ALAN M. ARAKAWA
Mayor

DAVID TAYLOR, P.E.
Director

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Deputy Director

DEPARTMENT OF WATER SUPPLY
COUNTY OF MAUI
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WAILUKU, MAUI, HAWAII 96793-2155
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April 23, 2018

Mr. Sananda K. Baz
Budget Director, County of Maui
200 South High Street
Wailuku, Hawaii 96793

Honorable Alan M. Arakawa
Mayor, County of Maui
200 South High Street
Wailuku, Hawaii 96793

4/23/18

For Transmittal to:

Honorable G. Riki Hokama
Chair, Budget and Finance Committee
Maui County Council
200 South High Street
Wailuku, Hawaii 96793

Dear Chair Hokama:

SUBJECT: REQUESTS/QUESTIONS FROM APRIL 19, 2018 (WS-2) (BF-1)

Thank you for your April 20, 2018, letter regarding the above-referenced subject. The Department of Water Supply (Department) is transmitting for your review and offers the following response to your questions:

Question:

1. *Relating to Countywide Facility Improvements (CBS-1075, page 822 of the Program Book):*

   a. *Why are there large increases in appropriation requests anticipated in Fiscal Years 2020 and 2022, and large decreases in Fiscal Years 2021, 2023, and 2024?*

Answer: **In Fiscal Years 2020 and 2022 the increases are attributed to construction funding for the Olinda Water Treatment Plant (WTP) Reservoir Spillway Improvements ($4,000,000) and Mahinahina WTP Reservoir Spillway Improvements ($1,700,000), respectively. In Fiscal Years 2021, 2023, 2024 there are no large construction projects.**

b. Provide the approximate cost of each project, listed in order of priority.

Answer: **Please refer to the table below for the approximate cost of each project and the order of priority.**

c. Indicate whether the projects are shovel-ready and the anticipated project completion dates.

Answer: **Please refer to the table below for the shovel-ready status and the anticipated project construction completion date.**

CBS-1075 Countywide Facility Improvements ($4,350,000)				
PRIORITY	**DETAILED PROJECT**	**AMOUNT**	**SHOVEL READY**	**COMPLETION DATE**
Priority #1	**1) Well and booster pump station improvements. Anticipated jobs include Conversion of the disinfection systems at the Kanoa 2, Waihee, and Mokuhau Wells from chlorine gas to on-site hypochlorite generation**	**$1,900,000**	**Shovel Ready - Bid advertisement upon appropriation of FY2019 funding.**	**6/30/2019**
Priority #2	**2) Water treatment facility and water tank improvements. Anticipated jobs include refurbishing water tanks at Napili Well C; Demolition of the existing Iao Water Treatment Plant; Conversion of the disinfection systems at the Olinda, Piiholo, Kamole, Lahainaluna, and Mahinahina WTPs from chlorine gas to on-site hypochlorite generation**	**$1,700,000**	**Shovel Ready - Ready for Bid upon appropriation of FY2019 funding, except Napili Well C is not shovel ready as the in-house completion December 2018.**	**6/30/2019, except Napili Well C – December 2019**

CBS-1075 Countywide Facility Improvements ($4,350,000) (cont.)				
PRIORITY	**DETAILED PROJECT**	**AMOUNT**	**SHOVEL READY**	**COMPLETION DATE**
Priority #3	**3) Tree clearing along the raw water line serving the Piiholo Water Treatment Plant to establish access for maintenance work**	**$500,000**	**Shovel Ready - Bid advertisement upon appropriation of FY2019 funding.**	**6/30/2019**
Priority #4	**4) Re-roofing of the clearwell at the Olinda Water Treatment Plant**	**$150,000**	**Not Shovel Ready - Design completion June 2019.**	**12/31/2020**
Priority #5	**5) Conduct facility assessments of all West Maui water treatment plants**	**$100,000**	**Not Shovel Ready - FY2019 is for an assessment.**	**12/31/2019**

Question:

2. *Relating to Countywide Upgrades and Replacements (CBS-2299, page 824 of the Program Book):*

    a. *Provide the approximate cost of each project, listed in order of priority.*

Answer: **Please refer to the table below for the approximate cost of each project and the order of priority.**

    b. *Indicate whether the projects are shovel-ready and the anticipated project completion dates.*

Answer: **Please refer to the table below for the shovel-ready status and the anticipated project construction completion dates.**

CBS-2299 Countywide Upgrades and Replacements ($1,100,000)				
PRIORITY	**DETAILED PROJECT**	**AMOUNT**	**SHOVEL READY**	**COMPLETION DATE**
Priority #1	**1) Water treatment facility, water tank and waterline improvements. Anticipated jobs include replacement of the existing 30,000 gallon Honokohau Tank**	**$ 100,000**	**Not Shovel Ready - Design completion June 2019.**	**12/31/2020**

CBS-2299 Countywide Upgrades and Replacements ($1,100,000) (cont.)				
PRIORITY	**DETAILED PROJECT**	**AMOUNT**	**SHOVEL READY**	**COMPLETION DATE**
Priority #2	**2) Well and booster pump improvements: Anticipated jobs include replacement of pump and motor assemblies, electrical control systems, and installation of emergency generators at Kalae Booster Pump and the Waipuka Wells**	**$1,000,000**	**Not Shovel Ready - FY2019 is for Design Funding. Design completion June 2019.**	**12/31/2020**

Question:

3. *Relating to Upcountry Reliable Capacity (CBS-1106, page 827 of the Program Book):*

   a. *Provide the approximate cost of each project, listed in order of priority.*

Answer: **Please refer to the table below for the approximate cost of each project and the order of priority.**

   b. *Indicate whether the projects are shovel-ready and the anticipated project completion dates.*

Answer: **Please refer to the table below for the shovel-ready status and the anticipated project construction completion dates.**

CBS-1106 Upcountry Reliable Capacity ($12,500,000)				
PRIORITY	**DETAILED PROJECT**	**AMOUNT**	**SHOVEL READY**	**COMPLETION DATE**
Priority #1	**1) Development of Pookela Well B**	**$4,000,000**	**Not Shovel Ready – Design completion January 2019.**	**6/30/2020**
Priority #2	**2) New raw water reservoirs at the Kamole Water Treatment Plant**	**$1,500,000**	**Not Shovel Ready - Design is expected to be completed June 2019.**	**12/31/2020**
Priority #3	**3) Phase 10 booster pump improvements (Pookela Tank, Maluhia Tank, West Olinda Tank sites)**	**$7,000,000**	**Not Shovel Ready - Design in progress with completion July 2018.**	**12/31/2020**

c. *What percentage of time is Pookela A Well utilized?*

Answer: **The percentage is calculated based on 365 days per year over the total run times for Pookela Well A as listed below for 2015-2017 with the total gallons of water withdrawn.**

Year	Number of Time Well Run	Percentage of Time Pookela A Utilized	Total Gallons
2017	21	5.75%	99,063,000 gallons
2016	23	6.30%	24,407,000 gallons
2015	20	5.48%	14,101,000 gallons

Question:

4. *Relating to Central Maui Reliable Capacity (CBS-1102, page 829 of the Program Book):*

a. *Provide the approximate cost of each project, listed in order of priority.*

Answer: **Please refer to the table below for the approximate cost of each project and the order of priority.**

b. *Indicate whether the projects are shovel-ready and the anticipated project completion dates.*

Answer: **Please refer to the table below for the shovel-ready status and the anticipated project construction completion dates.**

Central Maui Reliable Capacity ($2,600,000)				
PRIORITY	DETAILED PROJECT	AMOUNT	SHOVEL READY	COMPLETION DATE
Priority #1	1) Replacement well for Waiehu Heights Well 1	$2,500,000	Not Shovel Ready – Drilling completion June 2019.	6/30/2020
Priority #2	2) New water tank for North Kihei	$100,000	Not Shovel Ready – Design completion June 2020.	12/31/2021

c. *Explain what happened with the Waiehu Heights Well 1 such that the well water turned brackish and the well is no longer in operation.*

Answer: **Waiehu Well 1 was put into service in approximately 1975 and was used until September 2012, when the chloride level increased to 250 mg/L. Please refer to EXHIBIT A for the Preliminary Report Waiehu Heights Well A Refurbishment or Replacement, dated March 2012, for the explanation of what happened with Waiehu Heights Well 1.**

i. *Where will the replacement well be located?*

Answer: **The well will be located on the same County owned site as the existing Waiehu Well 1 and 2. Please refer to EXHIBIT B.**

ii. *Have the actions that turned the well water brackish mean the water source has been ruined? Explain.*

Answer: **The Iao Aquifer, which is the basal aquifer that is the water source for Waiehu Well 1 and 2, has not been ruined due to Well #1.**

Question:

5. *Relating to the West Maui Reliable Capacity (CBS-1092, page 831 of the Program Book):*

a. *Provide the approximate cost of the project.*

Answer: **Please refer to the table below for the approximate cost of each project and the order of priority.**

b. *Indicate whether the projects are shovel-ready and the anticipated project completion date.*

Answer: **Please refer to the table below for the shovel-ready status and the anticipated project construction completion date.**

West Maui Reliable Capacity ($10,350,000)				
PRIORITY	DETAILED PROJECT	AMOUNT	SHOVEL READY	COMPLETION DATE
Priority #1	1)) West Maui Source Development	$10,350,000	Not Shovel Ready – Design completion December 2018.	1/1/2021

c. *How much of the State Reserve Funds are available for Maui County for this project?*

Answer: **The State Fiscal Year 2019 funding available from the State Revolving Fund (SRF) for Maui County for this project is $10,000,000. But, due to the availability of Water Funds in Fiscal Year 2019, the amount being proposed from SRF for this project is $4,250,000.**

Question:

6. *Relating to grants and disbursements for Watershed Protection (pages 19-19 through 19-21 of the Budget Details), are there any entities that are profiting from the improvements and maintenance being made to these watersheds? Explain.*

Answer: **The watershed partnerships were formed by State, County and private landowners to protect the forested watersheds for water recharge and conservation values. Management projects funded by the Department focus on the forested watersheds critical for recharge of freshwater supplies. As of Fiscal Year 2019, the Department will have eleven (11) watershed protection grantees. The benefit to landowners, water purveyors and entities within and makai of managed watersheds have not been quantified. Thus, it can only be assumed that projects in the critical watersheds recharging aquifers and streams benefit the water sources developed in those aquifers and diverted from such streams. The Department has relied on United States Geological Survey (USGS) groundwater modeling and geographic information systems (GIS) mapping of its infrastructure and wells to determine the significance of watershed protection. Generally, we would not offer grants to projects that are beyond the areas where we source water from as a commitment to our mission statement and rate-payers, but we also consider and acknowledge the broader benefits from protecting native forested watersheds where efficient ecosystem services occur.**

The Department has not inventoried potential beneficiaries, which could include landowners, land and stream users makai of forested watersheds, including the near shore environment. Please refer to <u>EXHIBIT C</u> for the list of partners associated with each of our funded watershed management partnerships and grantees for Fiscal Year 2019, and sources of other funding that the grantees reported to the Department.

