

BEFORE THE
COMMISSION ON WATER RESOURCE MANAGEMENT
STATE OF HAWAII

In Re: Chairperson Recommendation)
to Designate the Iao and Waihee Aquifer Systems)
as Ground-Water Management Areas)

**IAO AND WAIHEE AQUIFER SYSTEMS
STATE AQUIFER CODES 60102 and 60103
GROUND-WATER MANAGEMENT AREA DESIGNATION
FINDINGS OF FACT**

Commission on Water Resource Management
Department of Land and Natural Resources
November 14, 2002

PREFACE

This FINDINGS OF FACT (FOF) has been prepared for the Commission on Water Resource Management (CWRM or Commission) for its consideration in designating the Iao and Waihee Aquifer Systems, State Aquifer Code 60102 and 60103, on the island of Maui as a ground-water management areas under the authority of Chapter 174C, HRS.

From February 1986 to August 1997, various Board of Land and Natural Resources and Commission initiated designation proceedings, investigations, findings of fact, and reports transpired and culminated in the Commission's latest action on August 13, 1997 to **not** designate the Iao Aquifer System. Although not designated, the Commission added the condition that if the 12-month moving average of pumpage from the aquifer ever exceeded 20 million gallons per day (mgd) in the future, the aquifer would automatically be designated. This condition remains active to date.

On July 12, 2001, Maui Meadows Homeowners Association submitted a petition to the Commission requesting designation of the Iao and Waihee Aquifer Systems as ground-water management areas. A copy of the petition is attached in Appendix A. This constitutes the third designation proceeding for the Iao Aquifer System and the first for the Waihee Aquifer System.

This FINDINGS OF FACT summarizes the CWRM staff investigations and research, comments from consultation with the County of Maui, the public's written and oral comments received at the public hearing, and other existing information on file with the Department of Land and Natural Resources.

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EXECUTIVE SUMMARY

In response to a petition to designate the Iao and Waihee Aquifer Systems as ground-water management areas, the Commission on Water Resource Management (CWRM or Commission) approved a continuance of the designation process. This FINDINGS OF FACT is part of the continuation for designation and addresses the current hydrologic conditions, future planned uses, and public interest information as required by the Water Code, §174C HRS, for the CWRM's designation decision-making duty. Under a ground-water management area the CWRM would regulate water withdrawals from the Iao and/or Waihee Aquifer Systems through a water use permit process. This FINDINGS OF FACT is based upon information on file in the Department of Land and Natural Resources, the research of independent investigators, the written and oral comments submitted to the CWRM at the public hearing, and other planning and scientific literature.

Annotated Summary of Water Management Area Designation Process

The process for taking action on a petition to designate a water management area as defined under the Water Code §174C-41, and the dates associated with progress to-date, follows. This information is restated in Section 2 of the report.

- (1) *Petition filed with the Commission* (July 12, 2001).
- (2) *Consultation with Mayor, County Council, and County Water Board* (August 6, 2001: staff mailed letters to the Mayor, County Council, and the Department of Water Supply for the County of Maui requesting comments to the petition).
- (3) *Comments received from Mayor, County Council, and County Water Board.* (On September 10, 2001, the Maui County Council Member, Charmaine Tavares, submitted a letter requesting more information about the Iao Aquifer System. On the same day, Maui County Council Member, Michael Molina, faxed a letter requesting more information about the Iao Aquifer System. On September 11, 2001, the Maui Department of Water Supply (MDWS) faxed their petition comments to the Commission.)
- (4) *Chairperson recommends to the Commission to accept (and to continue the designation process) or to reject the petition within 60 days of receipt of the petition* (August 15, 2001: following the Chairperson's recommendation, the Commission extended the 60-day deadline (September 10, 2001) to the November CWRM meeting to give the Maui County agencies more time to review and offer comments on the petition).
- (5) *Commission rejects petition or decides to continue designation process.* (On November 14, 2001, the Commission decided to continue the designation process and also reaffirmed the automatic designation of Iao if the 12-month moving average of pumpage exceeds 20 mgd).
- (6) *Publication of notice of public hearing* (December 10, 17, & 24).
- (7) *Public hearing is held* (January 9, 2002).
- (8) *Completion of staff investigation in cooperation with County and Federal agencies* (January through September 2002).
- (9) *Completion of draft of findings of fact* (September 2002).
- (10) *Consultation with Mayor, County Council, and County Water Board* (September 2002).

- (11) *Completion of final findings of fact*, following comments from County.
- (12) *Chairperson recommendation for Commission* for or against designation.
- (13) *Commission final action within 90-days* of chairperson recommendation in Step 12.

Iao Aquifer System's Current Ground-Water Issues

The Iao Aquifer System, State Aquifer Code 60102, is located in western Maui and includes high-level dike, basal, and caprock ground-water bodies and is hydraulically connected to the Waihee and Waikapu Aquifer Systems. A total of 48 wells, tunnels, and observation holes exist in this aquifer with 75 percent of the pumpage concentrated north of Iao Stream. The current total pumpage from this aquifer is 16± mgd on a 12-month moving average basis. The current CWRM established sustainable yield of the system is 20 million gallons per day (mgd) and is deemed reasonable at this time. Existing water use presently accounts for approximately 80 percent of the system's sustainable yield.

Presently, water level and chloride analyses reveal that the upper portion of the transition zone is presently rising and at least three Maui Department of Water Supply (MDWS) wells have experienced substantial increases in their chloride concentrations. The mid-point of the transition zone is presently rising at a rate of 4± ft/year while the top of the transition zone is not rising and remains 292 ft below the deepest production well. Staff believes that rising chlorides at individual wells are due more to localized upconing and infrastructure rather than regional degradation of the aquifer.

The MDWS is the primary large existing user of the Iao Aquifer System for municipal uses through its Central Maui Service Area (CMSA). The Iao Aquifer System is the major ground-water source for the CMSA supplying 77% of the total demand of the CMSA, although Waihee Aquifer System wells have recently come online. Long-range future demands to be satisfied through the CMSA may be at least 29.2 mgd. Therefore, authorized planned uses exceed the sustainable yields (Iao 20 mgd and Waihee 8 mgd = 28 mgd) available to the CMSA. Alternative sources in East Maui have been identified to supplement the Central Maui Water System. However, if this long-range additional water development fails to materialize then supply may fall short of meeting the future demand on the CMSA by 1.2 mgd.

Serious disputes between the interested public and the MDWS have been occurring related to the integrity of the aquifer and land use decisions that affect demand on the aquifer. Given the current data, the integrity of the aquifer is acceptable though current infrastructure constraints are limiting the optimal utility of the aquifer. Additionally, the MDWS has adopted the Iao Water Management Rule, §16-9, which identifies management actions to be taken once certain pumpage and chloride limits have been exceeded. However, this rule has not been enforced by MDWS. The CWRM has no jurisdiction on land use approvals that are under the purview of the County of Maui and the State Land Use Commission.

Waihee Aquifer System's Current Ground-Water Issues

The Waihee Aquifer System, State Aquifer Code 60103, is located in western Maui and includes high-level dike and basal ground-water bodies and is hydraulically connected to the Iao and Kahakuloa Aquifer Systems. A total of 15 wells, tunnels, and observation holes exist in this aquifer with the pumpage concentrated south of Makamakaole Stream. The current total pumpage from this aquifer is 5± mgd on a 12-month moving average basis. The current CWRM established sustainable yield of the system is 8 million gallons per day (mgd) and is deemed reasonable at this time. Existing water use presently accounts for approximately 62 percent of the system's sustainable yield.

Unlike Iao, there is no deep monitor well in Waihee to assess the actual behavior of the basal lens and the transition zone. In general, despite lower water levels than Iao, Waihee sources produce water with lower chloride concentrations.

The MDWS is the primary large existing user of the Waihee Aquifer System for municipal uses through its CMSA. The Waihee Aquifer System currently supplies 23 percent of the total demand from the CMSA. Long-range future demands to be satisfied through the CMSA may be at least 29.2 mgd. Therefore, authorized planned uses exceed the sustainable yields (Iao 20 mgd and Waihee 8 mgd = 28 mgd) available to the CMSA. Alternative sources in East Maui have been identified to supplement the CMSA. However, if this long-range additional water development fails to materialize then supply may fall short of meeting the future demand on the CMSA by 1.2 mgd.

Serious disputes between the interested public and the MDWS have been occurring related to the integrity of the aquifer and to land use decisions that affect demand on the aquifer. Given the current data, the integrity of the aquifer is acceptable though current infrastructure constraints are limiting the optimal utility of the aquifer. The CWRM has no jurisdiction on land use approvals that are under the purview of the County of Maui and the State Land Use Commission.

