	-157.833	21.400	Haiku Well		28	14	4.6	11	1.0	3.2	46		116	6.8	4		-0.96	3.0	11.0	215.0	0.229
3-3655-01	35	-157.917	21.600	Hauula Well		34	36	7.6	25	1.2	4.9	70	7.9	190	10.6	4		-0.29	4.7	21.0	155.8	0.136
3-2549-01	35	-157.817	21.417	Iolekaa Well		38	16	6.5	15	0.9	4.1	66	7.7	156	8.5	4		0.09	2.5	16.7	175.2	0.256
3-2651-03	35	-157.850	21.433	Kahaluu Well		31	21	7.5	16	1.4	4.2	74	8.2	167	11.0	4		-0.61	2.8	11.4	211.0	0.200
3-4057-15	35	-157.950	21.667	Kahuku Well No. 1		46	36	7.5	31	0.8	7	70	7.4	213	8.6	4		0.75	4.8	38.8	111.5	0.194
3-4057-16	35	-157.950	21.667	Kahuku Well No. 2		45	59	11.0	43	1.0	9.3	78	7.4	269	11.0	4		0.67	5.4	43.0	104.9	0.158
3-3655-03	35	-157.917	21.600	Kaipapau Well		26	24	7.8	20	1.1	4.8	82	7.9	178	12.0	4		-1.22	3.1	18.2	167.7	0.200
3-3554-04	35	-157.900	21.583	Kaluanui Expl. Well		33	29	7.0	19	1.2	4.7	68	8.2	174	11.0	4		-0.39	4.1	15.8	179.7	0.162
3-2348-06	35	-157.800	21.383	Kuou III		25	16	6.4	29	1.1	5.8	115	8.0	212.2	14.0	4		-1.35	2.5	26.1	139.0	0.363
3-2349-02	35	-157.817	21.383	Luluku Exp. Well		25	18	6.6	14	1.1	3.7	68	8.5	149	11.0	4		-1.35	2.7	12.7	200.2	0.206
3-3655-02	35	-157.917	21.600	Maakua 1		28	30	7.8	23	1.4	5.3	73	8.2	179	9.9	4		-0.96	3.8	16.4	176.5	0.177
3-3553-02	35	-157.883	21.583	Punaluu I		30	36	6.5	22	1.2	4.9	55	8.0	167	10.3	4		-0.72	5.5	18.4	166.6	0.136
3-3553-07	35	-157.883	21.583	Punaluu II		45	27	7.0	23	1.5	4.7	73	8.1	191	9.5	4		0.67	3.9	15.1	184.2	0.174
3-3453-07	35	-157.883	21.567	Punaluu II		27	42	8.5	20	1.3	6.1	49	8.1	166	11.0	4		-1.09	4.9	15.4	182.3	0.145
3-2042-13	35	-157.704	21.340	W420-1A WA		26	220	110.0	920	36.0	1720	830	150.0			3		-1.22	2.0	25.6	140.5	7.818
3-2550-01	35	-157.834	21.426	Heeia, 1975		30	19	4.3	13	0.6	3	34			6.6	3	1975	-0.72	4.4	21.7	153.3	0.179
3-3251-01	35	-157.850	21.541	W406		44	230	24.0	120	5.7	32	170			30.0	3	1974	0.60	9.6	21.1	155.5	0.139
3-3353-04	35	-157.886	21.552	KAHANA 2		39	28	8.3	22	1.2	5	79			18.0	3	1975	0.18	3.4	18.3	167.0	0.161
3-3353-02	35	-157.885	21.553	Kahana I-1		40	26	8.8	20	1.8	4	71			14.0	3	1975	0.27	3.0	11.1	213.9	0.142

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	S04	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	S04/CL
3-3352-01	35	-157.874	21.555	Kahana 1 P2		39	38	8.8	28	1.4	7	69			13.0	3	1972	0.18	4.3	20.0	159.7	0.182
3-3453-06	35	-157.891	21.573	Punaluu III P1		37	33	7.9	17	1.4	6	63			12.0	3	1975	0.00	4.2	12.1	204.9	0.167
3-3453-07	35	-157.891	21.573	Punaluu III P2		38	40	7.9	18	1.5	6	65			13.0	3	1974	0.09	5.1	12.0	206.1	0.150
3-3553-07	35	-157.891	21.586	Punaluu II P1 (W402-2D		45	53	10.0	24	1.4	8	81			16.0	3	1975	0.67	5.3	17.1	172.7	0.142
3-3655-01	35	-157.917	21.609	Hauula		37	32	8.3	25	1.0	4	59			10.0	3	1975	0.00	3.9	25.0	142.2	0.138
3-3856-06	35	-157.934	21.639	Quarry W-F (W377-F),		38	35	9.1	24	1.1	5	70			13.0	3	1975	0.09	3.8	21.8	152.7	0.140
3-3956-04	35	-157.936	21.650	Laie		45	63	12.0	36	1.2	10	89			16.0	3	1975	0.67	5.3	30.0	128.9	0.159
3-4057-01	35	-157.950	21.667	Kahuku P1 (W353A),		48	83	19.0	38	1.5	14	140			25.0	3	1975	0.90	4.4	25.3	141.2	0.169
3-4057-05	35	-157.951	21.676	Kahuku		1	330	33.0	82	3.4	1	290			62.0	3	1975	-12.12	10.0	24.1	144.9	0.003
3-4100-01	35	-158.000	21.693	Turtle Bay Golf Course		45	360	51.0	140	5.2	50	320			47.0	3	1975	0.67	7.1	26.9	136.7	0.139
3-4258-04	35	-157.973	21.706	Kahuku Air Field		41	535	70.0	120	4.3	40	590			120.0	3	1975	0.35	7.6	27.9	134.0	0.075
3-2901-001	36	-158.017	21.483	Schofield B	21.6	69	19	7.2								1	<1979	0.63	2.6			
3-2901-002	36	-158.017	21.483	Schofield B	23	64	18	7.4								1	<1979	0.56	2.4			
3-2901-007	36	-158.017	21.483	Schofield	23	69	19	7.2								1	<1979	0.63	2.6			
3-2901-008	36	-158.017	21.483	Wahiawa	22.7	72	19	6.4								1	<1979	0.67	3.0			
3-2901-009	36	-158.017	21.483	Wahiawa	21.5	74	21	7.8								1	<1979	0.70	2.7			
3-2901-011	36	-158.017	21.483	Wahiawa	21.5	74	19	7.0								1	<1979	0.70	2.7			
3-2902-001	36	-158.033	21.483	Wahiawa Expl.	23	81	17	6.1								1	<1979	0.79	2.8			
3-3102-002	36	-158.033	21.517	Helemano	21.1	72	18	7.7								1	<1979	0.67	2.3			
3-3203-001	36	-158.050	21.533	Halemanu P25	22	69	19	6.9								1	<1979	0.63	2.8			
3-2902-02	36	-158.033	21.483	Wahiawa II Well 2		55	18	7.9	19	1.6	8.7	73	7.0	199	10.0	4		0.40	2.3	11.9	207.1	0.483
3-2902-01	36	-158.033	21.483	Wahiawa Well		72	18	7.2	18	1.4	9.4	61	7.1	202	8.7	4		0.67	2.5	12.9	199.2	0.522
3-2902-02	36	-158.033	21.483	Wahiawa II Well 2		55	18	7.9	19	1.6	18	73	7.0	199	10.0	4		0.40	2.3	11.9	207.1	1.000
3-2901-12	36	-158.017	21.483	Wahiawa Well #4(New no. 2)		72	21	8.3	15	1.3	4.9	63	6.9	202	9.7	4		0.67	2.5	11.5	210.0	0.233
3-2901-08	36	-158.017	21.483	Wahiawa Wells Pump 3		53	20	7.8	15	1.5	6.5	61	6.9	181	9.6	4		0.36	2.6	10.0	225.1	0.325
3-2802-01	36	-158.041	21.471	Schofield MW2-6		76	21	8.5	22	1.5	14	61	7.1		10.3	3	2001	0.72	2.5	14.3	189.2	0.662
3-2902-03	36	-158.042	21.484	Schofield MW2-3		79	19	5.6	25	1.5	12	41	7.1		7.2	3	2000	0.77	3.3	17.0	173.4	0.656
3-2959-01	36	-157.987	21.489	Schofield MW2-5		60	18	6.8	12	0.6	4	47	7.3		7.5	3	2001	0.49	2.6	20.5	157.7	0.223
3-2901-12	36	-158.024	21.491	Wahiawa I P2		80	20	8.6	17	1.4	4	63	7.1		10.9	3	2004	0.78	2.3	12.3	204.0	0.226
3-2901-11	36	-158.024	21.491	Wahiawa I P1 (W330-9		80	19	8.4	17	1.4	5	61	6.2		10.4	3	2014	0.79	2.2	12.3	203.4	0.251
3-3100-02	36	-158.003	21.519	Wahiawa Deep		71	18	8.0	14	1.2	3	55	7.2		8.9	3	2000	0.66	2.2	11.4	210.9	0.153
3-3103-01	36	-158.060	21.519	Poamoho P5		81	17	5.8	20	1.4	13	43	7.5		7.6	3		0.79	2.9	14.3	189.2	0.765
3-3406-14	36	-158.104	21.576	Helemano Exp. Well I		67	69	10.0	50	2.7	20	89	7.9		19.2	3	2001	0.60	6.9	18.5	166.3	0.290
				Haiku Tunnel		21	15	3.9	11	0.8	2.5	39.5	8.3		6.2	4			3.7	13.5	194.5	0.172
				Kahaluu Tunnel		23	15	4.3	11	0.9	2.4	44	8.3		7.2	4			3.5	12.0	206.1	0.160
				Waihee Tunnel		28	18	5.2	13	1.3	2.8	53	7.9		8.1	4			3.5	10.3	221.8	0.156
		0.000		Kaimuki High Service		28	84	10.0	61	3.0	13	82	8.3	293	9.9	4			8.4	20.3	158.4	0.155
		0.000		Kalihi Low Service		38	80	15.0	44	2.4	14	76	8.1	289	14.0	4			5.3	18.3	167.0	0.175
		0.000		Kalihi Shaft		36	81	15.0	39	2.2	15	65	7.9	269	14.0	4			5.4	17.7	169.8	0.185
				Waimanalo Tunnel 1		32	24	6.2	17	1.2	3.7	66	7.5	161	11.0	4			3.8	14.3	188.9	0.157
				Waimanalo Tunnel 4		26	18	5.1	14	1.1	2.9	53.5	8.2	129	8.5	4			3.5	12.4	203.1	0.161
				KuouNo. 416-2		34	22	6.5	17	1.5	3.6	76.5	7.8	174	12.9	4			3.3	11.2	213.1	0.167
				Luluku Tunnel		24	17	4.5	12	1.0	2.7	47.5	8.2	117	8.0	4			3.7	11.9	206.9	0.164
4-0449-001	41	-156.817	21.067	Ualapue	20.0	47	65	7.7								1	<1979	0.35	8.4			
4-0457-01	41	-156.950	21.067	Kawela	22.5	32	58	11.0								1	<1979	-2.69	5.3			
4-0449-01	41	-156.817	21.067	Ualapue Shaft		47	53	7.7	39	3.7	8	55			9.2	3		0.35	6.9	10.5	219.4	0.145