We hope you find this information useful. Should further clarification be necessary, please contact me at Ext. 7834.

Sincerely,

Gladys C. Baisa

GLADYS C. BAISA
Deputy Director

Attachment
xc: Holly Ho, Waterworks Fiscal Officer
Wendy Taomoto, Engineering Program Manager
Eva Blumenstein, Planning Program Manager
Tony Linder, Water Treatment Plant Division Chief
Dean Tanimoto, Water Plant Division Chief
GCB:atn
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Preliminary Report
Waiehu Heights Well A Refurbishment or Replacement

Prepared for:

Ronald M. Fukumoto Engineering
1721 Wili Pa Loop, Suite 203
Wailuku, HI 96793

Prepared by:

Mink & Yuen
1670 Kalakaua Avenue, Suite 605
Honolulu, Hawaii 96826

and

Oceanit Laboratories, Inc.
828 Fort Street Mall, Suite 600
Honolulu, Hawaii 96813

March 2012

EXHIBIT A

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

The purpose of this report is to discuss the feasibility of refurbishing Waiehu Heights Well A (Well No. 6-5430-001; Figure 1-1; Figure 1-2). The County of Maui, Department of Water Supply (DWS), needs to bring another well on-line in the Waiehu Heights battery. The possible alternatives are to either refurbish the existing Well A or to drill another well. A brief discussion on the well site proposed by Ronald M. Fukumoto Engineering is included in Section 6.

Well A has excessively high chlorides. Peak chloride levels in the well when it was in operation approached 250 mg/L chloride. In Hawaii, the chloride anion concentration (measured in milligrams per liter or mg/L) is used to determine the salinity of ground water. It is also listed as a contaminant in the EPA Secondary Drinking Water Regulations. Chloride in small concentrations is not harmful to humans, but in concentrations above 250 mg/L, or two percent that of seawater, it imparts a salty taste in water that is objectionable to many people. It is commonly assumed that an acceptable salinity level is less than 160 mg/L chloride but definitely less than the Environmental Protection Agency (EPA) secondary contaminant recommended limit of 250 mg/L chloride.

We will discuss the feasibility of reducing the chloride levels in the well to acceptable levels using operational data, information from neighboring wells in the Iao Aquifer System and general knowledge of the hydrogeology of the Iao Aquifer System. In addition, a preliminary conceptual design shall be prepared for the well refurbishment.

The Department of Land and Natural Resources (DLNR), Commission on Water Resource Management (CWRM) is the applicable regulatory agency for water well refurbishments. The refurbishment conceptual design will conform to the Hawaii Well Construction and Pump Installation Standards (HWCPIS).

Two key data are missing to properly assess the feasibility of refurbishing the well; a conductivity profile and a video log. A conductivity, temperature and depths (CTD) log should be conducted in Well A. This will provide information on the vertical profile of salinity and temperature in the well and provides more accurate information for the preliminary well refurbishment design. In addition, there is no information on the physical condition of the well. The condition of the well casing, well screen and open hole is unknown at this point in time. A video log should also be conducted in the well. Although extremely important, these data are not available and will not be considered in this report.