Major Findings

Given the existing hydrologic data, analyses, and future committed withdrawals from the Iao Aquifer System, this report makes the following findings:

1. The sustainable yield of the Iao Aquifer System, independent of the existing well distribution system, is not more than 20 mgd.
2. The sustainable yield of the Waihee Aquifer System, independent of the existing well distribution system, is not more than 8 mgd.
3. MDWS is the sole major user in both the Iao and Waihee Aquifer Systems.
4. Verified small individual users constitute less than 0.5 percent of total pumpage from the Iao and Waihee Aquifer Systems.
5. The current Iao pumpage, based on a 12-month moving average, is 16± mgd, which is 80 percent of Iao's sustainable yield and is mostly concentrated in the northern half of the aquifer.

6. The current Waihee pumpage, based on a 12-month moving average, is 5± mgd, which is 62 percent of Waihee's sustainable yield and is concentrated in the southern third of the aquifer.
7. High-level dike impounded tunnel water flow is not counted against sustainable yield because their net effect is zero on sustainable yield.
8. Both the Iao and Waihee Aquifer Systems have been experiencing significant drought conditions since 1998.
9. Basal water levels in both Iao and Waihee have been generally decreasing until the year 2000 but have stabilized since then.
10. In Iao, the top of the transition zone is not rising while the mid-point continues to rise, resulting in a thinning phenomenon in the upper transition zone.
11. Chloride concentrations have risen significantly and are approaching the EPA guideline of 250 milligrams per liter (mg/L) in three Iao wells (Mokuhau 1 and 3, 5330-09, 11 and Waiehu Heights 1, 5403-01).
12. Long-range authorized planned future demands from community plans and specified in the Maui County Water Use and Development Plan and recent communications with the County of Maui show there may be a 1.2 mgd deficit should other long-range water developments fail to materialize.
13. Maui County adopted Title 16, Chapter 9; the Iao Management Rule on 3/15/99.
14. Criteria 1 and 4 of the 8 ground-water criteria cited in HRS §174C-44 have been met.

Conclusion

Present available data and information support a finding that the first of the two criteria listed below has been met in the Waihee Aquifer System, while both have been met in the Iao Aquifer System. These criteria are:

1. **[§174C-44(1)]** *Whether an increase in water use or authorized planned use may cause the maximum rate of withdrawal from the ground-water source to reach ninety percent of the sustainable yield of the proposed water management area;*
2. **[§174C-44(4)]** *Whether rates, times, spatial patterns, or depths of existing withdrawals of ground-water are endangering the stability or optimum development of the ground-water body due to upconing or encroachment of salt water;*

COMMISSION ON WATER RESOURCE MANAGEMENT
STATE OF HAWAII

In Re: Chairperson Recommendation)
to Designate the Iao Aquifer System)
as a Ground-Water Management Area)

**IAO and WAIHEE AQUIFER SYSTEMS
GROUND-WATER MANAGEMENT AREAS DESIGNATION
FINDINGS OF FACT**

1. PURPOSE

This Findings of Fact Report (FOF) has been prepared for the Commission on Water Resource Management (CWRM), in accordance §174C-43 to 46, HRS. This report should facilitate the Commission's decision of designating the Iao and Waihee Aquifer Systems as the IAO AQUIFER SYSTEM GROUND-WATER MANAGEMENT AREA and the WAIHEE AQUIFER SYSTEM GROUND-WATER MANAGEMENT AREA.

2. DESIGNATION BACKGROUND

The State Water Code process for designation is outlined in §174C-41 to 46, HRS. The process and history is summarized in the following sections.

2.1. Written Petition to Designate, (§174C-41(b), HRS)

On July 12, 2001 Maui Meadows Homeowners Association (MMHA) submitted a petition to the CWRM requesting designation of the Iao and Waihee Aquifer Systems as ground-water management areas. A copy of the petition is attached in Appendix A.

2.2. County Consultation (§174C-41(b), HRS)

On August 6, 2001, staff mailed letters to the Mayor, County Council, and the Maui Department of Water Supply (MDWS), as required by the Code, requesting comments to the petition.

On August 15, 2001, the CWRM extended the 60-day chairperson recommendation for designation deadline (September 10, 2001) to give the various agencies of the County of Maui more time to review and offer comments on the petition. The CWRM specified this extension would be up until the November CWRM meeting.

Responses were submitted as follows: The Mayor (December 10, 2001); MDWS (September 10, 2001); the County Council (December 3, 2001). Both the Mayor and County Council missed the extended deadline. County responses may be found in Appendix B.

2.3. Recommendation for ‘Continuance’ (§174C-42, HRS)

On November 14, 2001, the CWRM accepted the chairperson’s recommendation for designation by approving the continuance of the designation process. This was done to further investigate the hydrologic conditions and notify the County of the seriousness of the situation. The CWRM-approved action may be found in Appendix C.

2.4. Public Hearing (§174C-42, HRS)

After the CWRM decision to accept the petition and continue the designation process a public hearing is required. Notices for the public hearing were published in the Honolulu Star Bulletin and Maui News issues of December 10, 17, 24, 2001. On January 9, 2002, the CWRM held the public hearing on the island of Maui at the Wailuku Community Center to receive public testimony concerning designation of the Iao and Waihee Aquifer Systems. After the close of the public hearing, testimony was accepted until February 8, 2002. Notices and written public hearing testimony can be found in Appendix D.

2.5. Draft Findings of Fact and County Consultation (§174C-43,44, and 46, HRS)

After the public hearing and completion of staff investigations, a draft findings of fact was presented to the CWRM on September 18, 2002. This draft was circulated to the Mayor, County Council, MDWS, and the petitioner for comments. This draft was also posted on the CWRM website for other interested public access.

2.6. Findings of Fact Report (FOF) (§174C-43,44, and 46, HRS)

After the public hearing, completion of staff investigations and a draft of this FOF, and further consultation with the Mayor, County Council, and MDWS (comments found in Appendix E), this is the final FOF prepared in accordance with Water Code. This document presents the findings relative to the eight (8) ground-water designation criteria as specified in §174C-44, HRS.