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
4-0457-01	41	-156.950	21.067	Kawela Shaft (S4)		32	82	11.0	38	3.6	12	78			13.0	3		-2.69	7.5	10.6	219.3	0.146
4-0603-001	42	-157.050	21.100	Umipaa DW 14	24.5	53	750	55.0								1	<1979	1.29	13.6			
4-0700-001	43	-157.000	21.117	Kaluakoi	23.0	49	440	36.0								1	<1979	0.67	12.2			
4-1011-001	43	-157.183	21.167	Kahalelani	33.9		2890	395.0	820		244	44	7.3		393.0	5			7.3			0.084
4-0801-001	44	-157.017	21.133	Kauluwai	21.0	44	62	9.7								1	<1979	-0.18	6.4			
4-0901-001	44	-157.017	21.150	Kalualohe	19.5	47	56	8.0								1	<1979	0.35	7.0			
4-0902-001	44	-157.033	21.150	Kualapuu		39	340	64.8								1	<1979	-1.17	5.3			
4-0601-01	44	-157.017	21.100	Kaunakakai		28	30	11.0	25	1.7	5	78			13.0	3		-3.75	2.7	14.7	186.5	0.170
4-0603-01	44	-157.050	21.100	D 14		53	650	55.0	320	28.0	363	370			57.0	3		1.29	11.8	11.4	211.0	0.558
4-0700-01	44	-157.000	21.117	Kakalahale		49	470	36.0	240	15.0	58	200			22.0	3		0.67	13.1	16.0	178.8	0.123
4-0855-06	45	-156.917	21.133	Waikolu 4		33	11	3.3	9	1.4	2	30	8.1		6.6	3		-2.45	3.3	6.4	278.2	0.182
4-0801-01	45	-157.017	21.133	Kauluwai (DHHL 1)		44	58	9.7	30	2.8	13	62			8.8	3		-0.18	6.0	10.7	217.7	0.224
4-0801-02	45	-157.017	21.133	Kauluwai (DHHL2)		43	76	15.0	30	3.1	24	92			12.0	3		-0.36	5.1	9.7	228.7	0.316
4-0801-03	45	-157.017	21.133	Kualapuu Mauka		46	64	11.0	33	3.0	11	69	8.2		9.6	3		0.18	5.8	11.0	215.0	0.172
4-0901-01	45	-157.017	21.150	Kahanui, Well 17		47	60	8.0	21	2.8	7	52			7.8	3		0.35	7.5	7.5	258.4	0.118
4-1058-01	45	-156.967	21.167	NATIONAL PARK, KALAUPAPA		30	22	5.2	17	1.8	4	43	8.5		8.7	3		-3.20	4.2	9.4	231.4	0.177
6-3625-001	61	-156.417	20.600	La Perouse Bay	22.5	85	1482	178.0								1	<1979	1.83	8.3			
6-3726-02	61	-156.433	20.617	Glenn Fultz	23.5		1470	162.0								1	<1979		9.1			
6-3726-003	61	-156.433	20.617	Hunter's	24.5	87	1435	172.0								1	<1979	1.89	8.3			
6-3925-001	61	-156.417	20.650	Makena 68	20	41	500	64.2								1	<1979	-0.18	7.8			
6-3925-001	61	-156.417	20.650	Makena	20.4		621	66.0								1	<1979		9.4			
6-4019-001	61	-156.317	20.667	Poli Poli Tunnel			2	1.8		12.4	29		7.1		15.4				1.2	0.0		13.619
6-4020-002	61	-156.333	20.667	Cornwall	11.8		6	3.6								1	<1979		1.6			
6-4021-001	61	-156.350	20.667	Waikaahi	14.0		4	3.6								1	<1979		1.0			
6-4021-002	61	-156.350	20.667	Waihau Tunnel	13.0		10	5.0								1	<1979		1.9			
6-4022-004	61	-156.367	20.667	Waikaalo Tunnel	11.8		2	3.4								1	<1979		0.6			
6-4126-002	61	-156.433	20.683	Wailea 2	19	45	460	28.0								1	<1979	0.08	16.4			
6-4627-014	61	-156.450	20.767	TMK 3-9-01-3	23	59	280	18.0								1	<1979	0.82	15.6			
6-4727-001	61	-156.450	20.783	Kihei Shaft	24	48	575	64.0		378.0	314		6.9		194.0			0.26	9.0	0.0		0.546
6-4824-001	61	-156.400	20.800	Kihei Explor'y	24	57	73	18.0		2.4	74		6.8		844.0			0.73	4.1	0.0		1.014
6-4824-001	61	-156.400	20.800	Kihei Explor'y	23.2	32	81	21.0		2700.0			4.5		920.0			-0.86	3.9	0.0		
6-4825-001	61	-156.417	20.800	Kihei Shaft 15	23	58	340	35.0		3600.0				22157	2400.0			0.78	9.7	0.0		
6-4126-02	61	-156.433	20.683	Wailea 2 (W78-1)		45	590	53.0	325	21.0	93	300			33.0	3		0.08	11.1	15.5	181.8	0.158
6-4326-09	61	-156.433	20.717	Kihei Maui Vista		33	612	34.4	360	25.6	84	191	7.8		19.7	3		-0.76	17.8	14.1	190.6	0.137
6-4327-08	61	-156.450	20.717	Kalama Beach Well A1		33	132	97.6	696	42.0	188	548	7.8		58.3	3		-0.78	1.4	16.6	175.7	1.424
6-4327-09	61	-156.450	20.717	Kalama Beach Well A2		35	1410	95.8	739	46.2	198	531	7.9		54.5	3		-0.62	14.7	16.0	178.8	0.140
6-4327-10	61	-156.450	20.717	Kalama Beach Well A3		26	13500	874.0	6310	281.0	1960	4380	7.5		310.0	3		-1.44	15.4	22.5	150.4	0.145
6-4427-06	61	-156.450	20.733	Kihei Fire Well B1		36	668	62.3	445	29.9	151	448	7.4		76.3	3		-0.55	10.7	14.9	185.4	0.226
6-4427-07	61	-156.450	20.733	Kihei Fire Well B2		45	803	56.4	424	29.6	120	320	7.4		34.9	3		0.10	14.2	14.3	188.9	0.149
6-4427-08	61	-156.450	20.733	Kihei Fire Well B3		38	3520	306.0	1740	112.0	514	1600	6.9		136.0	3		-0.36	11.5	15.5	181.5	0.146
6-4427-04	61	-156.450	20.733	Waiohuli Homesteads		43	778	61.4	478	33.4	119	399	7.6		58.0	3		-0.08	12.7	14.3	189.0	0.153
6-4426-03	61	-156.433	20.733	Kihei Maui R&T Park		35	412	22.2	258	18.6	56	121	7.3		11.6	3		-0.58	18.6	13.9	191.9	0.137
6-4627-14	61	-156.450	20.767	Waiakea Homesteads		60	295	21.0	240	20.0	47	120			13.0	3		0.87	14.0	12.0	206.1	0.159
6-4835-001	62	-156.583	20.800	Ukumehame	33	60	400	29.0								1		1.55	13.8			
6-4835-001	62	-156.583	20.800	Ukumehame	33.1	46	459	26.0								1	<1979	0.12	17.7			
6-4835-001	62	-156.583	20.800	Ukumehame	33.0	71	437	22.1	206	18.8	44	116	7.4		62.0	1		2.46	19.8	11.0	215.4	0.101
6-4837-001	62	-156.617	20.800	Olowalu	25.5	45	460	67.0		9.3	27.3		6.7		4.5			0.00	6.9	0.0		0.059
6-4837-001	62	-156.617	20.800	Olowalu	26	40	676	96.0								1	<1979	-0.63	7.0			