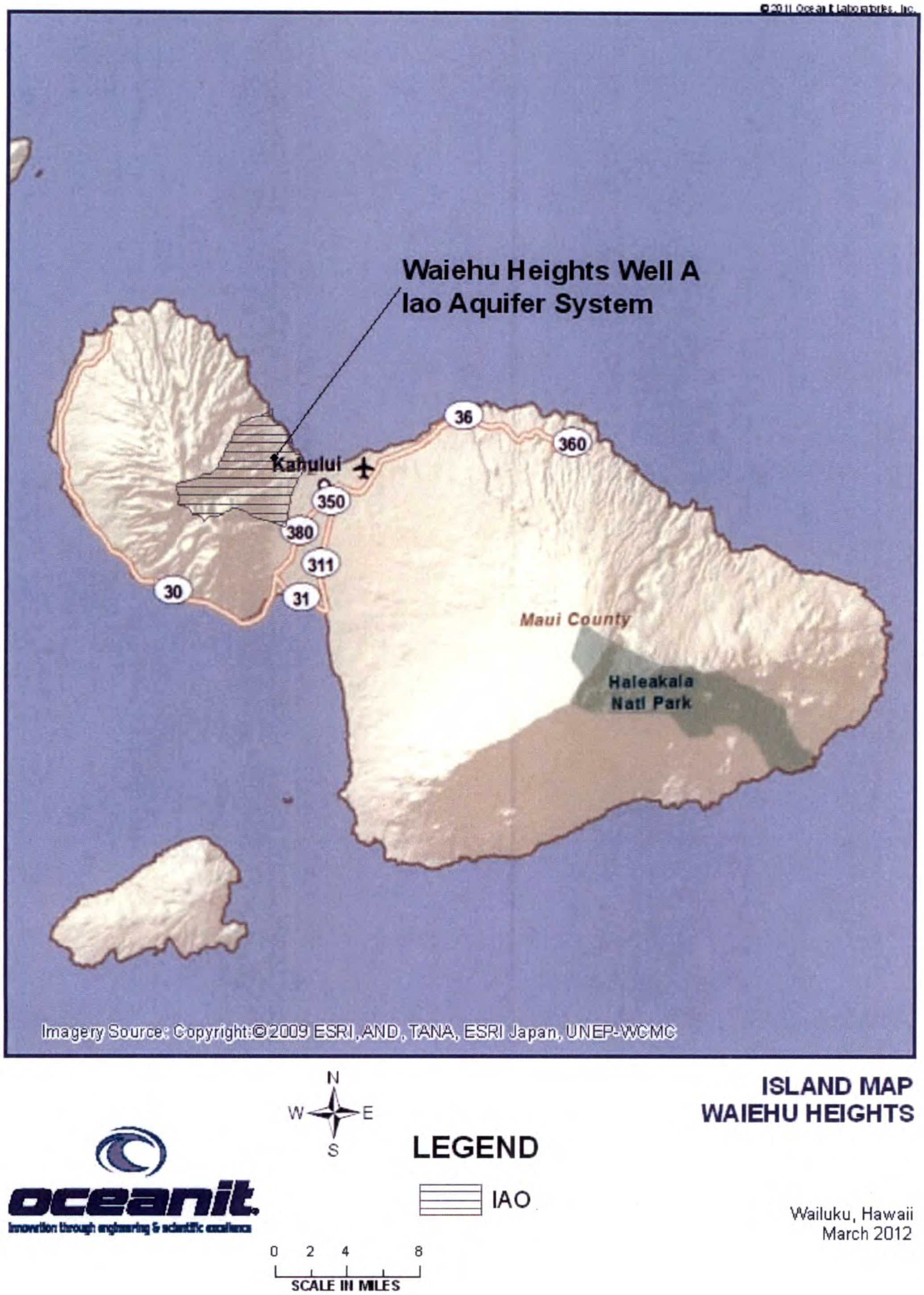

Figure 1-1. Maui Island Map showing Iao Aquifer System

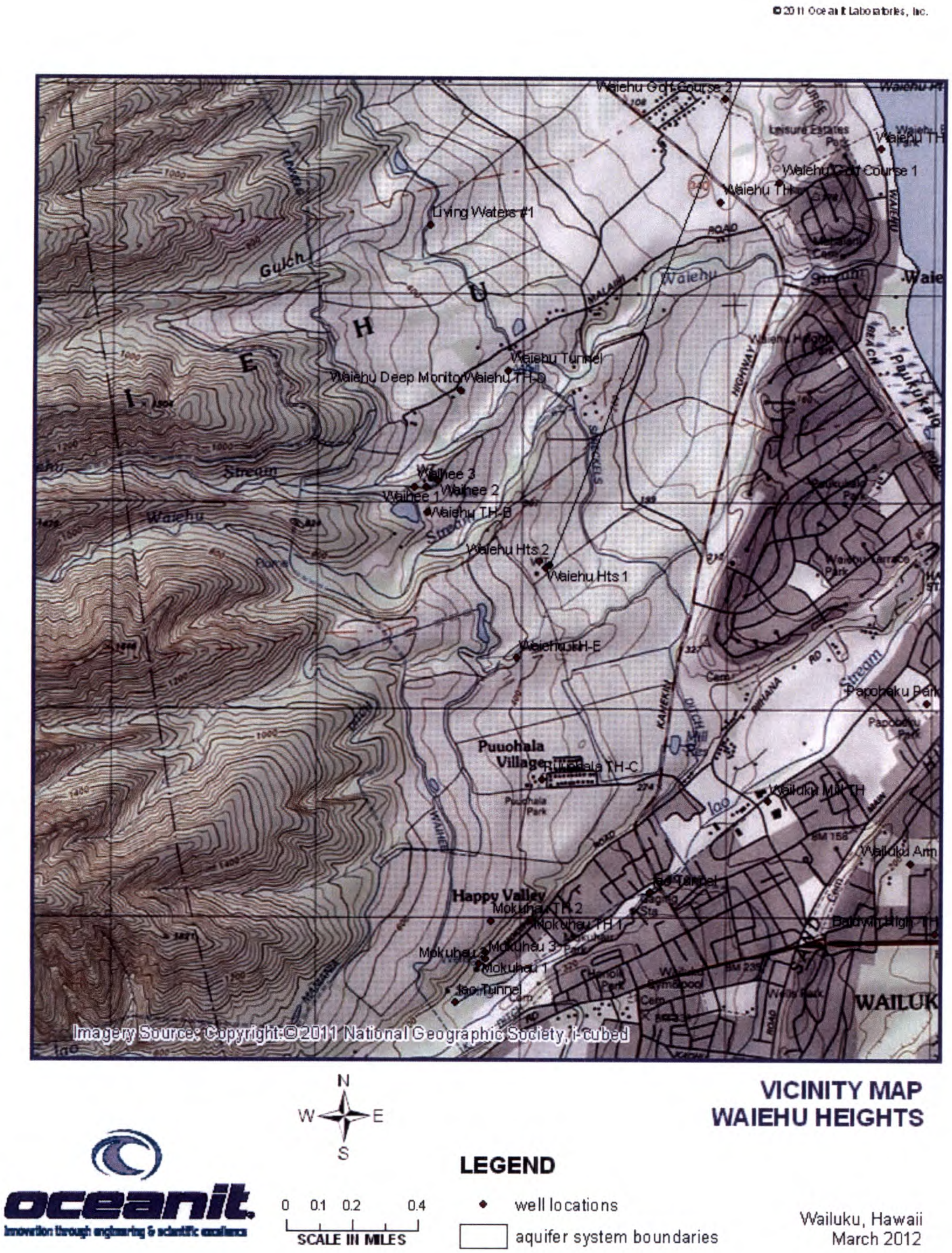

Figure 1-2. Waiehu Heights Well A Vicinity Map

2. GEOLOGY OF WEST MAUI

The West Maui Volcano is composed primarily of two different formations. The Wailuku Basalt comprises the majority of the volume of the volcano. The Honolua Formation forms cliffs on the north side of West Maui but it still only comprises a small fraction of the volume of the volcano. The Lahaina Formation is found on the south coast of West Maui.

Thin bedded, dike-free flows of pahoehoe and aa belonging to the Wailuku Basalt (Langenheim and Clague, 1987) crop out in the ridges behind Wailuku and Waiehu, and represent the shield-building phase of volcanic activity. These flank flows dip steeply away from the caldera region of the volcano. Flow dips range between 10° to 20° (Stearns and Macdonald, 1942), which are somewhat steep for Hawaiian shield-building lava flows. This formation is highly permeable and constitutes the primary aquifer of West Maui (Stearns and Macdonald, 1942; Yamanaga and Huxel, 1970).

Massive ponded lava flow, dikes, large intrusive bodies, and volcanic breccia associated with the development and filling of West Maui's caldera occur in the Iao Aquifer System. The West Maui caldera diameter is estimated to be two miles across and is mostly contained in Iao and Waikapu Valleys (Macdonald and others 1983).

Stearns and Macdonald (1942) mapped numerous north-striking dikes in Waihee Stream. The trends of these dikes suggest that a volcanic rift zone emanates north from Iao Valley. Their presence, and their influence on the ground-water hydrology, defines the northern boundary of the Iao Aquifer System. Dikes are sub-vertical sheet-like formations that intrude into the existing rock and are of low permeability. The dike structures impede the flow of water and form the high level aquifer (Macdonald and others, 1983). Dikes have been mapped to within one mile of the coast (Meyer and Presley, 2000; Yamanaga and Huxel, 1970 p. 25).

In the area between Waihee Valley and Wailoi Gulch the Wailuku Basalt is covered by the post-shield stage Honolua Volcanics. This formation is composed of thick bedded and relatively impermeable trachyte and andesite. After the eruption of the Honolua Volcanics, the West Maui Volcano underwent an extensive period of erosion. This erosion resulted in a thick sequence of terrestrial sediments known as caprock (Stearns and Macdonald, 1942). These sediments form a wedge that contacts the volcanic rock on the west and thickens to the east. These sediments are composed of young unconsolidated alluvium consisting of sand, silt, and gravel overlying older partly-consolidated to consolidated alluvium. Lithified calcareous dune sand overlies the older alluvium as a thin veneer (Yamanaga and Huxel, 1970). Mink (1977) found based on drill hole data that the Iao caprock wedge extending to a depth of –1200 feet MSL near the coast.

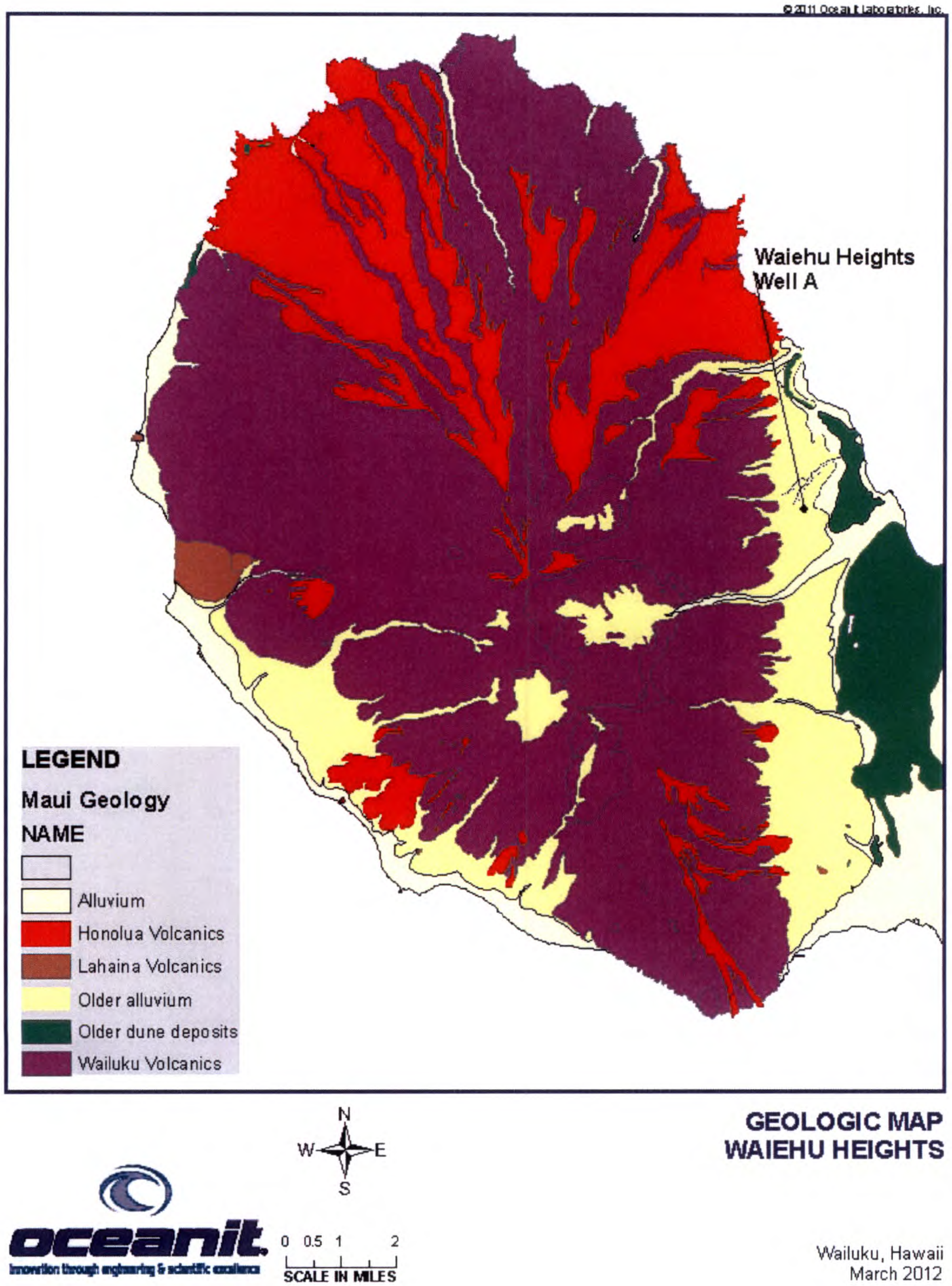

Figure 2-1 Geologic Map of West Maui

3. HYDROGY OF THE IAO AQUIFER SYSTEM

The Iao Aquifer System, State Aquifer Code 60102, is located in western Maui and includes high-level dike, basal, and caprock groundwater bodies. Approximately 50 wells, tunnels, and observation holes exist in this aquifer. The current total pumpage from this aquifer is about 16 mgd on a 12-month moving average basis. The Commission on Water Resource Management (CWRM) established sustainable yield of the system is 20 million gallons per day (mgd). CWRM designated the Iao Aquifer System Area as a ground water management area in July 21, 2003. Water use permits are now required for all non-individual domestic ground water uses.

Basal aquifers, the most important sources of freshwater supply in Hawaii, occur in dike-free volcanic rocks and in sedimentary deposits. Basal aquifers can be either confined or unconfined. Unconfined aquifers occur where the upper surface of the saturated aquifer is not bounded by a confining less-permeable layer. Confined water occurs where the aquifer is bounded by low permeability formations or poorly permeable formations. In many coastal areas there is a sequence of low permeability sediment commonly called caprock. Caprock tends to restrict the seaward flow of freshwater and causes the thickness of the freshwater lens to be greater than it would if the caprock was absent. Depending upon the effectiveness of the caprock, the resulting lens can range from local thickening of a relatively thin lens of a hundred feet to over 1800 feet thick. The amount of water stored in basal lens is significant. Water is withdrawn from the basal aquifer for various uses and basal aquifers provide the primary source for municipal water in Hawaii.

The thickness of the freshwater basal lens can be estimated using the Ghyben-Herzberg equation. Two important assumptions implicit the in the Ghyben-Herzberg theory are 1) there is a sharp interface between freshwater and seawater; and 2) the aquifer is at steady state. Ghyben-Herzberg indicates that for every foot of freshwater above mean sea level there is 40 feet of freshwater below mean sea level. For example, if freshwater is known to occur at an elevation 10 feet above mean sea level, it can be estimated that the hypothetical sharp interface would be approximately 400 feet below sea level. The Ghyben-Herzberg formula provides a reasonable estimate of the freshwater basal lens thickness; however, in actuality, the interface between freshwater and seawater occurs as a brackish transition zone, rather than a sharp interface, with salinity gradually increasing with depth. Therefore, the Ghyben-Herzberg formula is used to estimate the midpoint of the transition zone, which is 50% seawater and 50% freshwater.