3. PROPOSED IAO AND WAIHEE AQUIFER SYSTEMS WATER MANAGEMENT AREAS

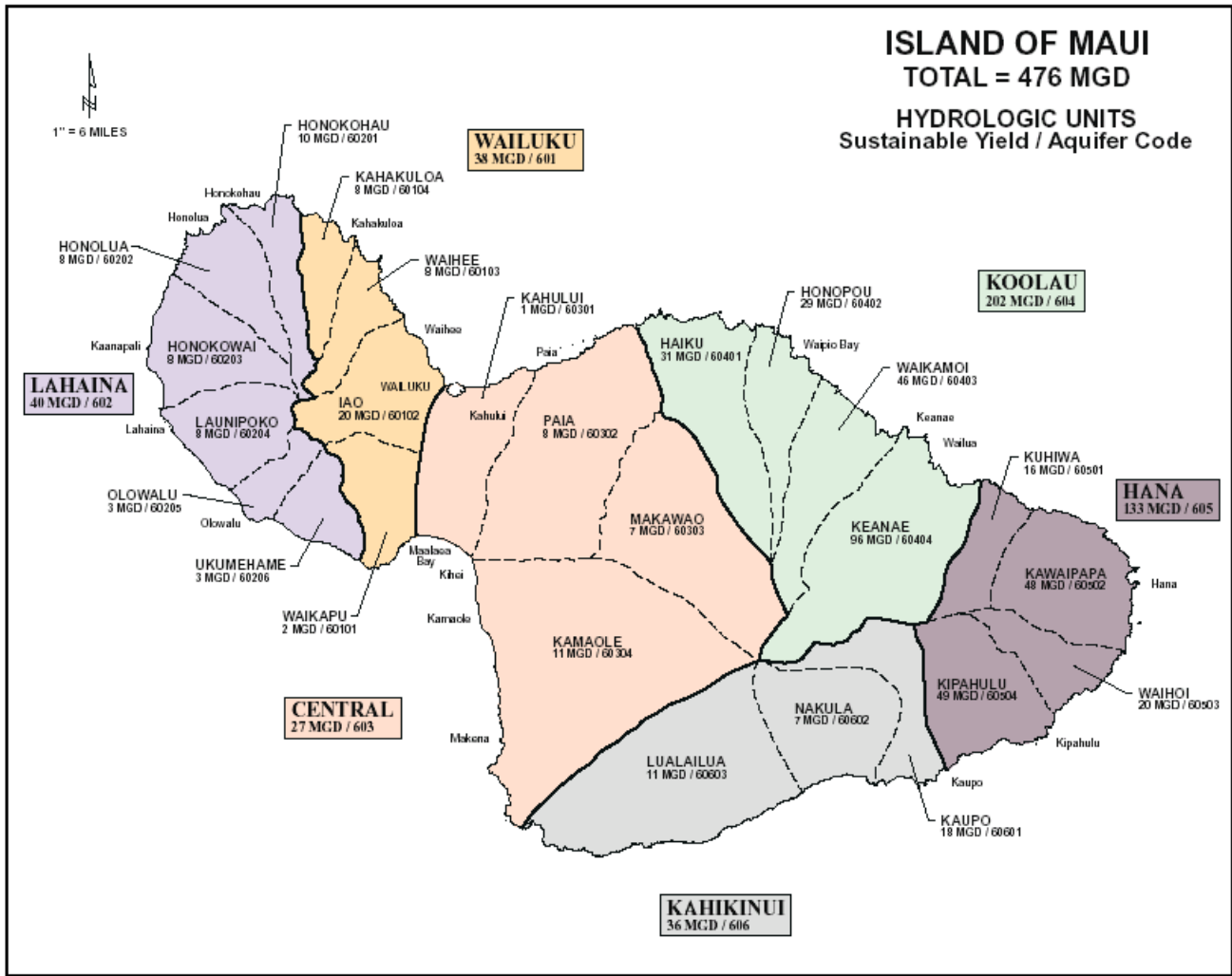
3.1. Areal Extent

The Iao and Waihee Aquifer Systems are two of four aquifer systems located within the Wailuku Aquifer Sector, Maui. The Iao Aquifer System area is 17.81 mi² (11,400 acres) or 33 percent of the total Wailuku Aquifer Sector area of 53.43 mi², while the Waihee Aquifer System is 11.87 mi² (7600 acres) or 22 percent of the total Wailuku Aquifer Sector area of 53.43 mi² (Yuen and Assoc., 1990, p. B-7). The systems' boundaries are shown in Figure 1 and follow the boundaries as defined in the State's Water Resources Protection Plan (WRPP). They have been accepted by the County of Maui in its Maui County Water Use and Development Plan.

A sector is the largest ground-water subdivision within an island. Maui has six sectors. West Maui is divided into the Wailuku and Lahaina Sectors. A sector is defined as a region having hydrogeological similarities, however, its aquifers are not necessarily hydraulically connected (Yuen and Assoc., 1990; Mink and Lau, 1990; Mink and Sumida, 1984).

Aquifer systems are subdivisions within a sector. Aquifer systems within a sector **are hydraulically connected** as is defined by the WRPP. The systems are considered connected despite their water-level differences. For example, within a system, the high-level dike impounded aquifer leaks water into the dike-free basal aquifer (Mink and Sumida, 1984). Likewise, the water-level differences between Iao and Waihee do not mean they are hydrologically independent of each other.

Figures 1 and 2 show the Iao and Waihee Aquifer System boundaries along with all well locations.



10/20/1995

Map Projection: Universal Transverse Mercator

Figure 1. Location of Iao and Waihee Aquifer Systems – Maui

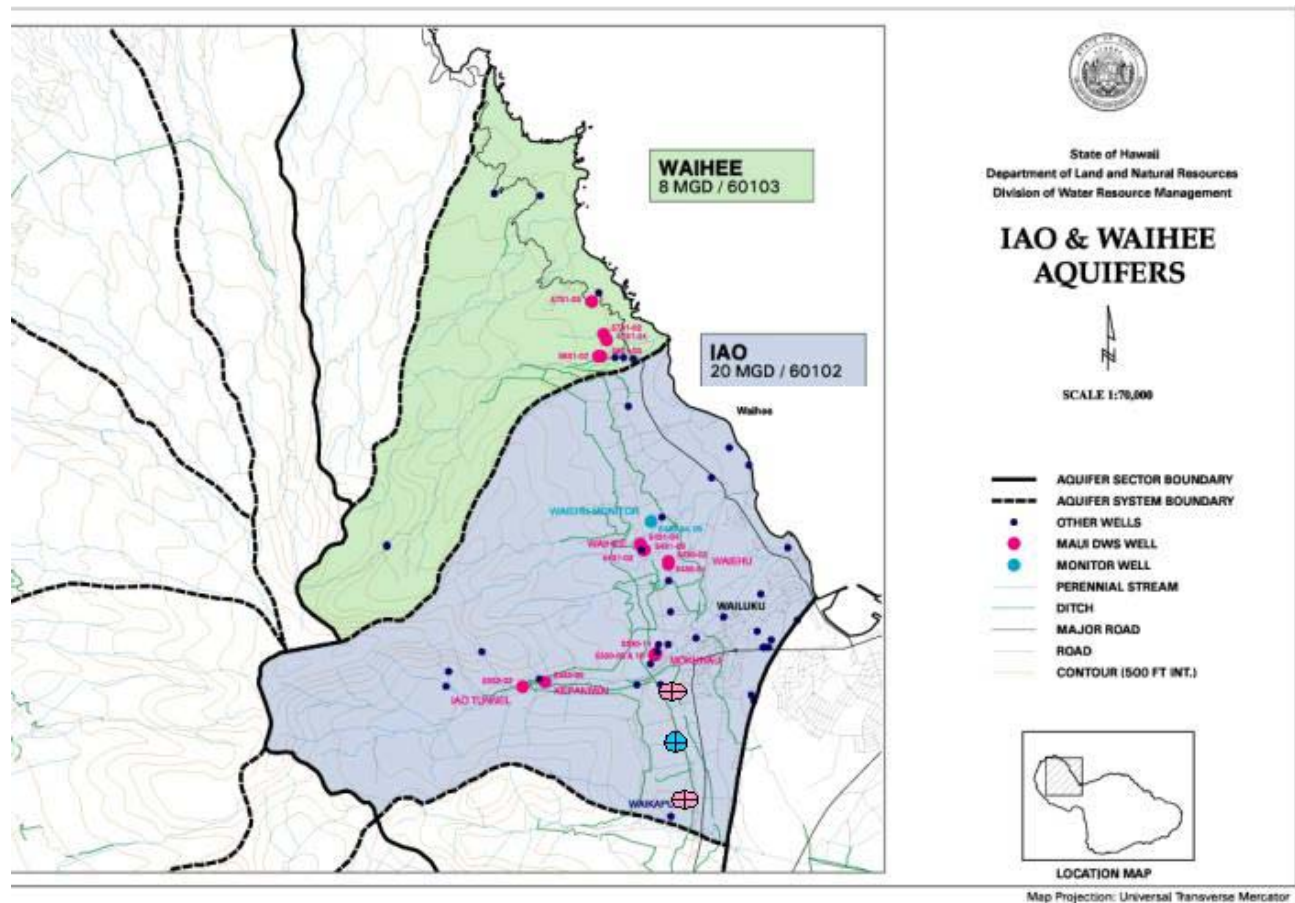


Figure 2. Map of Iao and Waihee Aquifer Systems 11/7/01 map- Maui

3.2. Geology of the Iao and Waihee Aquifer Systems

Figure 3 is the most current geologic map of West Maui (Meyer and Presley, 2001). 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 in the system (Stearns and Macdonald, 1942; Yamanaga and Huxel, 1970).