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	SiO2	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
6-4937-001	62	-156.617	20.817	Olowalu Sh 10	26	52	1400	120.0								1	<1979	0.78	11.7			
6-4937-001	62	-156.617	20.817	Olowalu Sh 10	26		669	78.0		28.0	211		7.8		37.6				8.6	0.0		0.315
6-5240-001	62	-156.667	20.867	Mill Pump c	24.5	55	980	111.0								1	<1979	1.08	8.8			
6-5240-001	62	-156.667	20.867	Mill Pump.C	26.8	39	1030	119.0								1	<1979	-0.77	8.7			
6-5240-002	62	-156.667	20.867	Lahaina A		40	1360	140.0								1	<1979	-0.63	9.7			
6-5240-003	62	-156.667	20.867	Lahaina B	28.0	60	600	109.0								1	<1979	1.55	5.5			
6-5240-003	62	-156.667	20.867	Lahaina B	24.9	37	1040	132.0								1	<1979	-1.06	7.9			
6-5339-001	62	-156.650	20.883	Lahaina 1	22	57	290	27.0								1	<1979	1.27	10.8			
6-5339-002	62	-156.650	20.883	Lahaina 2	20.0	57	200	30.0								1	<1979	1.27	6.7			
6-5339-003	62	-156.650	20.883	Kanaha 1	20	42	260	19.0								1	<1979	-0.37	13.7			
6-5339-004	62	-156.650	20.883	Kanaha 2	21	44	11	5.7								1	<1979	-0.12	1.9			
6-5339-004	62	-156.650	20.883	Kanaha 2	20.3	32	403	37.0								1	<1979	-1.84	10.9			
6-5340-001	62	-156.667	20.883	Wahikula 1	24.5	45	410	62.0								1	<1979	0.00	6.6			
6-5340-001	62	-156.667	20.883	Wahikula 1	25.2	32	1180	174.0								1	<1979	-1.84	6.8			
6-5340-002	62	-156.667	20.883	Kahona Sh 5	25	61	1100	23.0								1	<1979	1.64	47.8			
6-5340-002	62	-156.667	20.883	Kahona Sh 5	23.6	36	1070	102.0								1	<1979	-1.20	10.5			
6-5540-001	62	-156.667	20.917	Puukolii	23.3	49	362	34.0								1	<1979	0.46	10.7			
6-5540-001	62	-156.667	20.917	Puukolii	21.8	40	582	62.0								1	<1979	-0.63	9.4			
6-5540-002	62	-156.667	20.917	Hahakea 1		54	340	34.0								1	<1979	0.98	10.0			
6-5540-003	62	-156.667	20.917	Hahakea 2		46	149	20.0								1	<1979	0.12	7.5			
6-5640-001	62	-156.667	20.933	Honokowai	20.5	45	250	14.0								1	<1979	0.00	17.9			
6-5641-001	62	-156.683	20.933	Kaanapali D	22	50	850	56.0								1	<1979	0.57	15.2			
6-5641-001	62	-156.683	20.933	Kaanapali D	22.9	44	1530	149.0								1	<1979	-0.12	10.3			
6-5641-002	62	-156.683	20.933	Honokowai F	23	50	975	70.0								1	<1979	0.57	13.9			
6-5641-002	62	-156.683	20.933	Honokowai F	22.7	36	1470	128.0								1	<1979	-1.20	11.5			
6-5838-001	62	-156.633	20.967	Napili 1	21	51	148	13.0								1	<1979	0.67	11.4			
6-5840-001	62	-156.667	20.967	Alaeloa	21.1	53	352	10.8								1	<1979	0.88	32.6			
6-5840-001	62	-156.667	20.967	Alaeloa	21		291	20.0								1	<1979		14.6			
6-4937-01	62	-156.617	20.817	Olowalu Pump N (S10)		51	845	91.0	320	12.0	96	700			132.0	3		0.67	9.3	26.7	137.4	0.114
6-5138-01	62	-156.633	20.850	Launiupoko 1		60	170	24.0	66	6.2	24	150			22.0	3		1.55	7.1	10.6	218.4	0.141
6-5641-01	62	-156.683	20.933	Lahaina Sewage Treatment Plant		30	1800	140.0	840	19.0	250	980			160.0	3		-2.19	12.9	44.2	103.2	0.139
6-5739-01	62	-156.650	20.950	Kaanapali P-4		40	120	14.0	62	3.8	17	98	8.2		16.0	3		-0.63	8.6	16.3	177.1	0.142
6-5838-04	62	-156.633	20.967	Napili C		41	34	5.7	22	2.4	8	48			9.8	3		-0.50	6.0	9.2	234.7	0.238
6-5838-03	62	-156.633	20.967	Honokahua A		40	90	9.2	50	4.0	17	80			17.0	3		-0.63	9.8	12.5	202.0	0.189
6-5330-005	63	-156.500	20.883	Wailuku Sh 33	20.5	53	51	11.0								1	<1979	0.83	4.6			
6-5330-006	63	-156.500	20.883	Mokuhau Thl		50	42	14.1								1	<1979	0.63	3.0			
6-5330-009	63	-156.500	20.883	Mokuhau 1	23	31	85	10.0								1	<1979	-1.05	8.5			
6-5330-009	63	-156.500	20.883	Mokuhau 1	24	38	82	16.0								1	<1979	-0.33	5.1			
6-5330-010	63	-156.500	20.883	Mokuhau 2	22	53	74	13.0								1	<1979	0.83	5.7			
6-5330-010	63	-156.500	20.883	Mokuhau 2	23.6	36	158	23.0								1	<1979	-0.52	6.9			
6-5330-011	63	-156.500	20.883	Mokuhau 3	22	76	43	13.0								1	<1979	2.09	3.3			