The thickness of transition zone depends on various chemical and physical parameters including, but not limited to, pumpage, advection and dispersion, mechanical mixing, physical properties of the aquifer, tidal fluctuation, and atmospheric pressure variation. The movement of the brackish transition zone, both horizontally inland from the seacoast and vertically upward, potentially affects all basal wells.

Iao Aquifer System pumpage began in 1948 with the operation of Wailuku Shaft 33 (5330- 05). Prior to the onset of pumpage, groundwater use was limited to high-level tunnel water. Pumpage from the shaft peaked in 1971 when the average pumpage was 11.7 mgd (Mink, 1986). The Mokuhau Wells (Nos. 5330-09, 10, 11) constituted the second major well field developed in the Iao Aquifer. Mokuhau Wells 1 and 2 were drilled in 1953 and Mokuhau 3 was completed in 1967. During the mid 1970's and early 1980's the Waiehu Heights wells, the Waihee wells, and Kepaniwai Well were added to supply potable drinking water. Pumpage in the Iao Aquifer System steadily increased from about

10 mgd the early 1980's to over 20 mgd in 1997. Since 1997, aquifer pumpage has been reduced to about 16 mgd.

Presently, water level and chloride analyses reveal that the upper portion of the transition zone in the Iao Aquifer is presently rising. The mid-point of the transition zone as shown in Waiehu Deep Monitor Well is presently rising at a rate of about four feet per year. The available information indicates that there is a possibility that more wells in the aquifer will be affected by rising salinity in the future.

4. HYDROGEOLOGY OF WAIEHU HEIGHTS WELL A

4.1 Well Description and Pump Testing

Waiehu Heights Well A ("Well A") was drilled to a total depth of 675 feet in 1975 by Water Resources International, Inc. The well was completed with 337 feet of solid 14 inch, 5/16 inch wall thickness casing, 30 feet of louvered 5/16 inch, 14 inch casing and 308 feet of 13 inch open hole. Although the casing material is assumed to be steel the type of steel is unknown. Figure 4-1 shows an as-built well section drawn from data supplied by the Maui Department of Water Supply.

The current condition of the well casing and open hole is unknown. The type of well casing and its corrosion resistance are also unknown. The well is 37 years old and the condition of the casing should be considered questionable without further investigation. The well has a history of elevated chloride concentrations which may have resulted in increased corrosion of the casing. It is also possible that the open hole is blocked or partially collapsed. In the event that the Department wants to begin using the well again, the well should be video-logged to confirm the condition of the casing and open hole.

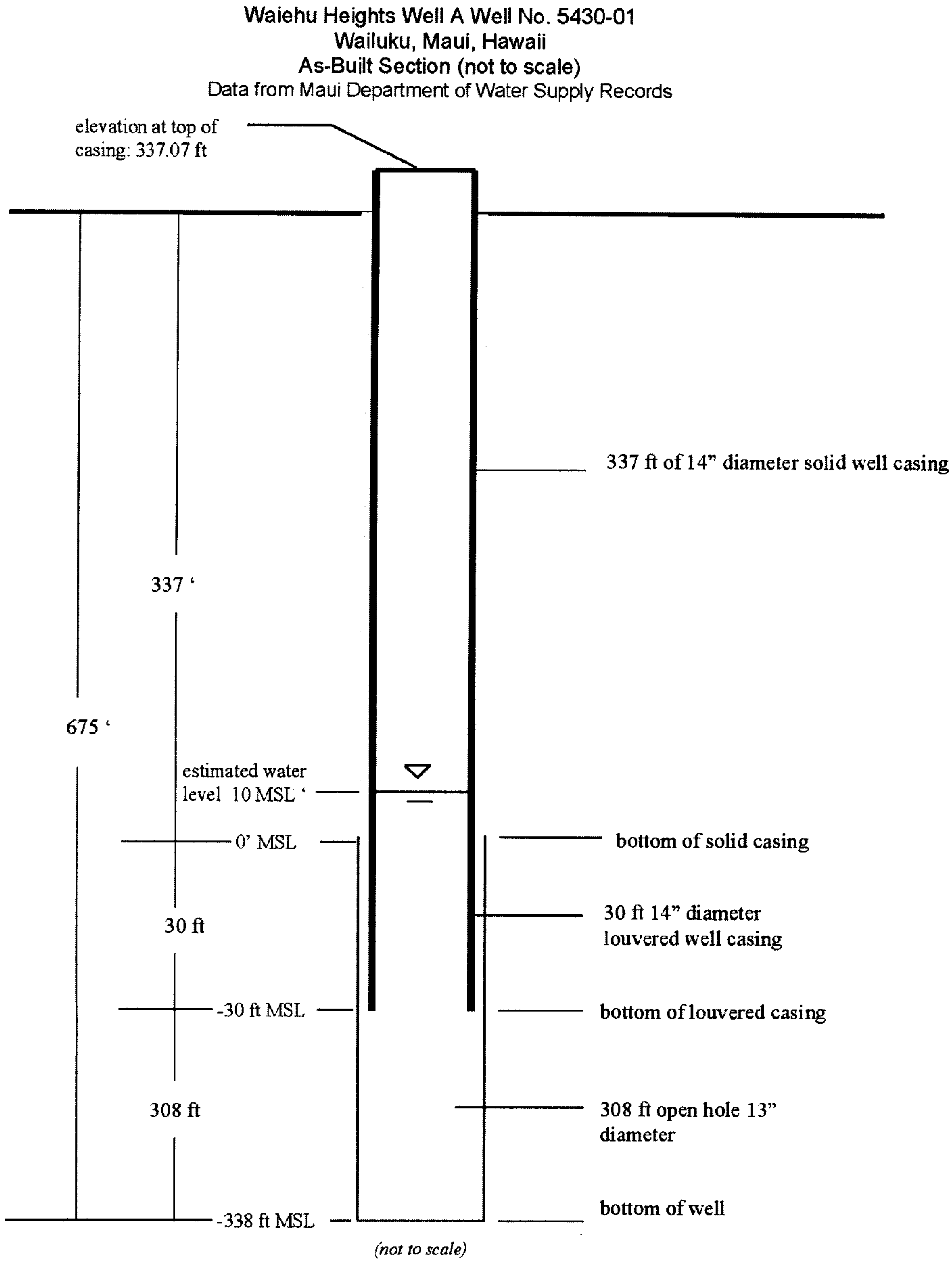

Figure 4-1. well cross section (not to scale)

The well was test pumped twice during construction. The first test was conducted when the well was 555 feet deep on April 4, 1975. It was pumped at a rate of 400 gallons per minute with the pump set at 29 feet below mean sea level. According to CWRM and Maui Department of Water Supply records, water levels declined to 13 feet below mean sea level. The static water level at this time was 18 feet MSL. In other words the drawdown during this initial test pumping at 400 gpm was 32 feet. If we assume that the casing was installed at this point then there were 188 feet of open hole and 30 feet of louvered borehole to yield water to the well. This is a relatively high drawdown for the length of open and louvered borehole in a basal aquifer. It is probable that the production capacity was not considered high enough and that the decision was made to increase the length of open hole.

The well was subsequently deepened by 125 feet to 675 feet total depth and the well was test pumped again on April 21, 1975. It appears that at this point the well was fully constructed with the current configuration of solid casing, louvered casing and open hole.

On April 21, a step drawdown test was conducted. Figure 4-2 shows the results of this test presented graphically. The well was tested at rates between 500 and 1700 gallons per minute with drawdown varying from 2 feet to 9.5 feet.

The long-term test was conducted on April 24, 1975. The well was test pumped for 72 hours at rate of 1300 gallons per minute. Water levels stabilized at 8 feet above mean sea level. Assuming that he static water level was 18 feet MSL this equates to a drawdown of 10 feet at 1300 gpm. During the three days of the test, chloride contest of the pumped water increased from 44 ppm (parts per million; for the purposes of this report ppm is roughly equivalent to mg/L) to 51 ppm. This is a significant rise in chloride concentration for such a short long-term test.