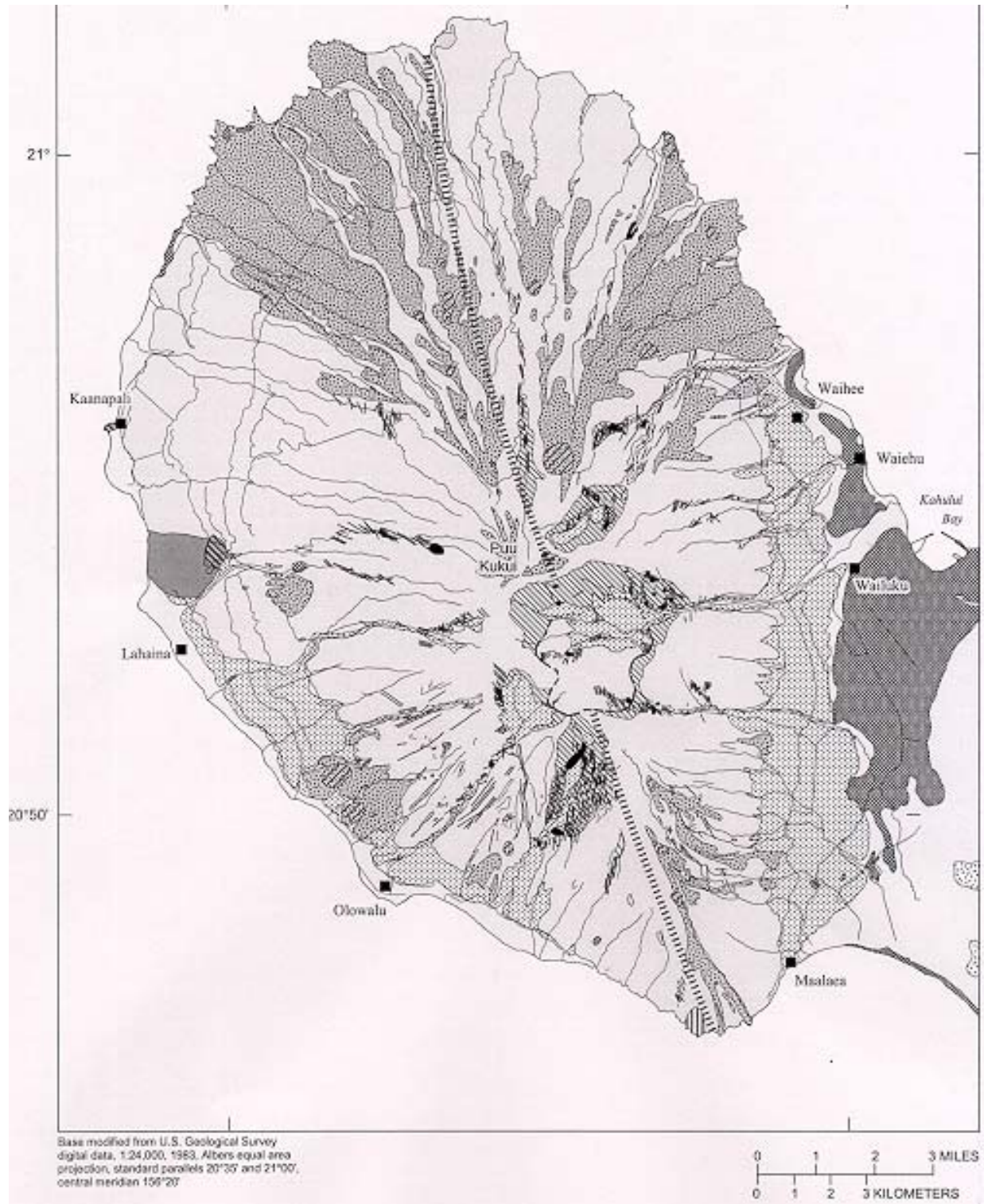


Figure 3. Geology of West Maui.
(modified from Stearns and Macdonald, 1942, and Langenheim and Clague, 1987)

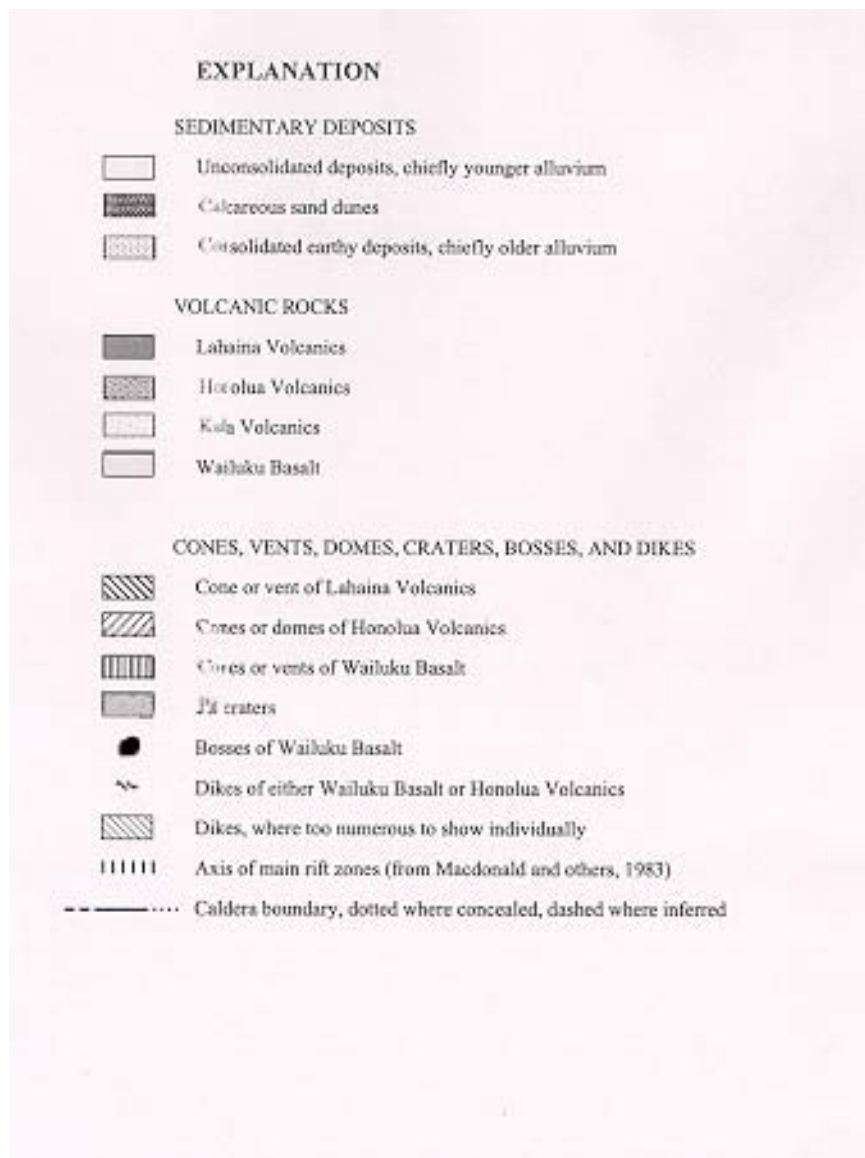


Figure 3 continued. Geology of West Maui.
(modified from Stearns and Macdonald, 1942, and Langenheim and Clague, 1987)

Massive ponded lava flow, dikes, large intrusive bodies, and volcanic breccia associated with the development and filling of West Maui's caldera occur in Iao but not in Waihee. The caldera diameter is estimated to be two miles across and is mostly contained in Iao and Waikapu Valleys (Macdonald and others 1983). Runoff is higher in the caldera area because of the lower permeability of the caldera rock. Therefore, there is a higher proportion of runoff to recharge in the interior of Iao and Waikapu than in the interior of Waihee.

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 dikes in Waihee are composed of both Wailuku Basalt and

Honolua Volcanics. 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. Mink (1997) suggests that the Honolua Volcanics form a barrier to ground-water flow through the Wailuku Basalt and impedes the outflow of ground water into the ocean. This could account for the relatively high heads in the Waihee Aquifer System basal wells and is different than the alluvial caprock over Iao.

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.

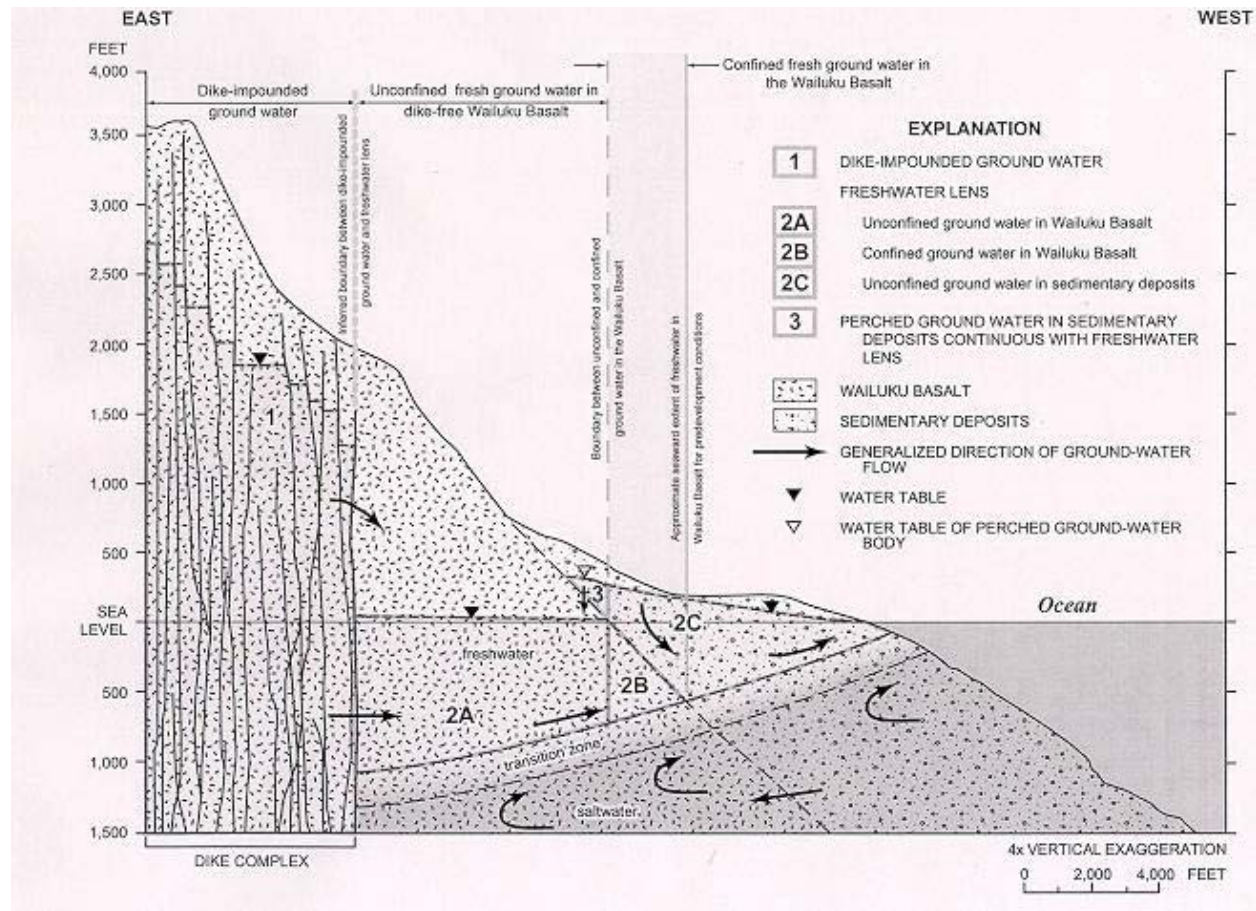


Figure 4. Cross –section of Iao aquifer from Meyer and Presley, 2001.