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
6-5330-011	63	-156.500	20.883	Mokuhau 3	23.5	38	48	14.0								1	<1979	-0.33	3.4			
6-5430-001	63	-156.500	20.900	Waiehu Heights 1		54	53	11.0								1	<1979	0.90	4.8			
6-5430-001	63	-156.500	20.900	Waiehu Heights 1	23.5	38	45	7.2								1	<1979	-0.33	6.3			
6-5430-002	63	-156.500	20.900	Waiehu Heights 2	23.9	46	13	5.4								1	<1979	0.33	2.4			
6-5731-001	63	-156.517	20.950	Mende	22.8		25	8.9								1	<1979		2.8			
6-5130-02	63	-156.500	20.850	Waikapu 2		34	16	9.5	74	3.6	9	69			12.0	3		-0.72	1.7	20.6	157.5	0.563
6-4928-002	64	-156.467	20.817	Puunene		44	390	45.0								1	<1979	-0.67	8.7			
6-5021-001	64	-156.350	20.833	Pukalani	21.0	43	480	103.0								1	<1979	-0.78	4.7			
6-5128-002	64	-156.467	20.850	Waikapu	24	51	410	42.0								1	<1979	0.00	9.8			
6-5130-002	64	-156.500	20.850	Waikapu 2	21	21	34	16.0								1	<1979	-4.06	9.5			
6-5130-002	64	-156.500	20.850	Waikapu 2	21	34	16	9.5								1	<1979	-1.85	1.7			
6-5130-002	64	-156.500	20.850	Waikapu 2	21.6	32	36	13.0								1	<1979	-2.19	2.8			
6-5224-001	64	-156.400	20.867	Haiku Ditch	23	59	287	36.0								1	<1979	0.67	8.0			
6-5224-002	64	-156.400	20.867	Puunene 9	23.8	62	390	31.0								1	<1979	0.89	12.6			
6-5226-001	64	-156.433	20.867	Puunene 5	26	59	477	62.0								1	<1979	0.67	7.7			
6-5226-002	64	-156.433	20.867	Puunene 6	23.5	56	376	34.0								1	<1979	0.43	11.1			
6-5228-006	64	-156.467	20.867	Passion Acre		46	113	19.3								1	<1979	-0.51	5.9			
6-5229-001	64	-156.483	20.867	Waiale	22	61	260	32.0								1	<1979	0.82	8.1			
6-5323-001	64	-156.383	20.883	Paia 2A	22	56	448	46.0								1	<1979	0.43	9.7			
6-5323-001	64	-156.383	20.883	Paia 2A	22.8		543	47.9								1	<1979		11.3			
6-5328-001	64	-156.467	20.883	Cannery Shaft	22	47	159	26.0								1	<1979	-0.37	6.1			
6-5329-004	64	-156.483	20.883	Mem.Gym	22.0	42	300	37.0								1	<1979	-0.89	8.1			
6-5422-001	64	-156.367	20.900	Paia Mill 13A	22.5		531	53.0								1	<1979		10.0			
6-5422-002	64	-156.367	20.900	Paia Pump 17	21.2		316	33.3								1	<1979		9.4			
6-5423-001	64	-156.383	20.900	Kailua Gulch Country Club	23.2	99	706	56.4								1	<1979	3.03	12.5			
6-5423-002	64	-156.383	20.900	Low Paia 16D	25	51	342	40.0								1	<1979	0.00	8.5			
6-5423-002	64	-156.383	20.900	Low Paia 16D	23.5	102	1572	123.0								1	<1979	3.17	12.8			
6-5424-001	64	-156.400	20.900	Sprecklesville	23	66	640	37.0								1	<1979	1.18	17.3			
6-5522-001	64	-156.367	20.917	Kuau Pump 12	23	52	300	17.0								1	<1979	0.09	17.7			
6-5522-001	64	-156.367	20.917	Kuau Pump 12	21.3		295	18.0								1	<1979		16.4			
6-5128-02	64	-156.467	20.850	Waikapu Shaft (S16),		51	420	37.0	325	15.0	66	240			33.0	3		0.00	11.4	21.7	153.3	0.157
6-5319-001	65	-156.317	20.883	Silveno Spring	19.8		17	4.1								1	<1979		4.2			
6-5321-001	65	-156.350	20.883	Kaheka 18	21.0	5	76	11.0								1	<1979	-10.44	6.9			
6-5321-001	65	-156.350	20.883	Kaheka 18	20.5		431	32.5								1	<1979		13.3			
6-5419-001	65	-156.317	20.900	Haiku	22		26	6.6								1	<1979		4.0			
6-5420-001	65	-156.333	20.900	Maui High	22.2	53	100	4.7								1	<1979	1.22	21.3			
6-5420-001	65	-156.333	20.900	Maui High	21.5		44	3.3								1	<1979		13.6			
6-5519-001	65	-156.317	20.917	Pauwela (Haiku School)	19.1		130	'14.6								1	<1979		8.9			
6-5519-002	65	-156.317	20.917	Haiku (Behnke)		41	21	1.0								1	<1979	-0.13	21.0			
6-5519-002	65	-156.317	20.917	Haiku (Behnke)	23.5		18	0.8								1	<1979		21.6			
6-5520-001	65	-156.333	20.917	Maliko II	20.5		887	64.5								1	<1979		13.8			
6-5615-001	65	-156.250	20.933	Jeremy Storm	23.5		38	4.2								1	<1979		9.1			
6-5620-001	65	-156.333	20.933	Maliko Tunnel	22.1		23	0.4								1	<1979		58.0			
6-5108-01	65	-156.133	20.850	Keanae Well		43	11	8.9	20	3.9	5	64	7.8		11.0	3		0.13	1.2	5.1	310.0	0.445
6-4600-001	66	-156.000	20.767	Hana Ranch	20		68	16.1		218.0	598		7.5		293.0				4.2	0.0		8.807