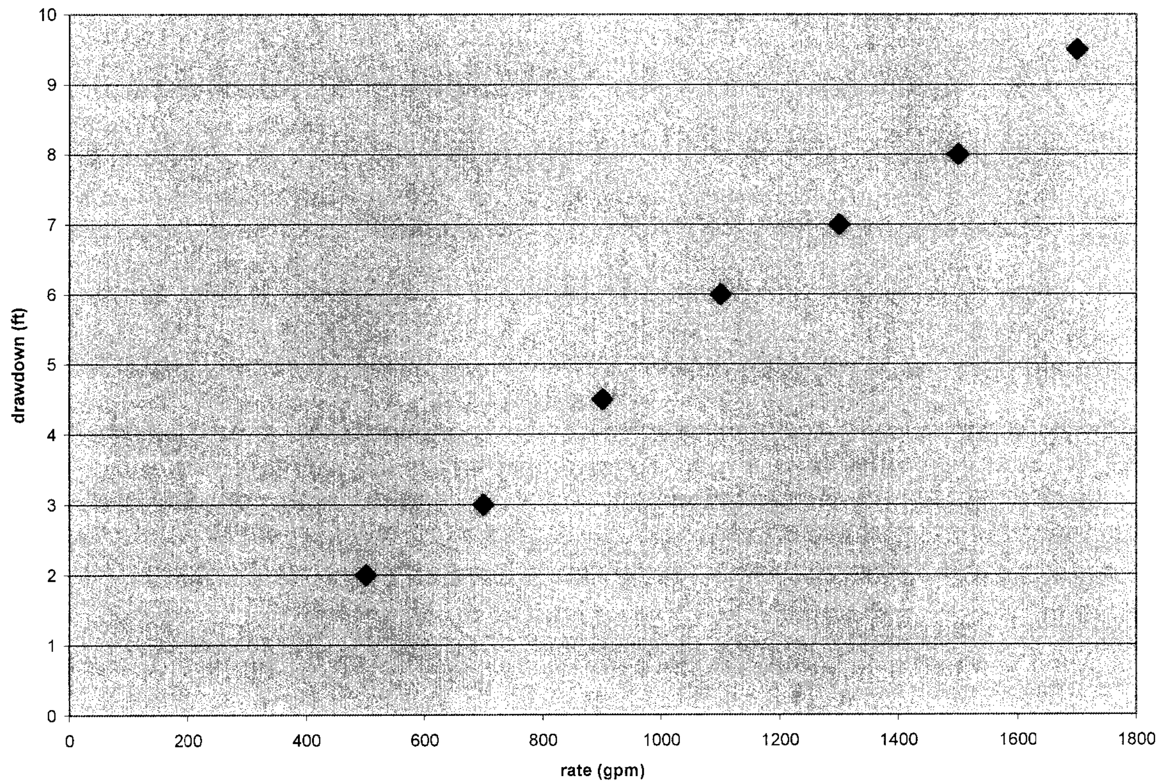

Figure 4-2. Step drawdown test results April 21, 1975

4.2 Well Chloride History

As discussed in Section 4.1, the initial well chloride level was 44 ppm. Figure 4-3 shows the historic trends in chloride levels in water samples from Waiehu Heights Well A. Chloride increased from 52 mg/L in 1975 to 250 mg/L in 2001. The current chloride levels are not known but it is not expected that chloride levels have decreased. The most recent known water quality of 250 mg/L chloride exceeds the EPA secondary contaminant limit.

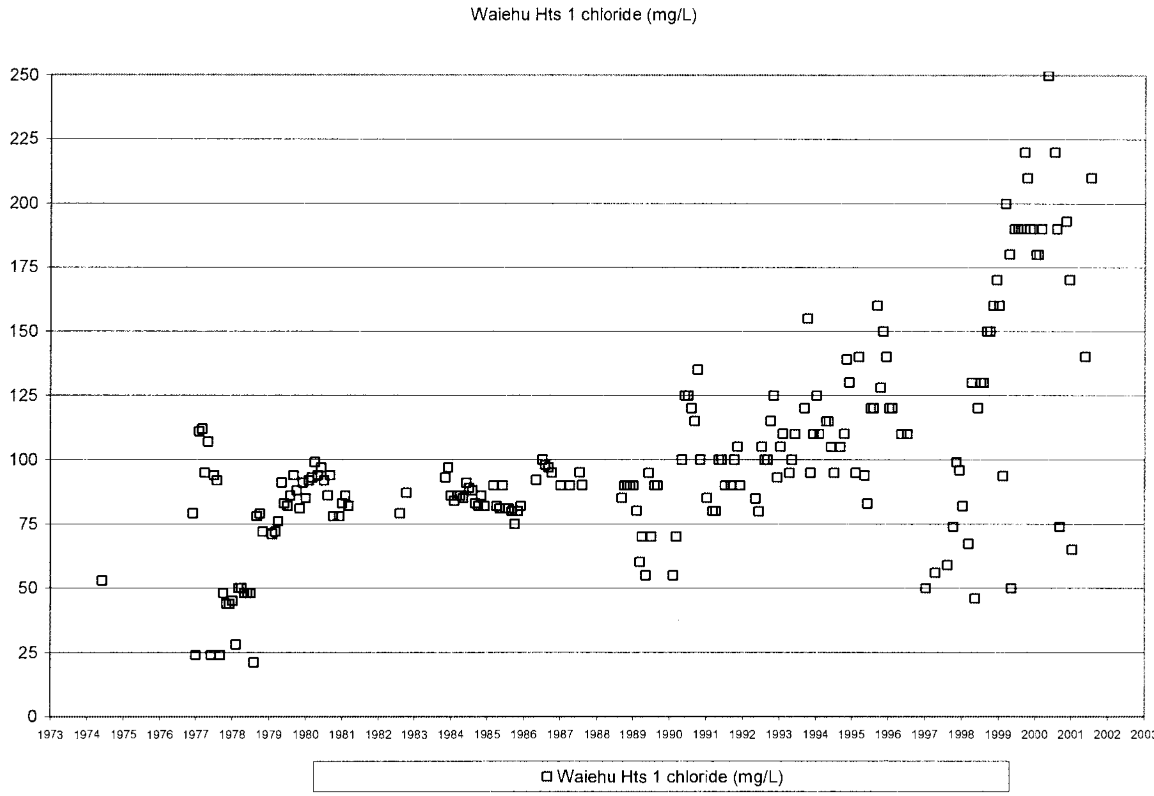

Figure 4-3. Chloride history at Waiehu Heights Well A

4.3 Water Levels

Water level data are available from two nearby monitor wells operated by the U.S. Geological Survey. Test Hole E (5430-03) was monitored from 1982 to 2006. Water levels declined from about 21 feet to about 11 feet above sea level (Figure 4-4). This station is about 0.3 mile south of Waiehu Heights Wells and is not located near any other sources of pumpage.

Test Hole B (5431-01) is located near the Waihee Well Field, about 0.4 mile northwest from Waiehu Heights. Water levels have declined from about 18 feet in the early 1980's to the current level of slightly over 8 feet above sea level (Figure 4-5). Test Hole B is near a large well field and is probably influenced by drawdown from the field. On the other hand, the test hole is also still being monitored so there is recent data.

In the absence of recent, accurate data, water levels at Waiehu Heights are assumed to be between 8 and 11 feet above sea level. For the purposes of this report we will assume that the current average groundwater level is about 10 feet.