3.3. Water Balance

A water balance or mass balance is a water accounting method used to estimate aquifer recharge. Figure 5 shows the simplified water budget for an aquifer. For aquifer system recharge the water balance can be characterized with the following parameters: rainfall (P) and fog drip (FD); runoff (RO); evapotranspiration (ET); aquifer inflow/outflow (IO) and aquifer recharge (R). In many aquifers, return-irrigation recharge is also calculated, but currently there is negligible return irrigation in both the lao and Waihee Aquifer Systems. These parameters are used to form a simple equation:

$$\text{Recharge} = (P + \text{FD}) - (\text{ET} + \text{RO}) = \text{Natural Discharge} + \text{Pumpage}$$

Recharge is equal to total precipitation minus evapotranspiration and runoff. The parameters on the right side of the equation can be measured or estimated in order to calculate a number for recharge.

The results of previous water balances calculated in the West Maui area are presented on Table 2. It is important to note these were calculated for different times (such as when return irrigation was occurring in lao) and over different areal extents (some including caprock or wider areas). John Mink calculated water balances specifically for the lao and Waihee Aquifer Systems in the WRPP (Yuen and Assoc., 1990). The other balances are presented for 'approximate' comparison purposes.

A water balance calculation does not account for ground-water flows between aquifer systems. It is very difficult to quantify subterranean flow between aquifers. One would need a calibrated numerical ground-water flow model to address flow issues, but to address recharge within an aquifer system's boundaries a water balance calculation is sufficient. Currently, Geographic Information System (GIS) modeling is the state of the art in computing water balances. GIS water balance calculations have been done for lao (see Shade, 1997) but not for Waihee.

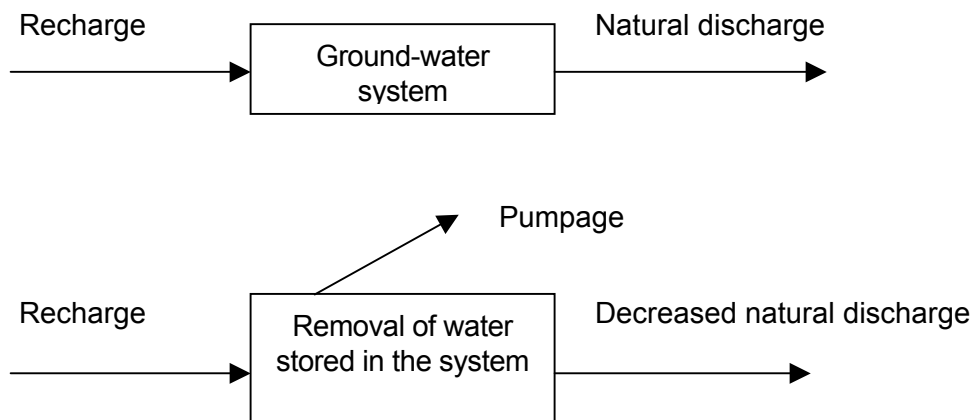


Figure 5. Diagrams illustrating water budgets for a ground-water system for predevelopment and development conditions (adapted from Alley and others, 1999).

A water balance is a good way of looking at a simplified version of the water resources of an area. The following discussion divides the systems' hydrology into the following parameters: rainfall, fog drip, runoff, evapotranspiration and recharge.

3.4. **lao Aquifer System Hydrology**

3.4.1. **Ground-Water Occurrence**

Ground water in the lao Aquifer System occurs in three areas: 1) upper regional high-level dike confined water, 2) lower regional basal water, and 3) caprock water (see Figure 4, Meyer and Presley, 2001, modified from Mink, 1977) and generally flows from the high-level to the basal to the alluvium caprock and to the ocean. Some ground water also discharges into streams as baseflow. Some lao ground water may flow into the Waihee Aquifer System through the Waihee River alluvium (Mink, 1997). Potable ground water in the lao Aquifer System is found in the high-level and basal portions of the system. Non-potable ground water is found in the caprock. The areal boundaries show that the basal source is relatively narrow as imposed by the constraints of the subsurface geology and the location of the high-level dike water boundary. Mink (1977) computed the basal aquifer's initial volume at 220 billion gallons.

3.4.2. **Rainfall**

The lao Aquifer System receives a substantial amount of rainfall but with great geographical variation. Mean annual rainfall within the system varies from 20 inches over the noncontributory caprock region near the coast to almost 400 inches at the Puu Kukui summit (Giambelluca and others, 1986). Figure 8 is an isohyetal map of lao and Waihee. Table 1 lists rain gage stations and corresponding data that occur within the system.

Table 1. Summary of lao Aquifer System rainfall station data

STATION	NO.	ELEVATION (FT)	MEAN ANNUAL RAIN (IN)	MEDIAN ANNUAL RAIN (IN)	PERIOD OF RECORD
Puu Kukui	380	5788	391.6 380.9	381 NA	R76, p 202 1928-02
lao Valley Cave	380.1	1720	162	NA	1911-14
lao Needle	387.2	1250	70	70	1949-77
lao Valley	387.1	720	67.3	66.8	1949-02

Median rainfall is the 50 percent ranking of rainfall events. It is normally lower than the mass average rainfall given the nature of extreme events such as storms and is more conservative in estimating rainfall. This is evident from the values in Table 1. Although the 50 percent occurrence would seem a more conservative value to use in estimating rainfall, the mass average must be used in water balance calculations that consider mass-balances computations.

Station No. 387.1 in lao Valley recorded the most continuous daily record of rainfall within the recharge area. Figure 6 shows annual rainfall data at Station No. 387.1 over the entire period of record.

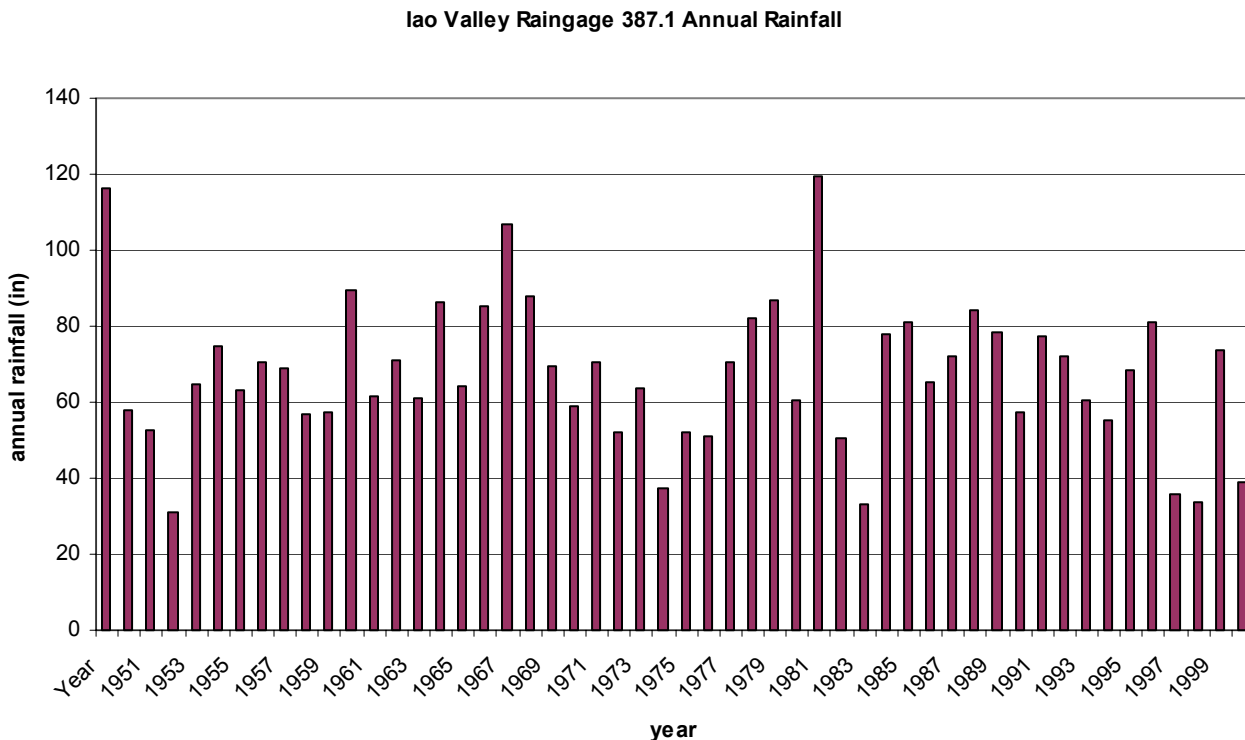


Figure 6. Annual Rainfall at station no. 387.1 in the lao Aquifer System

Figure 7 illustrates another way of looking at rainfall data from Station No. 387.1. Annual rainfall is taken as a percentage of long-term historical average mean for this gage. Therefore, rainfall percentages greater than 100 percent represent a wet year and rainfall percentages less than 100 percent represent dry years. Over the length of record there have been four major drought periods. The most recent period began in 1998 and continues to the present time, with 2000 being slightly above the mean rainfall.