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	SiO2	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
6-4600-002	66	-156.000	20.767	Maui County A	20.2		115	3.9								1	<1979		29.5			
6-4600-003	66	-156.000	20.767	Maui County B	18.5		30	1.5		68.0	69.2		7.4		84.0				20.1	0.0		2.299
6-3806-01	66	-156.100	20.633	PUNAHOU SPRINGS		18	220	13.0	130	5.7	27	84			12.0	3		-0.23	16.9	22.8	149.2	0.123
6-3904-01	66	-156.067	20.650	KIPAHULU		18	55	46.0	300	12.0	550	260			27.0	3		-0.23	1.2	25.0	142.2	10.000
6-3904-03	66	-156.067	20.650	Mahina 1		17	6	2.5	9	1.7	2	21			4.1	3		-0.73	2.4	5.4	302.1	0.390
6-3903-03	66	-156.050	20.650	NATIONAL PARK SVC		19	4	1.1	7	2.0	1	11	8.1		2.7	3		0.23	3.8	3.4	381.0	0.119
6-4300-02	66	-156.000	20.717	Hamoa W-1		17	7	1.6	9	1.6	2	16	8.7		3.8	3		-0.73	4.3	5.4	303.0	0.333
6-4600-01	66	-156.000	20.767	Heilani (W55)		28	110	22.0	54	3.6	17	130			15.0	3		3.57	5.0	15.0	184.6	0.155
6-4600-03	66	-156.000	20.767	WAKIU B		20	70	3.8	55	2.9	8	22			2.7	3		0.67	18.4	19.0	164.1	0.107
6-4600-02	66	-156.000	20.767	Wakiu W-A		20	190	12.0	110	5.5	26	69			7.8	3		0.67	15.8	20.0	159.7	0.137
8-3457-002	81	-155.950	19.567	Keauhou 2		33	1700	110.0								1	<1979	-1.89	15.5			
8-3557-001	81	-155.950	19.583	Kahaluu A	22	52	14	6.4								1	<1979	0.48	2.2			
8-3557-002	81	-155.950	19.583	Kahaluu B	20	42	32	7.1								1	<1979	-0.67	4.5			
8-3557-003	81	-155.950	19.583	Kahaluu C	20	44	11	5.2								1	<1979	-0.44	2.1			
8-3557-004	81	-155.950	19.583	Kahaluu D	20	45	17	4.9								1	<1979	-0.28	3.5			
8-3758-001	81	-155.967	19.617	Kailua Kona	25	43	459	27.0								1	<1979	-0.51	17.0			
8-4360-001	81	-156.000	19.717	Kalaoa	21	39	740	46.0								1	<1979	-1.02	16.1			
8-4858-001	81	-155.967	19.800	Kona Village 1	20	78	370	73.0								1	<1979	2.59	5.1			
8-4858-002	81	-155.967	19.800	Kona Village 2	22	84	380	77.0								1	<1979	3.00	4.9			
8-4858-003	81	-155.967	19.800	Kona Village 3	20	48	580	92.7								1	<1979	0.05	6.3			
8-4953-001	81	-155.883	19.817	Kiholo	21	36	330	26.0								1	<1979	-1.44	12.7			
8-3957-001	81	-155.952	19.650	KEOPU PUU HONIU	21	54	5	22.0	15	3.4	8.6			140	7.3	2		0.67	0.2	4.4	333.2	1.792
8-3857-001	81	-155.948	19.634	WAIAHA		54	4	17.0	14	2.7	8.3			76	6.8	2		0.67	0.3	5.2	308.3	1.930
8-3657-001	81	-155.952	19.613	HOLUALOA	21	50	210	80.0	120	7.9	35			490	20.0	2		0.27	2.6	15.2	183.5	0.167
8-4057-001	81	-155.958	19.667	KEAHUOLU	20	54	5	22.0	17	3.2	9.7			140	7.7	2		0.67	0.2	5.3	304.7	1.940
8-4158-002	81	-155.964	19.682	HONOKOHAU WELL	22	59	7	30.0	26	4.1	20			180	8.9	2		1.14	0.2	6.3	280.0	2.941
8-4358-001	81	-155.976	19.719	KALAOA WELL	23	61	8	41.0	31	5.2	29			190	9.6	2		1.31	0.2	6.0	288.4	3.580
8-3557-005	81	-155.954	19.581	KAHALUU SHAFT	20	53	350	120.0	200	8.9	54			810	28.0	2		0.58	2.9	22.5	150.4	0.154
8-3557-001	81	-155.950	19.583	KAHALUU A		53	190	78.0	110	5.8	35			500	21.0	2		0.58	2.4	19.0	164.1	0.184
8-3557-003	81	-155.949	19.583	KAHALUU C		52	100	50.0	64	4.2	23			320	15.0	2		0.48	2.0	15.2	183.2	0.230
8-2653-001	81	-155.886	19.443	KEEI C WELL	20	57	55	40.0	34	3.5	17			220	11.0	2		0.96	1.4	9.7	228.3	0.309
8-3155-002	81	-155.916	19.518	HALEKII WELL PUMPHEAD	21	54	3	12.0	17	2.2	14			100	5.7	2		0.67	0.3	7.7	254.8	4.242
8-2753-003	81	-155.880	19.462	KEEI D	20	51	3	13.0	13	1.8	9.6			84	5.5	2		0.38	0.2	7.2	263.1	3.200
8-2753-002	81	-155.891	19.453	KEEI B	19	54	280	95.0	180	7.7	46			660	14.0	2		0.67	2.9	23.4	147.3	0.164
8-0953-01	81	-155.883	19.150	Okoe W-1		36	920	56.0	510	21.0	160	340			42.0	3		-1.44	16.4	24.3	144.4	0.174
8-2653-01	81	-155.883	19.433	Keei W-C		49	28	5.1	22	2.5	10	36			6.0	3		0.17	5.5	8.8	239.4	0.357
8-2753-02	81	-155.883	19.450	Keei W-B		50	135	12.0	80	4.7	26	74			10.0	3		0.27	11.3	17.0	173.3	0.193
8-3155-02	81	-155.917	19.517	Halekii		44	4	2.7	15	1.9	13.6	25	8.0		5.6	3		-0.41	1.4	7.9	251.5	3.627
8-3255-02	81	-155.917	19.533	Kainaliu Test Well		48	4	2.8	13	2.0	11	26	7.8		5.8	3		0.06	1.5	6.5	276.7	2.619
8-3557-03	81	-155.950	19.583	Kahaluu W-C		43	85	9.0	52	3.5	19.6	69	8.0		12.7	3		-0.50	9.4	15.0	184.9	0.231
8-3557-01	81	-155.950	19.583	Kahaluu W-A		49	7	4.0	12	2.1	9.9	35			7.2	3		0.17	1.8	5.7	294.3	1.414
8-3657-01	81	-155.950	19.600	N. Kona Holualoa		41	97	10.7	61	5.2	18.1	76	8.0		12.8	3		-0.75	9.1	11.6	209.8	0.186
8-4057-01	81	-155.950	19.667	Keahuola QLT 1, HI		45	5	4.7	15	3.1	9.43	38	8.1		7.3	3		-0.31	1.2	4.9	316.2	1.718
8-3957-05	81	-155.950	19.650	Keopu Mauka, HI		43	5	4.7	15	3.4	8.46	37	7.7		7.2	3		-0.56	1.1	4.3	339.0	1.605

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
8-3959-01	81	-155.983	19.650	Kamakana, HI		14	17200	1140.0	9120	342.0	2240	5620	7.8		374.0	3		-6.37	15.1	26.7	137.4	0.130
8-4061-01	81	-156.017	19.667	KAHO Well 1,		28	6320	416.0	3300	125.0	839	2060	7.9		140.0	3		-2.70	15.2	26.4	138.1	0.133
8-4158-02	81	-155.967	19.683	Honokohau Well		47	7	6.4	24	4.1	19	48	8.1		8.7	3		-0.05	1.1	5.8	292.9	2.630
8-4161-02	81	-156.017	19.683	KAHO Well 2		35	3650	178.0	1370	55.9	490	895	7.8		63.4	3		-1.62	20.5	24.5	143.7	0.134
8-4161-01	81	-156.017	19.683	KAHO Well 3		33	3940	221.0	1740	69.1	516	1100	7.7		75.6	3		-1.88	17.8	25.2	141.6	0.131
8-4161-11	81	-156.017	19.683	Kohanaiki MW401		17	14100	897.0	7190	263.0	1840	4440	7.9		295.0	3		-5.32	15.7	27.3	135.5	0.130
8-4262-02	81	-156.033	19.700	Kohanaiki 2		34	5910	311.0	2360	92.6	807	1570	7.9		114.0	3		-1.74	19.0	25.5	140.7	0.137
8-4258-03	81	-155.967	19.700	Hualalai Exp Well		49	7	7.7	26	3.6	25.0	53			8.7	3		0.17	1.0	7.2	263.1	3.378
8-4358-01	81	-155.967	19.717	Kalaoa EX A		33	9	9.3	29	5.0	28	62	8.1		9.4	3		-1.89	0.9	5.7	294.3	3.237
8-4360-01	81	-156.000	19.717	Kalaoa N. Kona (W12-11),		11	871	40.6	332	16.0	83	223	7.7		22.1	3		-7.63	21.5	20.8	156.7	0.095
8-5548-001	82	-155.800	19.917	Parker 1	28	56	520	49.0								1	<1979	-1.16	11.1			
8-5548-001	82	-155.800	19.917	Parker 1		68	26	8.6								1	<1979	0.21	11.1			
8-5745-001	82	-155.750	19.950	Parker 5	26	47	23	10.5								1	<1979	-2.43	3.0			
8-5745-001	82	-155.750	19.950	Parker 5		71	27	9.9								1	<1979	0.52	2.2			
8-5745-002	82	-155.750	19.950	Parker 4	27	57	28	10.4								1	<1979	-1.04	2.7			
8-5745-002	82	-155.750	19.950	Parker 4		71	100	13.0								1	<1979	0.52	2.7			
8-5946-001	82	-155.767	19.983	Lalamilo	27	55	78	15.0								1	<1979	-1.29	5.2			
8-5948-001	82	-155.800	19.983	Hapuna Bch.	25	49	440	37.0								1	<1979	-2.11	11.9			
8-5948-001	82	-155.800	19.983	Hapuna Bch.		68	436	42.0								1	<1979	0.21	10.4			
8-6048-001	82	-155.800	20.000	Kawaihae 2	26	30	504	27.8								1	<1979	-5.58	18.1			
8-6048-002	82	-155.800	20.000	Kea Bch.	26	51	390	34.0								1	<1979	-1.83	11.5			
8-6048-002	82	-155.800	20.000	Kea Bch.		71	394	40.0								1	<1979	0.52	9.9			
8-6049-001	82	-155.817	20.000	Kea Bch.	25	51	590	34.0								1	<1979	-1.83	17.4			
8-6049-001	82	-155.817	20.000	Kea Bch .		66	406	40.0								1	<1979	0.00	10.2			
8-6049-001	82	-155.817	20.000	Kea Bch .		66	406	40.0								1	<1979	0.00	10.2			
8-6049-002	82	-155.817	20.000	Kea Resort 3	26	50	1740	119.0								1	<1979	-1.97	14.6			
8-6049-003	82	-155.817	20.000	Kea Resort 4	25	53	3600	270.0								1	<1979	-1.55	13.3			
8-6147-001	82	-155.783	20.017	Kawaihae 3	31	84	253	32.0								1	<1979	1.71	7.9			
8-6147-001	82	-155.783	20.017	Kawaihae 3		51	171	8.5	132	14.0	52	105	7.1		32.0			-1.83	20.1	9.4	231.6	0.304
8-6148-001	82	-155.800	20.017	Kawaihae 1	27	66	360	32.0								1	<1979	0.00	11.3			
8-6148-001	82	-155.800	20.017	Kawaihae 1		75	352	36.0								1	<1979	0.91	9.8			
8-6148-002	82	-155.800	20.017	Kawaihae 4	26	52	460	29.9								1	<1979	-1.69	15.4			
8-6148-002	82	-155.800	20.017	Kawaihae 4		77	370	38.0								1	<1979	1.09	9.7			
8-5746-001	82	-155.771	19.964	PARKER 4	27	67	130	80.0	89	7.0	31			400	12.0	2		0.11	1.6	12.7	200.3	0.238
8-5846-003	82	-155.771	19.969	PARKER 3	27	69	35	54.0	37	4.6	17			220	8.8	2		0.31	0.6	8.0	249.9	0.486
8-5846-001	82	-155.771	19.978	PARKER 1		67	31	50.0	36	4.3	16			240	8.1	2		0.11	0.6	8.4	245.2	0.516
8-5846-002	82	-155.771	19.978	PARKER 2		72	120	88.0	85	6.8	30			400	13.0	2		0.62	1.4	12.5	202.0	0.250
8-5946-004	82	-155.777	19.994	LALAMILO D		66	99	70.0	69	6.4	24			320	11.0	2		0.00	1.4	10.8	217.1	0.242
8-5946-003	82	-155.776	19.989	LALAMILO C		66	82	66.0	59	5.8	23			310	11.0	2		0.00	1.2	10.2	223.2	0.280
8-5946-002	82	-155.774	19.984	LALAMILO B	27	68	37	53.0	37	4.6	17			220	9.1	2		0.21	0.7	8.0	249.9	0.459
8-6240-002	82	-155.665	20.031	WAIMEA	21	60	6	27.0	12	2.8	1.8			100	7.2	2		-0.67	0.2	4.3	337.9	0.327
8-6239-002	82	-155.661	20.031	PARKER RANCH 1	22	60	6	26.0	12	2.9	3			110	8.1	2		-0.67	0.2	4.1	343.7	0.517
8-5239-01	82	-155.650	19.867	Waikii Ranch W-1		62	18	9.9	71	8.2	54	62	8.0		8.3	3		-0.50	1.8	8.7	241.2	3.000