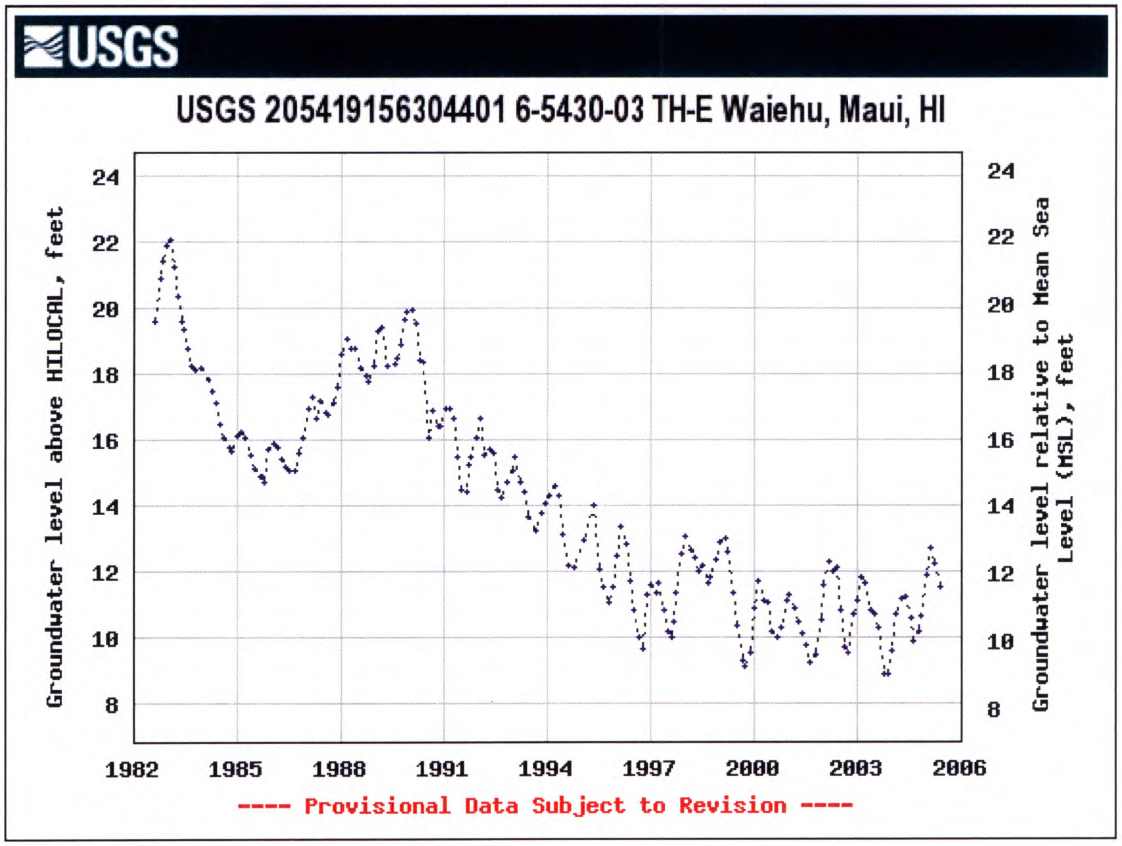

Figure 4-4. Water levels in Test Hole E

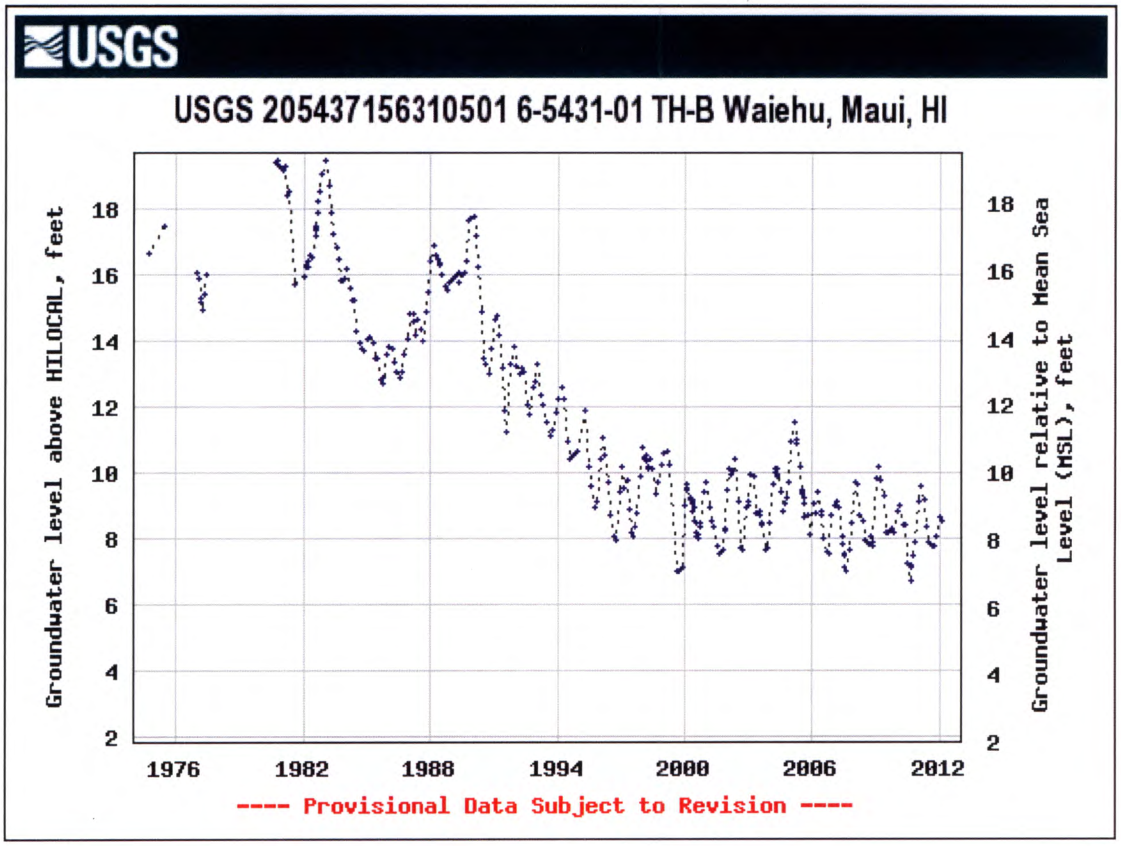

Figure 4-5. Water levels in Test Hole B

4.4 Deep Monitor Well Data

The nearest deep monitor well is Waiehu Deep Monitor Well (well no. 5430-05). It is located about 0.6 miles north of the Waiehu Heights Wells. Although it is a significant distance away, it the best source of data available on the vertical distribution of salinity in the aquifer. Therefore this information is very useful in estimating the salinity profile in Waiehu Heights Well A.

Waiehu Deep Monitor Well penetrates the freshwater portion Iao Aquifer to water with near seawater salinity. A deep monitor well penetrates the entire water column from freshwater into saltwater. Figure 4-6 is a schematic diagram showing three wells, including a deep monitor well, in a basal aquifer.

Data collected from a deep monitor well is used to track the movement of the transition zone over time. By definition, the transition zone is the vertical zone with water quality that varies from 250 mg/L chloride to 19,000 mg/L chloride (approximately seawater). The midpoint (MPTZ) of the transition zone is defined as the area in the vertical profile where the water contains 9,500 mg/L chloride. Because the amount of water that can be developed from a freshwater lens for potable use is constrained by the salinity of the water, the altitude of the top of the transition zone (TTZ; where chloride concentration is two percent that of seawater) and the thickness of the transition zone are important. The transition zone is in constant flux, responding to changes caused by variations in pumping and ground water recharge.

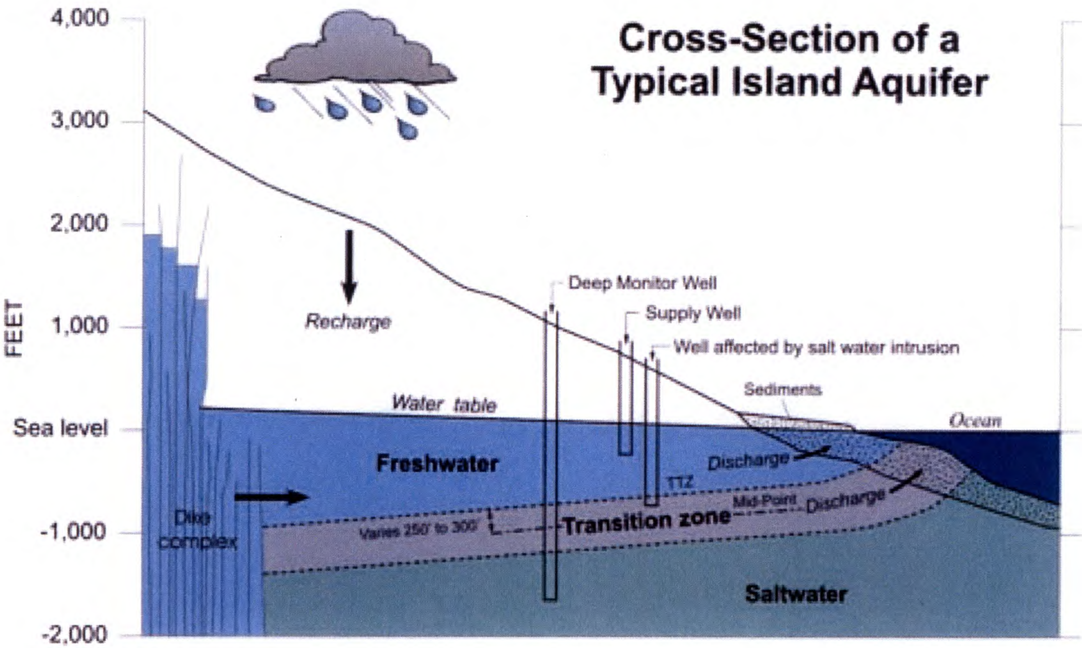

Figure 4-6 Schematic Cross-Section of Basal Aquifer Wells

The transition zone has been rising in Iao as shown by data from Waiehu Deep Monitor Well. Figure 4-7 shows data on the elevations of the top of the transition zone and the midpoint of the transition zone collected by CWRM scientists. Since 1984 the elevation of the midpoint has risen about 160 feet and the elevation of the top of the transition zone has risen about 140 feet. The rising trend appears to be continuing. In 2008 the elevation of the top of the transition zone was at approximately 500 feet below sea level.

Figure 4-8 shows similar results from discrete water samples collected by the U.S. Geological Survey (USGS) between January 2011 and January 2012. The USGS collected individual samples from predetermined depths. These data are useful to corroborate the data collected by CWRM. These data show that both the top of the transition zone and the mid point were rising at Waiehu Deep Monitor Well in 2011. In January 2012, the top of the transition zone was at about 500 feet below sea level.

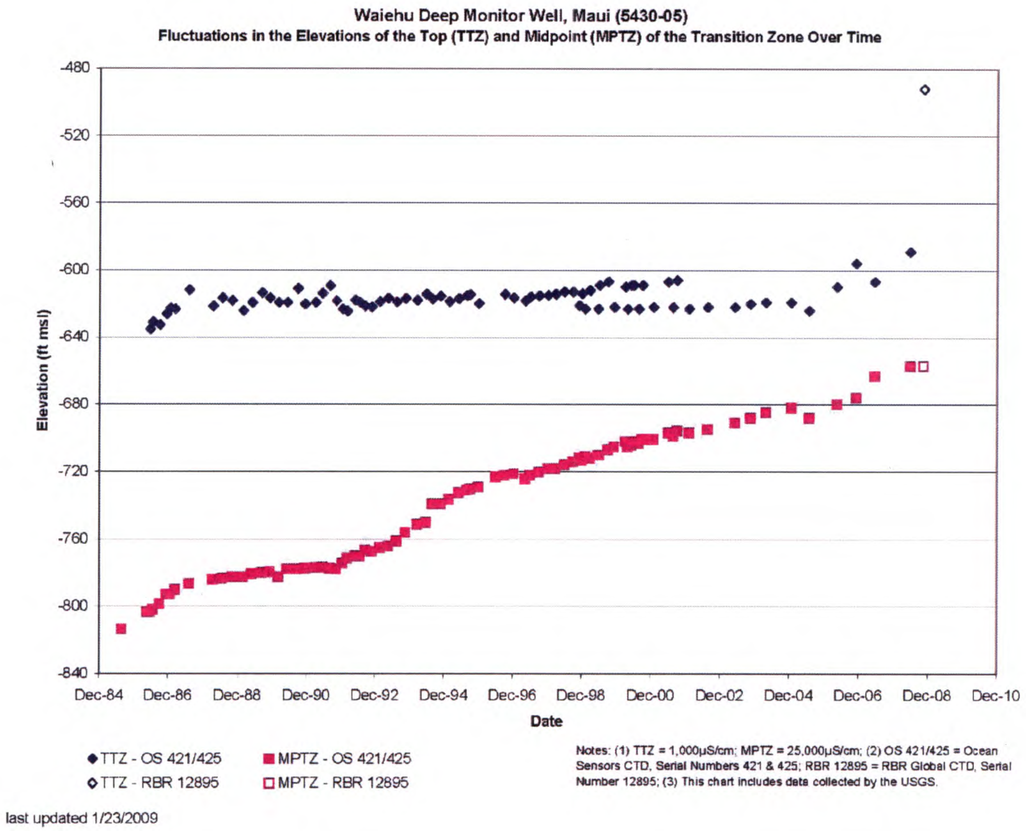

Figure 4-7. Graph showing the elevation of the midpoint and top of the transition zone at Waiehu Deep Monitor Well (CWRM 2012).