lao Valley Raingage 387.1

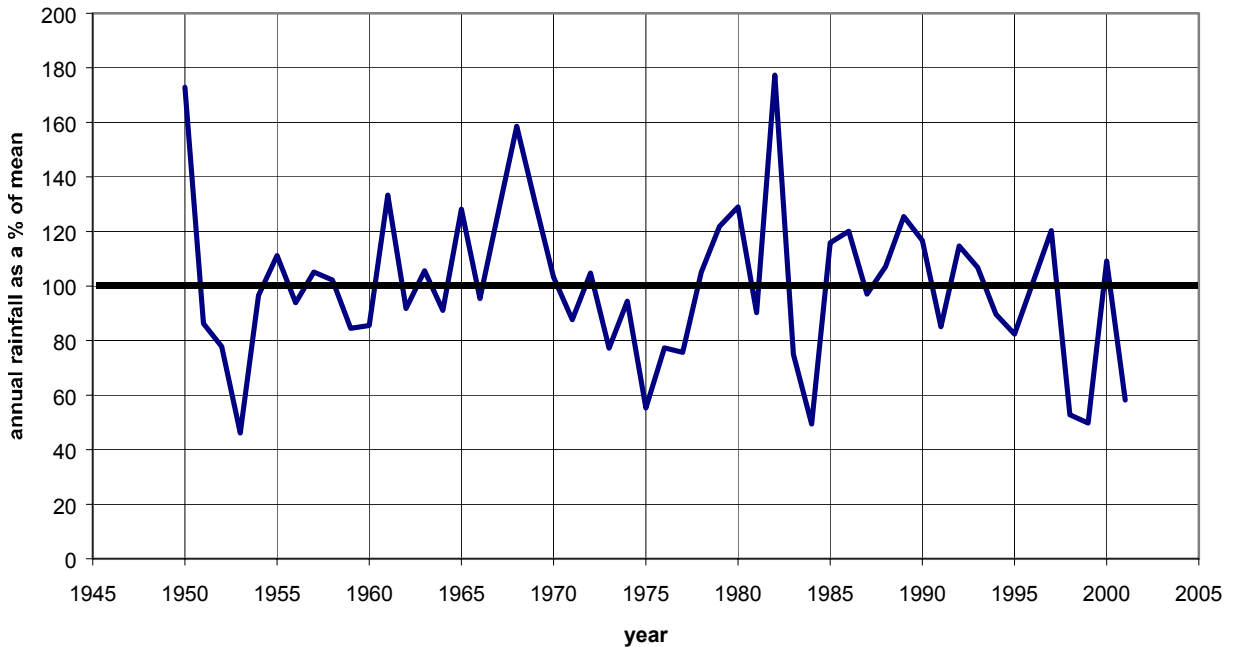


Figure 7. Annual rainfall as a percent of the mean, station no. 387.1 in the lao Aquifer System.

(Source: Wailuku Agribusiness Rain Gage Reports)

Other stations in Table 1 were read less frequently. Obviously, data for rainfall over the entire system is sparse. However, isohyets can be constructed using existing West Maui rainfall data. Besides areal aquifer location Figure 8 also shows the distribution of mean yearly rainfall over lao Aquifer System and is consistent with other literature.

Previous reports on lao rainfall are summarized in Table 2. Table 2 also incorporates other water budget parameters.

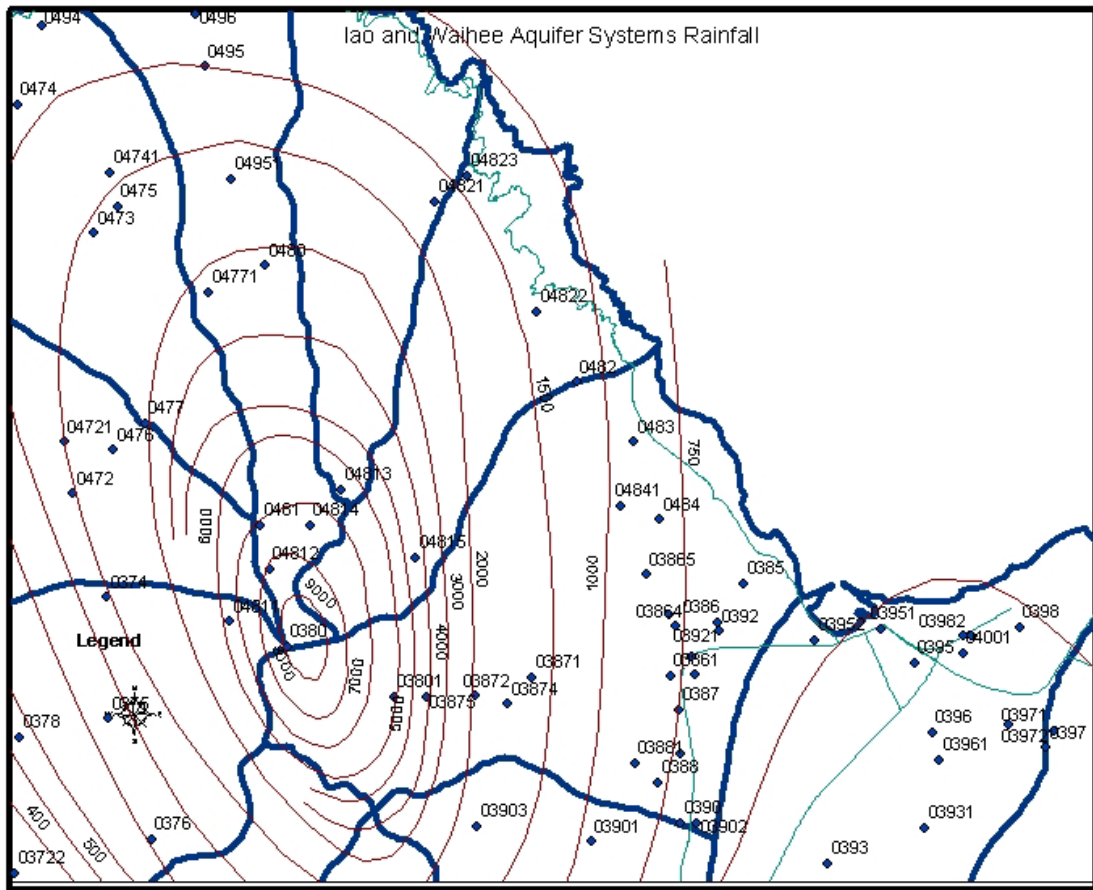


Figure 8. Rainfall map of the lao and Waihee Aquifer Systems.

Table 2. Relevant water balances for lao Aquifer System.

Note that these estimates refer to different areas and may not be directly comparable.

Region	Report	Area	Rainfall		Runoff		ET		Recharge			SY
			square miles	mgd	mgd/mi sq	mgd	% of rainfall	mgd	% of rainfall	mgd	% of rainfall	
Iao Aquifer System	Mink and Yuen (2001) Mink (2002) *1	17.81								25 to 30		
Iao Aquifer System	Shade (1997)	16.15	87	5.39	40	46%	18	21%	29	33%	1.8	
Lahaina District	Shade (1996) natural cond	96	330	3.44	95	29%	90	27%	145	44%	1.51	
Iao Aquifer System	Mink (1995)	17.81	82	4.6	16.75	20%	34	41%	31.57	39%	1.77	20.2
Iao Aquifer System	USGS (Perry, Maui News, 1992)	17.81										24 to 28
Iao Aquifer System	USGS CWRM presentation (1991)	17.81										20 +
Iao Aquifer System	WRPP (Yuen and Assoc., 1990)	17.81	82	4.6	33	40%	34	41%	15	18%	0.84	20
Iao Aquifer System	Mink (1991) appendix to Mink (1977)	17.81							20		1.12	
Wailuku	Takasaki (1978)	NA	370		175	47%	130	35%	65	18%		
Lahaina District	State of Hawaii, 1977 (R54)	60	265	4.42	53	20%	119	45%	93	35%	1.55	
Maalaea to Waihee	State of Hawaii, 1970 (R38)	32.8	230	7.01	120	52%	50	22%	60	26%	1.83	
Iao	State of Hawaii, 1970 (R38)	9.2	95	10.33	50	53%	10	11%	35	37%	3.8	30
northwest Maui (Honokohau to Honokeana)	State of Hawaii, 1969 (R33)	NA	122		40	33%	53	43%	29	24%		
Iao Valley	Caskey (1968)	6.02	83.33	13.84	38.7	46%	12.33	15%	32.3	39%	5.37	
West Maui	Stearns & Macdonald (1942, p 43)	140	580	4.14					145	25%	1.04	
	Average (not weighted)					39%		29%		32%	2.2	

*1 In a memo dated 9/6/2001 to the Maui Dept of Water Supply, John Mink wrote that recharge is 20 to 25 mgd. On November 12, 2002 he said that this was a typographical error and he intended to write that recharge is 25 to 30 mgd.