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date
8-4203-002	84	-155.050	19.700	Waiakea TH 2	21	33	11	4.4								1	<1979
8-4203-002	84	-155.050	19.700	Waiakea TH 2	25	39	10	3.3								1	<1979
8-4203-003	84	-155.050	19.700	Waiakea TH 3	24	36	8	3.6								1	<1979
8-4203-003	84	-155.050	19.700	Waiakea TH 3	21	36	9	3.1								1	<1979
8-4203-04	84	-155.050	19.700	Waiakea 4	26	55	7	3.0								1	<1979
8-4203-004	84	-155.050	19.700	Waiakea 4	21	38	40	5.9								1	<1979
8-4203-005	84	-155.050	19.700	Hilo Electric 6	23	39	27	4.8								1	<1979
8-4203-006	84	-155.050	19.700	Kanoelehua 2	21	37	18	3.5								1	<1979
8-4203-006	84	-155.050	19.700	Kanoelehua 2		39	28	5.0								1	<1979
8-4203-007	84	-155.050	19.700	Kanoelehua 3	26	55	7	2.9								1	<1979
8-4203-007	84	-155.050	19.700	Kanoelehua 3	23	36	25	4.6								1	<1979
8-4203-010	84	-155.050	19.700	Hilo Electric 4	20	37	38	5.8								1	<1979
8-4304-001	84	-155.067	19.717	Waiakea	21	44	16000	390.0								1	<1979
8-4304-002	84	-155.067	19.717	Waiakea	20	33	12500	800.0								1	<1979
8-4304-003	84	-155.067	19.717	Waiakea	20	46	6250	460.0								1	<1979
8-4306-001	84	-155.100	19.717	Piihonua	18	37	2	3.3								1	<1979
8-4306-001	84	-155.100	19.717	Piihonua		41	1	3.4								1	<1979
8-4706-001	84	-155.100	19.783	Papikou		30	15	3.6								1	<1979
8-4706-001	84	-155.100	19.783	Papikou	20	34	2	5.0								1	<1979
8-5005-001	84	-155.083	19.833	Pepeekeo	21	45	12	10.0								1	<1979
8-5005-001	84	-155.083	19.833	Pepeekeo	22	32	10	9.1								1	<1979
8-5005-002	84	-155.083	19.833	Pepeekeo		12	13	9.6								1	<1979
8-5005-004	84	-155.083	19.833	Pepeekeo	20		5720									1	<1979
8-5005-005	84	-155.083	19.833	Pepeekeo	20	23	322	33.0								1	<1979
8-5814-001	84	-155.233	19.967	Laupahoehoe	19	40	100	13.0								1	<1979
8-6117-001	84	-155.283	20.017	Ookala Shaft	18	43	135	14.0								1	<1979
8-6321-001	84	-155.350	20.050	Paauilo Mill	18	37	195	19.0								1	<1979
8-6321-002	84	-155.350	20.050	Paauilo Shaft	20	27	320	14.0								1	<1979
8-4003-002	84	-155.063	19.673	PANAEWA 2	20	40	3	11.0	5	1.7	2.5			85	6.0	2	
8-4003-003	84	-155.063	19.673	PANAEWA 3	21	39	3	10.0	5	1.7	2.6			86	5.9	2	
8-4003-001	84	-155.185	19.697	PANAEWA 1	20	40	3	11.0	5	1.8	2.5			82	6.1	2	
8-4211-001	84	-155.185	19.697	OLAA FLUME		14	2	3.6	3		2.5			38	2.3	2	
8-4110-001	84	-155.167	19.683	SADDLE RD A		43	1	15.0	10	2.3	7.7			95	4.8	2	
8-4208-001	84	-155.139	19.710	PIIHONUA C	17	43	1	19.0	7	2.2	2.1			88	7.6	2	
8-4306-002	84	-155.103	19.719	PIIHONUA B	17	42	1	16.0	8	2.2	5.4			93	5.3	2	
8-4306-001	84	-155.102	19.719	PIIHONUA A	18	42	1	16.0	9	2.2	5.5			93	5.2	2	
8-4706-001	84	-155.101	19.784	PAPAIKO Deep		36	3	22.0	7	1.6	1.6			94	9.6	2	
8-4708-002	84	-155.131	19.789	KAIEIE MAUKA	21	43	3	24.0	8	1.6	1.5			98	9.8	2	
8-5207-001	84	-155.120	19.864	HONOMU	17	39	7	23.0	12	2.0	2.2			110	9.0	2	
8-5307-001	84	-155.125	19.889	HAKALAU	21	31	10	29.0	10	1.1	2.8			100	14.0	2	
8-6331-002	84	-155.519	20.051	AHUALOA WELL	19	44	5	25.0	10	2.4	3.6			400	12.0	2	
8-5307-001	84	-155.125	19.889	HAKALAU	21	32	10	30.0	10	1.1	2.7			110	14.0	2	
8-4708-003	84	-155.131	19.789	KAIEIE WELL	20	41	3	23.0	7	1.4	1.4			110	10.0	2	
8-4706-001	84	-155.101	19.784	PAPAIKAO WELL		35	3	22.0	7	1.4	1.6			88	10.0	2	
8-4306-001	84	-155.102	19.719	PIIHONUA WELL A	18	44	1	16.0	8	2.2	5.6			98	5.3	2	
8-4003-003	84	-155.063	19.673	PANAEWA 3	21	39	3	10.0	5	1.5	2.3			87	6.0	2	