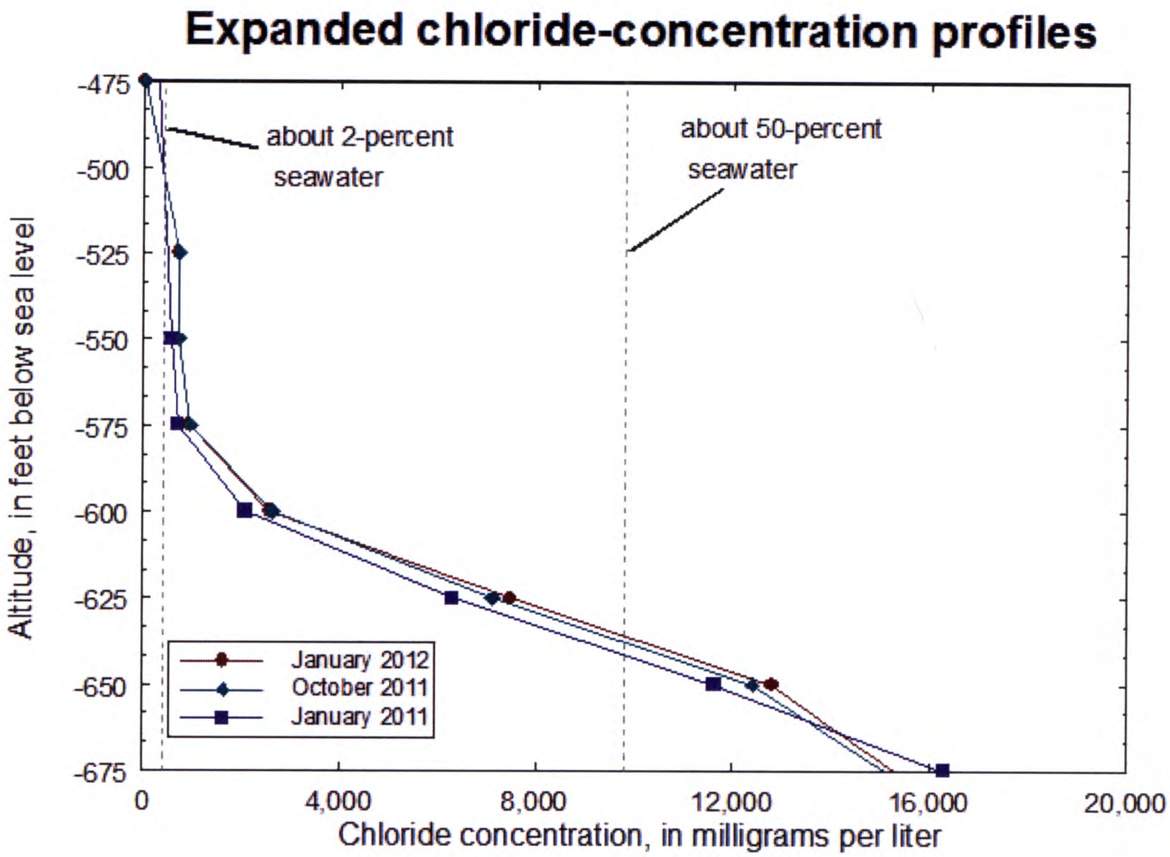

Figure 4-8. Graph results of USGS sampling of Waiehu Deep Monitor Well in 2011 to 2012

4.5 Well Construction and CWRM Rules

The original construction of Waiehu Heights Well A would not be in compliance with the Hawaii Well Construction and Pump Installation Standards (HWCPIS). If the well is modified, the new design must comply with the HWCPIS unless the Chairperson of the Commission on Water Resource Management finds that compliance is impractical and grants a waiver. In particular, the depth of the well and wall thickness of the casing are not in compliance with HWCPIS.

According to the HWCPIS, "any well constructed in basal aquifers for the purpose of nonpotable or potable water withdrawal shall be initially designed and pump tested at a depth below sea level not exceeding on-fourth of the theoretical thickness (41 times the head) of the basal ground-water body, unless authorized by the Chairperson" (HWCPIS 2004). The head or water level at Waiehu is assumed to be about 10 feet so ideally the well should not extend more than 100 feet below sea level. The HWCPIS has provision for the Chairperson to allow wells to extend up to one-half of the theoretical thickness of the basal ground-water body or in the case of Waiehu Heights up to 200 feet below sea level. Waiehu Heights Well A currently extends to 338 feet below sea level. To comply with the HWCPIS it should the hole should be backfilled at least 138 feet but ideally 238 feet.

In addition, according to Department of Water Supply Records, the well was installed with 5/16 inch wall thickness casing. According to the HWCPIS and the County Water System Standards (2002), 14 inch diameter well used for public water supply should be installed with 3/8 inch minimum wall thickness steel casing. Well casing of 5/16 inch diameter is not adequate for a public water supply well of this size.

5. PRELIMINARY WELL SITE

This chapter presents preliminary recommendations for the new well site. Figure 5-1 shows the location of the well site selected by Ronald Fukomoto Engineers. The proposed well site is 0.2 mile south of the Waiehu Heights Wells and 1 miles north of the Mokuhau Well field. The new well site is approximately 380 feet above sea level. Although the site is adequate for a replacement well for Waiehu Heights Well A, the new well should not be used to develop additional water from the area. A drawback of the proposed well site is that it is actually located closer to the center of pumpage in the southern part of the Iao Aquifer System. There is a higher likelihood of effects from regional up-coning.

The new well should be constructed to a total depth of 490 feet, or to 110 feet below sea level and should be cased with 16 inch solid casing. Based on this preliminary evaluation a pump size of 1000 gallons per minute is recommended.

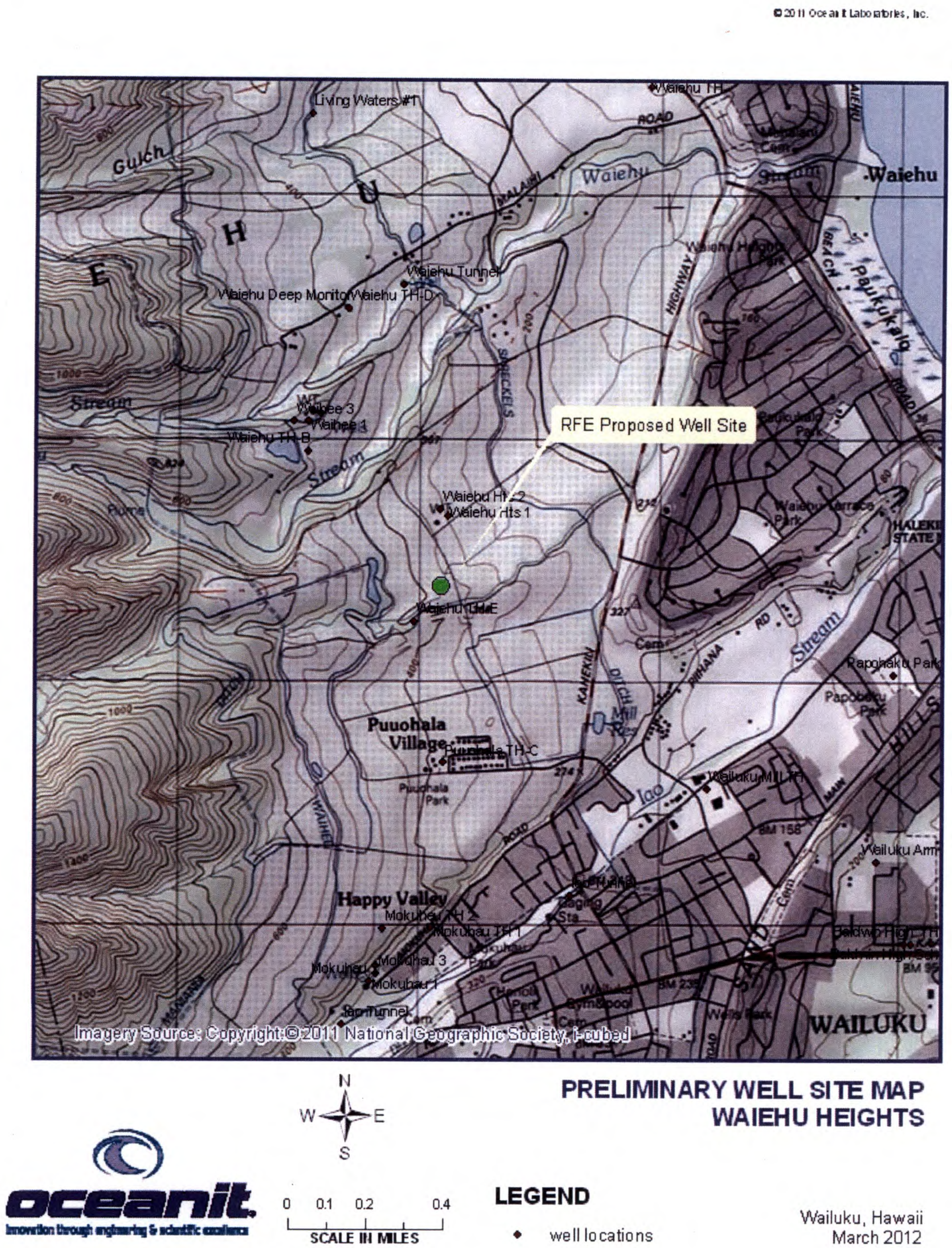

Figure 5-1. Map showing the location of the preliminary proposed well site

6. CONCLUSION

Based on a review of the available data, Waiehu Heights Well A should not be refurbished. The as-built depth of the well is too deep. It is probable that the original well designer knew this but it was necessary to deepen the well in order to yield an adequate amount of water with acceptable drawdown. There are several reasons illustrating the drawbacks of refurbishing the well.

1. The condition of the casing is unknown. In the absence of further information, it should be assumed that there is corrosion damage to the casing, in particular to the louvered portion of the casing. The originally installed casing also had a wall thickness of 5/16 inch and is not in compliance with current standards. Both CWRM rules as defined in the Hawaii Well Construction and Pump Installation Standards (2004) and County Water System Standards (2002) require a minimum wall thickness of 3/8 inch for 14 inch diameter well casing.

2. A potential solution to the elevated chloride problem is to backfill the well by 138 feet to a depth of -200 feet MSL or a total depth of 537 feet. Upon receipt of a waiver from CWRM, the well depth would be in compliance with CWRM well standards. The well would extend half-way through the theoretical thickness of the basal aquifer. At this depth, there would be a strong possibility that, in the long term, the well will continue to yield water with high chloride concentration.

3. Backfilling of the well to a total depth of 537 feet would also result in a large reduction in well yield at an acceptable drawdown. At this depth the well drawdown at 400 gpm will be greater than 32 feet. This would be an unacceptable drawdown for the current depth of louvered casing. The louvered casing extends to -30 feet MSL and the current water level is about 10 feet MSL. The drawdown would extend to only 8 feet above the bottom of the louvered casing. The intake of the permanent pump would have to be installed below the bottom of the casing.