Given the factual data, review of previous investigations, other literature, and staff analysis an estimate for average annual rainfall of 82 mgd is reasonable for the Iao Aquifer System.

3.4.3. Fog Drip

In addition to rainfall, fog drip is probably a significant contributor to the Iao Aquifer System's water resources. Fog drip is the direct interception of water from clouds and fog by condensation on surface areas such as vegetation. Earlier fog drip studies on the islands of Hawaii and Lanai

indicate that fog drip is a significant contributor to ground-water recharge on those islands (Anderson, 1984; Ekern, 1964; Mink, 1983).

Earlier estimations of fog drip have not been made for the lao Aquifer System. Caskey (1968) concluded that fog drip is significant but made no quantitative estimate. Ekern (1978, p.3) notes that at an elevation of about 5,000 feet, fog drip is about 33 percent of rainfall. As the elevation increases above 5,000 feet the proportion of fog drip to rainfall also increases, though total precipitation is substantially less. The elevation of most ridges surrounding lao Valley and above Waiehu are less than 5,000 feet, though the headwall of lao Valley rises above 5,000 feet. Therefore, fog drip may be something less than 33 percent of rainfall.

3.4.4. Return Irrigation

Agricultural water use provides a source of additional infiltration water that contributes to the overall ground-water recharge rate. In the past, plantation ditches transported an average of 46 mgd of surface-water from within and outside the lao Aquifer System boundaries (from the Waihee and Waikapu Aquifer Systems) to irrigate sugarcane within the lao Aquifer System boundaries. The ditches and their areal relationship with the high-level, basal, and caprock aquifers are shown in Figure 2. Most of the irrigated lands were over the caprock. Presently about 1100 acres are in diversified agriculture and are cultivated over areas that contribute to the basal aquifer recharge through return irrigation. In addition, ditch leakage contributes to the total recharge rate of the basal aquifer. Shade (1997) provides four scenarios for the irrigation component in the water budget done by the USGS. Under Scenario I (natural conditions) there is no irrigation component. Under Scenario II (period from 1926-79) the mean irrigation component was 25 mgd. Under Scenario III (period from 1980-85) when sugar and macadamia nuts were irrigated by drip method, the component decreased to 9 mgd. Under Scenario IV (period from 1986-95) when irrigation was reduced to a mean of 3 mgd. The present condition is very low and most likely between Scenarios I and IV. Shade (1997, Table 4) calculated return irrigation recharge under Scenario IV as 2 mgd greater than under natural conditions. CWRM staff estimates the current return irrigation to be less than 3 mgd.

3.4.5. Runoff

Runoff is the average total stream flow for the aquifer system. It includes the direct runoff from rainfall and base-flow runoff derived from dike zone ground water. Runoff is estimated from existing stream flow data in the aquifer system and similar aquifer systems (Yuen and Assoc., 1990).

Runoff occurs from drainage basins that feed lao, South Waiehu and North Waiehu Streams. Presently, stream gaging in the lao Aquifer System is limited to only lao Stream. In the past, the USGS gaged all three streams (Figure 9). Diversion ditches within the lao and Waiehu drainages were also measured, though ditches diverted water during average to low stream flows (Caskey, 1968).

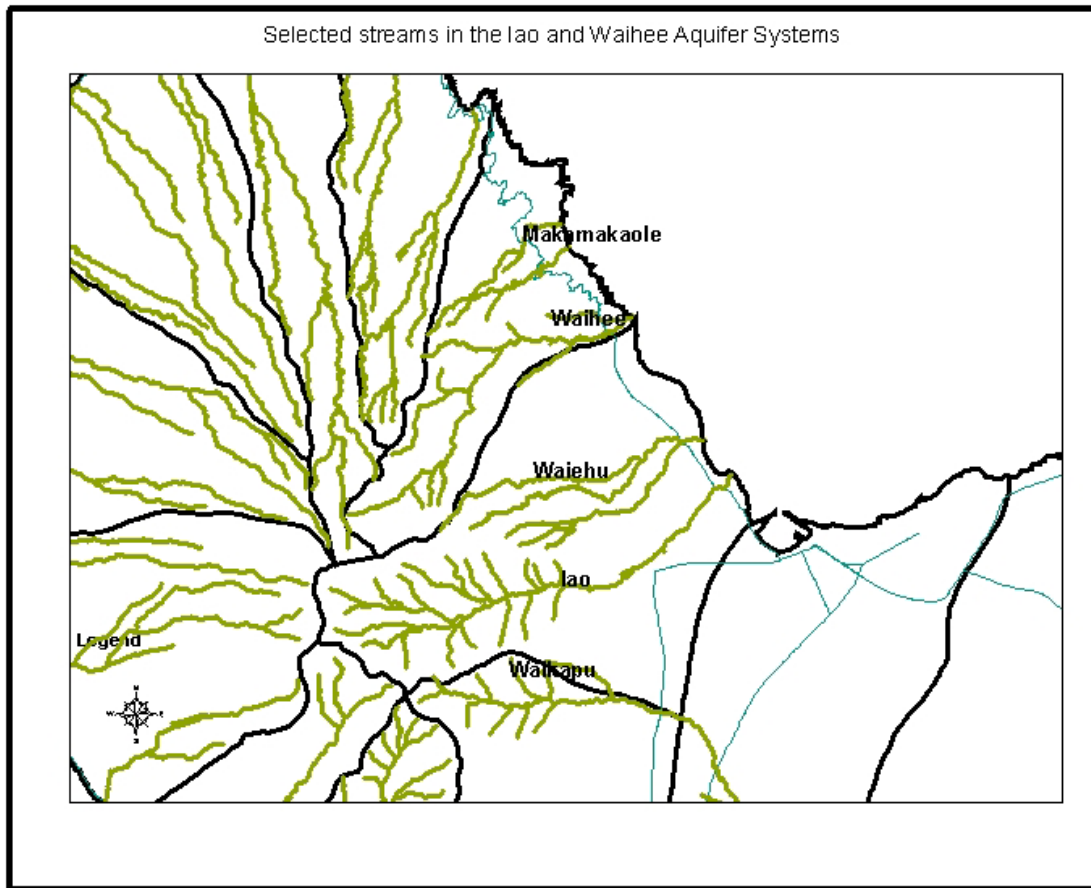


Figure 9. Selected streams in the lao-Waihee area.

Table 3 summarizes stream discharge data and statistical parameters from various sources (Caskey, 1968; Kunish, and others, 1939; C-61 and R-38, 1970).

Table 3. lao Aquifer System stream gage discharge data

GAGE	DRAINAGE AREA (MI ²)	PERIOD OF RECORD	Qave (MGD)	Q50 (MGD)	Q90 (MGD)
lao Stream	NA	1910-15	51.2 ¹ 38.7 ²	35.0 ¹	13.6 ¹
lao Stream	5.98	1983-00	42.1 ⁵	26.5 ³	12.9 ³
South Fork Waiehu Stream	0.88	1910-17	7.1 ¹ 6.4 ² 5 ⁴	5.1 ¹	2.4 ¹
North Fork Waiehu Stream	0.90	1910-17	5.5 ¹ 7.1 ² 5 ⁴	4.0 ¹	2.7 ¹

¹Kunish & others (1939)

²Caskey (1968)

³Matsuoka (Personal Communication, 1991)

⁴C-61 and R-38 (1970)

⁵U.S.G.S. Water Summary (20000)

Data presented in Table 3 shows that the short period of record can greatly influence estimations of mean discharge from lao and Waiehu Streams. The Q50 and Q90 discharges presented by Kunish and others (1939) are interpolated. Caskey (1968) developed his data from

correlations with long-term gaging stations. The most reliable data is from Matsuoka (1991) given the recent measurement and longest record.