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	SiO2	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
8-4003-001	84	-155.063	19.673	PANAEWA 1	20	40	3	11.0	5	1.5	2.2			84	6.1	2		0.21	0.3	3.4	378.2	0.667
8-4003-002	84	-155.062	19.674	PANAEWA 2	20	42	3	11.0	5	1.6	2.3			80	6.3	2		0.62	0.3	3.3	383.1	0.697
8-4211-001	84	-155.185	19.697	OLAA FLUME		13	1	3.5	3	0.0	2.5			28	2.3	2		-9.26	0.4			1.786
8-4110-001	84	-155.180	19.683	SADDLE RD A		43	1	14.0	10	2.2	7.7			76	4.7	2		0.82	0.1	4.3	336.7	6.417
8-4306-002	84	-155.103	19.719	PIIHONUA WELL B	17	40	1	15.0	8	2.0	5.5			79	5.0	2		0.21	0.1	3.9	355.9	4.583
8-4208-001	84	-155.139	19.710	PIIHONUA WELL C	17	43	1	19.0	7	2.0	2.1			72	7.6	2		0.82	0.1	3.4	381.0	1.615
8-5814-001	84	-155.237	19.979	LAUPAHOEHOE 1	20	43	100	60.0	49	4.0	14			340	16.0	2		0.82	1.7	12.3	204.0	0.140
8-5814-002	84	-155.238	19.979	LAUPAHOEHOE 2		41	73	49.0	34	3.3	10			260	14.0	2		0.42	1.5	10.3	221.9	0.137
8-6428-002	84	-155.473	20.075	HONOKAA WELL B	24	35	86	65.0	35	7.3	8.6			320	18.0	2		-0.91	1.3	4.8	320.1	0.100
8-6017-005	84	-155.284	20.010	OOKALA	20	37	12	31.0	9	1.5	3.5			130	14.0	2		-0.44	0.4	5.7	293.8	0.292
8-5307-001	84	-155.125	19.889	HAKALAU SPRING INTAKE	21	26	5	21.0	7	0.0	1.1			90	9.1	2		-3.42	0.2			0.234
8-4708-003	84	-155.131	19.789	KAIEIE INTAKE	20	31	5	36.0	7	0.0	2.4			110	13.0	2		-1.94	0.2			0.444
8-4706-001	84	-155.101	19.784	PAPAIKOU SPRING INTAKE		11	6	28.0	6	0.0	8			150	28.0	2		-10.67	0.2			1.270
8-5207-001	84	-155.120	19.864	HONOMU	17	40	6	24.0	14	2.1	2.2			120	9.3	2		0.21	0.3	6.7	273.4	0.361
8-3188-001	84	-154.965	19.515	KEONEPOKONUI 1 WELL	20	54	4	21.0	10	2.8	4.9			120	7.6	2		2.74	0.2	3.6	369.2	1.400
8-3188-002	84	-154.965	19.515	KEONEPOKONUI 2 WELL	20	54	3	21.0	10	2.8	4.7			84	7.4	2		2.74	0.2	3.6	369.2	1.382
8-3802-002	84	-155.031	19.631	KEAAU OLAA WELL 2		39	5	12.0	7	2.2	7.7			88	5.9	2		0.00	0.4	3.3	382.8	1.540
8-3802-001	84	-155.031	19.631	KEAAU OLAA WELL 1		39	3	12.0	7	2.2	6.9			86	5.7	2		0.00	0.3	3.0	399.3	2.226
8-3603-001	84	-155.051	19.606	OLAA STATION WELL 3	20	41	3	13.0	6	2.2	4.6			66	6.2	2		0.42	0.3	2.8	415.0	1.394
8-2783-01	84	-154.893	19.455	W9-9		1	4600	210.0	2500	140.0	510	1190	7.2		130.0	3		-29.35	21.9	17.9	169.2	0.111
8-3802-03	84	-155.033	19.633	KEAAU 1		36	5	3.1	7	2.0	6.2	30			6.9	3		-0.67	1.6	3.3	386.7	1.240
8-3900-01	84	-155.000	19.650	W9-2		39	62	7.7	38	3.8	14	51			7.8	3		0.00	8.1	10.0	225.1	0.226
8-4203-06	84	-155.050	19.700	W8-2B		37	19	3.5	12	2.1	5	42			11.0	3		-0.44	5.4	5.7	294.3	0.263
8-5005-02	84	-155.083	19.833	MAKAI		11	13	8.4	1	11.0	29	11	62.0		8.5	3		-10.67	1.5	0.1		2.231
8-5814-01	84	-155.233	19.967	Laupahoehoe W-1		91	101	13.0	46	4.1	14	91			15.0	3		7.14	7.8	11.2	212.9	0.139
8-6223-01	84	-155.383	20.033	PAAUILO		43	8	5.0	9	2.3	4	43	7.6		9.0	3		0.84	1.6	3.9	353.1	0.475
8-6337-02	84	-155.617	20.050	PUUKAPU SHALLOW WELL		26	6	2.2	7	0.9	1.3	26	7.6		6.7	3		-3.42	2.8	8.1	248.9	0.210
8-6528-01	84	-155.467	20.083	Haina Well		100	71	14.0	43	3.7	14	100			17.0	3		7.94	5.1	11.6	209.3	0.197
8-0335-001	85	-155.583	19.050	Naalehu 1	19	43	10	4.6								1	<1979	-0.49	2.2			
8-0533-001	85	-155.550	19.083	Honuapo Mill	19	43	1240	86.0								1	<1979	-0.49	14.4			
8-0533-002	85	-155.550	19.083	Honuapo 1	19	43	580	44.0								1	<1979	-0.49	13.2			
8-0533-003	85	-155.550	19.083	Honuapo 3	19	43	500	38.0								1	<1979	-0.49	11.4			
8-0632-001	85	-155.533	19.100	Honuapo 2	19	41	440	33.0								1	<1979	-0.67	13.3			
8-0830-001	85	-155.500	19.133	Punaluu	19	32	205	16.0								1	<1979	-1.61	12.8			
8-0831-001	85	-155.517	19.133	Ninole	18	41	130	12.0								1	<1979	-0.67	10.8			
8-0831-002	85	-155.517	19.133	Ninole A	18	43	150	18.0								1	<1979	-0.49	8.3			
8-0831-003	85	-155.517	19.133	Ninole B	21	48	166	18.0								1	<1979	-0.08	9.2			
8-1128-001	85	-155.467	19.183	Pahala Shaft	19	42	4	3.6								1	<1979	-0.58	1.0			
8-1128-002	85	-155.467	19.183	Palima	21	54	12	4.3								1	<1979	0.37	2.8			
8-1229-001	85	-155.483	19.200	Pahala	17	42	32	33.0								1	<1979	-0.58	1.0			
8-2102-001	85	-155.033	19.350	Pulama	28	72	345	31.2	170	16.0	65	54	7.4		8.5	7		1.46	11.1	10.6	218.6	0.188
8-2317-001	85	-155.283	19.383	Kilauea	83	163	1660	63.5	610	130.0				7.1	124.0	7		4.56	26.1	4.7	323.5	
8-2487-001	85	-154.952	19.413	Keauohana 1	24	41	70	3.3	95	12.4	28.6		7.1		15.4	7		-0.67	21.2	7.7	255.7	0.409