4. Although it is difficult to explain precisely why with the available information, it seems evident that the well was drilled in an "unlucky location". The hydrogeology of the well site was not typical of basal basalt aquifers. The original well designer and drillers had to drill the well to excessive depth to get the required capacity. It would be a poor decision to invest more money in the well when the pumpage history already demonstrates that there is relatively poor yield and high chloride concentrations.

7. REFERENCES

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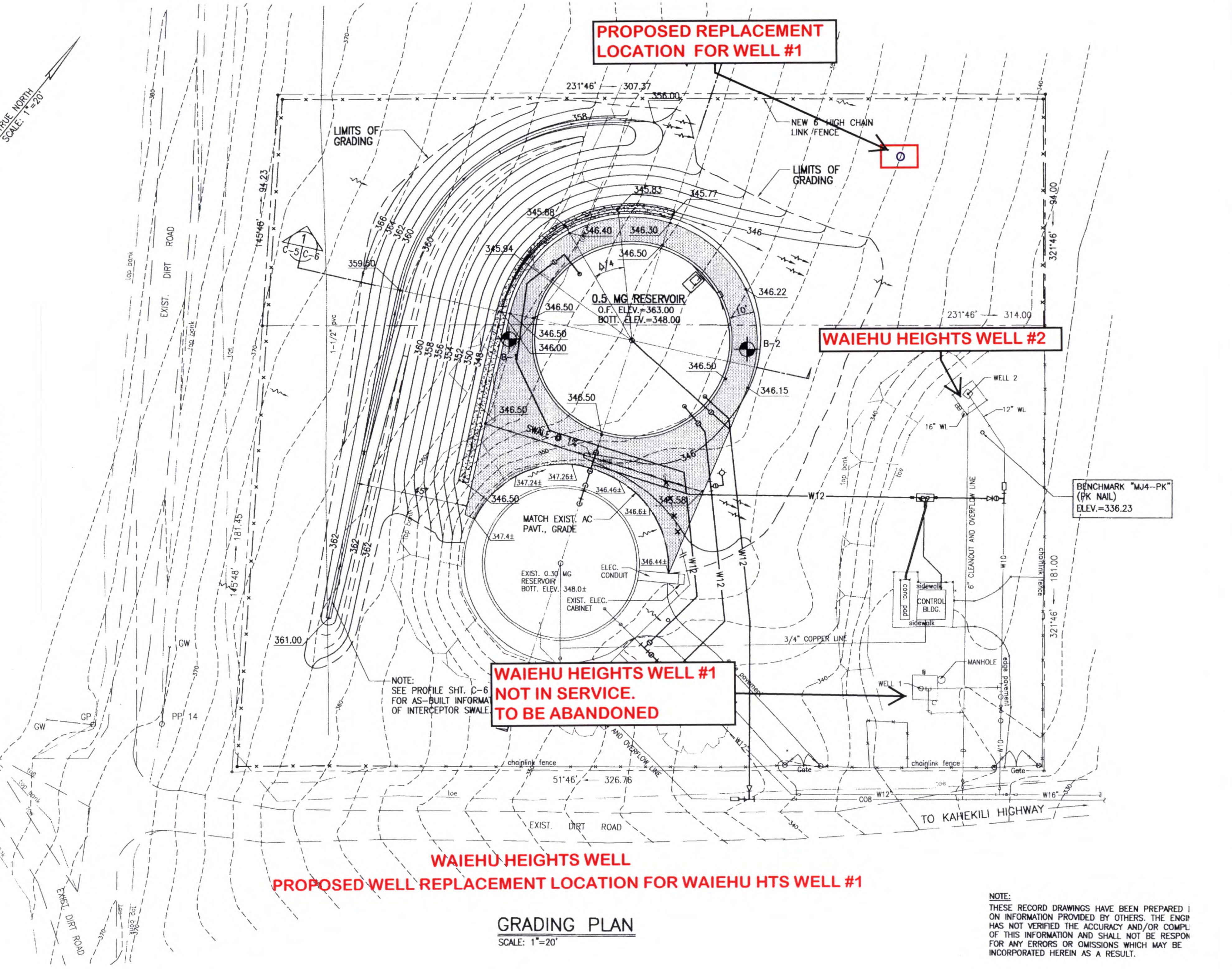
EXHIBIT B

WAIEHU HEIGHTS WELL

PROPOSED WELL REPLACEMENT LOCATION FOR WAIEHU HTS WELL #1



Department of Water Supply Water Resources and Planning Division
Watershed Protection Grants Program

GRANTEE	PARTNERS	OTHER FUNDING
East Maui Watershed Partnership (EMWP-UH)	1. DLNR 2. Haleakala National Park 3. East Maui Irrigation Company 4. Haleakala Ranch Company 5. The Nature Conservancy	DLNR-WPP $300,000.00 Total $300,000.00
Leeward Haleakela Watershed Restoration Partnership (LHWRP-UH)	1. DHHL 2. DLNR 3. Haleakala National Park 4. Haleakala Ranch 5. Ka'ono'ulu Ranch 6. Kaupo Ranch 7. Nu'u Mauka Ranch 8. Thompson Ranch 9. Ulupalakua Ranch	Waiting for revision for: Atherton Family Foundation Haleakalā: National Park Service (NPS) Hawaii Invasive Species Council (HISC) Hawaii Tourism Authority (HTA) Hawaii Wildfire Management Organization (HWMO) Laurence H Dorcy Hawaiian Foundation State of Hawaii Division of Forestry and Wildlife (DOFAW) U.S. Fish and Wildlife Service (USFWS)
Maui Invasive Species Committee (MISC-UH)	1. HISC 2. Hawaii DOA 3. DLNR 4. Haleakala National Park 5. Kalaupapa National Historic Park 6. Molokai-Lanai Soil and Water Conservation District 7. Molokai Land Trust 8. UH-CTAR 9. UH-PCSU 10. US DOA-Plant Materials Center 11. USDAFWS 12. USDA-NRCS 13. USFWS 14. TNC Hawaii	HISC $705,845.00 Total $705,845.00
West Maui Mountains Watershed Partnership (WMMWP-UH)	1. Kaanapali Land Management Corp./TNC 2. Kahoma Land Co. 3. Kamehameha Schools 4. Makila Land Co. 5. ML&P Co. Inc. 6. State of Hawaii - NAR 7. State of Hawaii – Forest Reserves 8. Wailuku Water Co. LLC 9. USFWS 10. Tri-Isle RC&D	DLNR-WPPG $330,000.00 DLNR PKW/KAPUNAKEA FENCING $250,000.00 USFWS (PENDING) $25,000.00 DLNR-HISC $3,800.00 Total $608,800.00

EXHIBIT C

Department of Water Supply Water Resources and Planning Division
Watershed Protection Grants Program

East Molokai Watershed Partnership (EMoWP-TNC)	1. Molokai Ranch 2. Kawela Plantation 3. Kamehameha Schools 4. Kapualei Ranch 5. Thacker 6. Wond/Pedro 7. DLNR 8. Suzuki Dunnam 9. Friel 10. Hutchison 11. Molokai Land Trust 12. KNHP 13. Molokai Lanai SWCD 14. MoMISC 15. PCSU Molokai Plant Extinction Program 16. DOH 17. USDA NRCS 18. US EPA 19. US Fish and Wildlife Service 20. USGS	DLNR-WPP $100,000.00 State NAPP $200,000.00 Kamehameha Schools (match for NAPP) $60,000.00 TNC $100,000.00 Total $460,000.00
Puukukui Watershed Preserve (PKW – Tri Isle)	1. TNC 2. DLNR 3. Haleakala National Park 4. US Fish and Wildlife Services 5. O'ahu Army Natural Reserve Program 6. USGS 7. NOAA 8. DOH 9. US EPA 10. US Fire Service 11. Hunter Education 12. Ua'u Kani Wedge Tailed Shearwater Protection 13. Forestry Stwewardship 14. The Rain Follows the Forest 15. Ridge to Reef 16. Na Alahele 17. Aquatic Resources 18. Honolua Coalition 19. Surf Rider Foundation 20. Aha Moku Council 21. West Maui Fire Prevention Task Force 22. West Maui SWCD 23. Hawaii Island Land Trust 24. Na Pilli Foundation	DLNR/NAPP $200,720.00 DOH $500,000.00 ML&P $100,360.00 Total $801,080.00

Department of Water Supply Water Resources and Planning Division
Watershed Protection Grants Program

Bio-Economic Models (Dr. Leary- UH)	1. MISC-UH	DWS only
Auwahi Forest Restoration Project (AFRP – UH)	1. Ulupalakua Ranch	USFWS - MAHOE $47,095.00 USFWS - RODENT $48,732.00 NRCS $57,529.00 ULUPALAKUA RANCH $26,000.00 HTA (NOT AWARDED YET) $77,519.00 Total $256,875.00
Kapunakea Honokowai-Wahikuli Watershed Management (TNC)	1. Haleakala National Park 2. Maui Forest Bird Recovery Program 3. Kamehameha Schools 4. DLNR 5. DOH 6. USDA NRCS 7. US EPA 8. US Fish and Wildlife 9. Kaanapali Land Management Corporation	NAPP $110,600.00 Private Sources $15,253.00 Total $125,853.00
Waikamoi Upcountry East Maui Source Protection (TNC)	1. Haleakala National Park 2. Maui Forest Bird Recovery Program 3. Kamehameha Schools 4. DLNR 5. DOH 6. USDA NRCS 7. US EPA 8. US Fish and Wildlife 9. East Maui Irrigation	NAPP - WAIKAMOI PRESERVE $200,200.00 NAPP - WAIKAMOI EMI $75,000.00 NFW FOUNDATION $50,000.00 Private Sources $70,000.00 Total $395,200.00
Hawaii Agricultural Research Center (HARC)	1. USDA Forest Service 2. Haleakala Ranch 3. Ulupalakua Ranch 4. DOFAW	USFS/DLNR-DOFAW $57,800.00 HARC ADMIN/FACILITIES $10,200.00 Total $68,000.00