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	Si02	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
8-2487-001	85	-154.952	19.413	Keauohana 1	21	45	160	5.1	95	12.4	28.6		7.1		15.4	7		-0.32	31.4	7.7	255.7	0.179
8-2487-002	85	-154.952	19.413	Keauohana 2	24	45	160	5.9								1	<1979	-0.32	27.1			
8-2686-002	85	-154.944	19.437	Geoth. Test 2	83											1	<1979	-14.75				
8-2753-001	85	-154.883	19.450	Keei A	21	53	180	12.0								1	<1979	0.30	15.0			
8-2753-002	85	-154.883	19.450	Keei B	20	50	180	12.0								1	<1979	0.08	15.0			
8-2783-001	85	-154.881	19.455	Malama-Ki	53	59	5850	324.0								1	<1979	0.70	18.1			
8-2783-001	85	-154.881	19.455	Malama-Ki	53	101	5380	295.0	3333	218.0	598		7.5		293.0	7		2.73	18.2	15.3	182.9	0.111
8-2783-001	85	-154.881	19.455	Malama-Ki	53	83	6887	267.0	2695	129.0	583	178	7.1		122.0	1		2.01	25.8	20.9	156.2	0.085
8-2783-001	85	-154.881	19.455	Malama-Ki		445	4480	302.0	3150	185.0	445			8730	158.0	8	Dec-00		14.8	17.0	173.3	0.099
8-2881-001	85	-154.850	19.467	Allison Well	38	24	281	15.0								1		-2.70	18.7			
8-2881-001	85	-154.850	19.467	Allison Well	38	24	2042	102.0	1188	68.0	69.2		7.4		84.0	7		-2.70	20.0	17.5	171.1	0.034
8-2881-001	85	-154.850	19.467	Allison Well	38	39	840	15.0	216	10.8	69.2	132	7.2		13.4	1		-0.90	56.0	20.0	159.7	0.082
8-2982-001	85	-155.367	19.483	Geoth.Test 3	93	97	3410	59.0								1		2.59	57.8			
8-2982-001	85	-155.367	19.483	Geoth.Test 3	93	97	4645	122.0	2572	378.0	314		6.9		194.0	7		2.59	38.1	6.8	270.7	0.068
8-2982-001	85	-155.367	19.483	Geoth.Test 3	89	156	3684	55.5	2025	193.0	325	30	6.4		78.9	1		4.39	66.3	10.5	219.9	0.088
8-2982-001	85	-155.367	19.483	Geoth.Test 3		251	4050	122.0	2090	174.0	270			8500	132.0	8	Sep-00		33.2	12.0	206.0	0.067
8-2883-02	85	-154.890	19.468	Lanipuna 1	149	12	8100	0.7	3988	2.4	74		6.8		844.0	7		-5.40	11571.4	1661.7		0.009
8-2883-03	85	-154.891	19.477	Kapoho State 1	343	2000	21000	2.0	10000	2700.0			4.5		920.0	7		14.06	10500.0	3.7	362.7	
8-2883-04	85	-154.887	19.479	Kapono State 2	354	1100	1600	20.0	15000	3600.0				22157	2400.0	7		11.79	80.0	4.2	342.6	
8-2883-05	85	-154.882	19.476	Lanipuna 6	168	135	15600	15.0	8380	420.0	403		8.3	2651	1524.0	7		3.84	1040.0	20.0	159.9	0.026
8-2986-001	85	-154.944	19.483	Pahoa 2A	23	39	12	0.9								1	<1979	-0.86	13.3			
8-2986-001	85	-154.944	19.483	Pahoa 2A	23	50	5	3.1	17	9.3	27.3		6.7		4.5	7		0.08	1.6	1.8	523.0	5.538
	85	-154.944	19.483	Pahoa 2A		53	5	2.9	17	3.4	0			114	4.2	8			1.6	4.9	316.0	
8-2986-002	85	-154.994	19.483	Pahoa 2B	23	55	6	2.4								1	<1979	0.44	2.4			
8-3080-001	85	-154.836	19.500	Kapoho Crater	25	58	170	31.0								1	<1979	0.64	5.5			
8-3081-001	85	-154.864	19.500	Kapoho Test	28	71	320	17.1								1	<1979	1.38	18.7			
8-3081-001	85	-154.864	19.500	Kapoho Test	37	71	364	27.4	241	28.0	211		7.8		37.6	7		1.41	13.3	8.6	241.9	0.580
8-3081-001	85	-154.864	19.500	Kapoho Test	36	63	450	24.1	231	15.2	160	46	7.1		16.5	1		0.94	18.7	15.2	183.5	0.356
	85	-154.870	19.450	Thermal Spring Issac Hale Beach	36	82	3534	200.0								1	<1979	1.93	17.7			
8-2883-001	85	-154.893	19.472	HGP-A	250	942	1040	1.0								1	<1979	11.20	1040.0			

Appendix IV

Well Number	Aquifer code	longitude	latitude	Name	TEMP. (oC)	SiO2	Cl	Mg	Na	K	SO4	HCO3	pH	TDS	Ca	Data Source	Analysis Date		Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
8-2883-001	85	-154.893	19.472	HGP-A	300	501	1150	1.0	800	149.0	176	45	4.4		96.0	1			8.81	1150.0	5.4	303.2	0.153
8-1331-001	85	-155.518	19.229	ALILI TUNNEL		21	5	4.0	4	0.0	14			90	18.0	2			-3.21	1.2			3.043
8-1229-001	85	-155.487	19.204	PAHALA WELL 1	17	46	3	16.0	7	1.6	7.7			110	7.7	2			-0.24	0.2	4.1	346.8	2.750
8-1229-004	85	-155.490	19.207	PAHALA WELL2	19	45	3	15.0	6	1.6	7.6			96	7.3	2			-0.32	0.2	4.0	349.4	2.815
8-0936-001	85	-155.613	19.155	NEW MOUNTAIN HOUSE		28	5	13.0	6	1.4	23			88	7.2	2			-2.12	0.4	4.6	327.6	4.340
8-0335-001	85	-155.593	19.060	NAALEHU WELLHEAD	19	50	9	31.0	16	2.0	11			150	9.2	2			0.08	0.3	8.0	250.6	1.279
8-0545-001	85	-155.765	19.089	HOVE WELL	27	44	72	68.0	120	7.7	220			580	37.0	2			-0.41	1.1	15.6	181.2	3.056
8-2487-001	85	-154.952	19.413	KEAUOHANA	24	56	140	35.0	90	6.3	24			360	13.0	2			0.51	4.0	14.3	189.2	0.171
8-0335-01	85	-155.583	19.050	Ninole B		43	8	4.6	11	1.5	13	35			6.4	3			-0.49	2.4	7.3	261.2	1.548
8-0437-01	85	-155.617	19.067	Waiohinu, HI		44	5	2.4	8	1.2	9.1	23	7.4		5.3	3			-0.41	1.9	6.7	273.4	2.022
8-0831-03	85	-155.517	19.133	Ninole B		43	180	18.0	100	5.9	29	110			13.0	3			-0.49	10.0	16.9	173.7	0.161
8-1128-02	85	-155.467	19.183	Palima		47	11	4.3	12	1.2	7.5	33			6.1	3			-0.16	2.6	10.0	225.1	0.682
8-1229-01	85	-155.483	19.200	Pahala		42	3	3.3	6	1.3	6.6	32			7.5	3			-0.58	1.0	4.4	334.2	2.063
8-2883-03	85	-154.893	19.467	THERMAL PWR JV		93	1600	0.5	1000	94.0	210	160	9.5		65.0	3			2.43	3200.0	10.6	218.5	0.131
8-2986-02	85	-154.944	19.483	Pahoa, W-2B		55	7	2.4	16	3.2	13	20			3.9	3			0.44	2.9	5.0	313.7	1.857
8-2986-01	85	-154.944	19.483	Pahoa, W-2A		50	6	3.3	17	3.4	13	20			2.7	3			0.08	1.8	5.0	313.7	2.167
8-3080-02	85	-154.836	19.500	Kapoho Shaft		58	110	31.0	80	7.0	19	280			60.0	3			0.64	3.5	11.4	211.0	0.173
				Thermal Spring Issac Hale Beach	36	89	4062	219.5	2080	86.8	530	58.5	7.3		32.4	1				18.5	24.0	145.4	0.130
				Puuwaawaa	35	60	28	5.3								1	<1979			5.3			
				Waikaloa		64	821	61.0								1	<1979			13.5			
				Allison Springs		100	6500									1							
				CHAVES SPRING INTAKE		36	5	24.0	7	0.0	2.6			110	12.0	2				0.2			0.520
				WELLHEAD		41	8	28.0	10	2.4	3.4			120	12.0	2				0.3	4.0	347.6	0.453
				KULAIMANO Well B		45	1	19.0	8	2.5	1.6			90	7.1	2				0.1	3.0	399.7	1.231
				AKAKA FALLS SPRING INTAKE		23	4	21.0	6	0.0	2.6			82	8.7	2				0.2			0.634
		0.000		HAAO SPRING		37	14	25.0	10	1.6	38			150	11.0	2				0.6	6.3	281.9	2.714
		-155.533	19.755	PTA well no. 1		104	47	2.3	85	10.0	28.7				3.6	9				20.7	8.5	212.2274658	0.612

Sources of Data

1: Malcolm E. Cox and Donald M. Thomas. Chloride/Magnesium Ratio of Shallow Groundwater As a Regional Geothermal Indicator in Hawaii. Hawaii Institute of Geophysics, University, 1979

2: Hawaii Department of Water Supply supplied by email from D. Thomas

3: United States Geological Services Data Base http://waterdata.usgs.gov/hi/nwis/qw/

4: Honolulu Board of Water Supply supplied by email from Nancy Matsumoto, Chief Geologist, March 6, 2015

5: 1983 Geothermal Resources of Hawaii Map

6: Investigation into the Geothermal Potential of Waianae Calder. Thomas et al. HIG 79-8

7: GeothermEx, Inc. 1994. Annual report: Geothermal resources assessment. Richmond (CA): GeothermEx, Inc.

8: Department of Health Data provided by Robert Whitter on July 6, 20015 by email

9: D. Thomas email

	Z value for ln(Siconc.)	Cl/Mg	Na/K Ratio	Na/K Geotherm.	SO4/CL
		34807.7	10117.7	91107.1	402.2
Mean	-0.21	41.095	21.481	198.490	0.847
adj. Mean		7.4	9.9		
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