Other statistical stream characteristics such as Q50 (median flow) and Q90 (base flow) are difficult to resolve for the relatively short-term records that are available. Iwao Matsuoka (personal communication, September, 1991) of the USGS indicated that ideally a minimum of ten years of stream flow record is needed to determine these parameters. He calculated Q50 and Q90 for lao Stream at Kepaniwai Park (based upon 1983-1991 records for Stream Gage No. 16604500) as 28.4 mgd and 12.9 mgd respectively, while the mean or average discharge at this gage is 43.5 mgd (USGS Water-Data Report HI-00-1, p. 200). Figures 10 and 11 present stream flow data for lao (1983 to 2000) and South Waiehu Stream (1911 to 1915).

Though stream flow data is limited, previous studies (e.g., Caskey, C-61 and R-38) estimate mean flow through correlation with long-term gaging stations. Stearns and Macdonald (1942) also estimated streamflow. The WRPP gives a mean total Aquifer System runoff quantity in inches per year. The aggregate runoff of the CWRM isohyetal interval analysis along with previous studies estimates are shown in Table 2. CWRM analysis covers the basalt area and includes the caprock area.

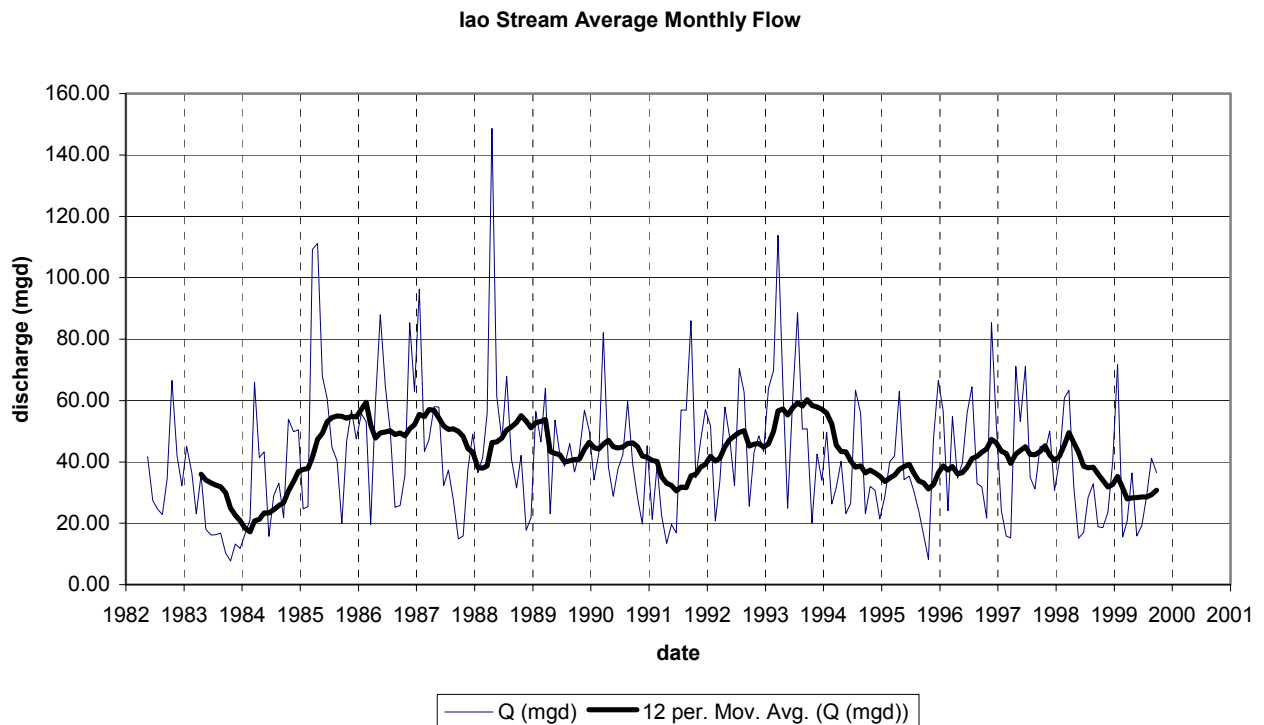


Figure 10. Total historical lao Stream flow USGS gage 16604500

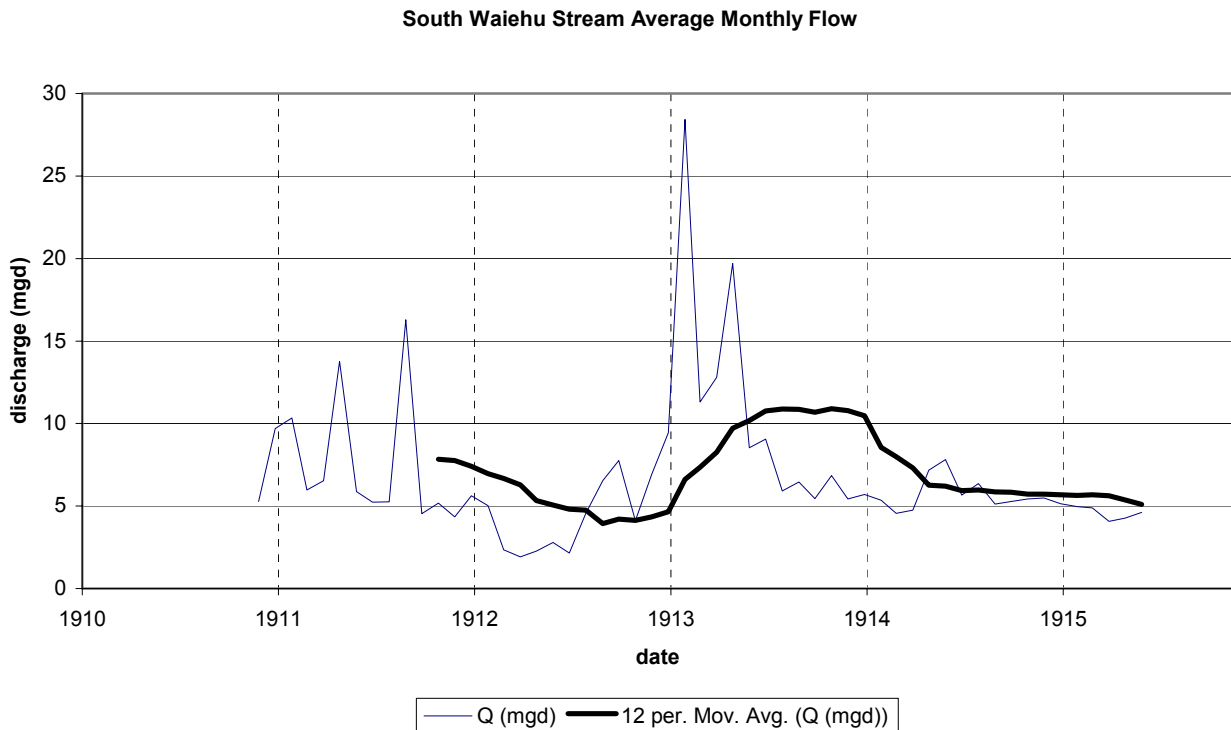


Figure 11. Total historical Waiehu Stream flow USGS gage 16610000

Although the most recent consultant estimate of average runoff for the entire system is 39 in/yr over 17.8 mi² or 33 mgd (Yuen and Assoc., 1990), CWRM analysis and past studies suggest a greater amount of runoff is occurring. The CWRM-correlated rainfall and stream flow for Iao Stream over the longest continuous streamflow record, which was a 7-year period, and simulated streamflow based on long-term rainfall data. The resulting runoff for Iao alone constituted 43.5 mgd. Runoff for other areas within the areal extent of the Iao Aquifer was also estimated. Incorporating all runoff estimates for the entire Iao Aquifer System the CWRM estimates an annual runoff of 54.4 mgd. This estimate seems reasonable given the range of previous studies. Shade (1997) estimated direct runoff to be 40 mgd over an area comparable to the basalt portion of Iao, and 41 mgd for direct runoff for the entire area including the caprock portion of the aquifer system.

3.4.6. Evapotranspiration

Evapotranspiration is the surface and subsurface water released to the atmosphere through direct evaporation and by transpiration through plants (Todd, 1980 p 361). Evapotranspiration can be estimated from pan evaporation data. Evapotranspiration has been estimated in previous studies and results are tabulated in the water balance table (Table 2).

Data for evaporation is limited within the Iao Aquifer System. The only reported Iao Aquifer System pan evaporation measurements, found in State Report R74, come from evaporation pan stations, State Key No. 385, near the Wailuku coast. Report R74 shows that adjusted annual evaporation near Kahului is 81 inches per year.

Evapotranspiration due to vegetation depends on plant and climatological factors. For a relative sense, evapotranspiration from a water hungry plant such as sugarcane is estimated by multiplying pan evaporation by a factor that typically ranges from 0.8, for sugarcane in wet areas, to 1.2, sugarcane in very hot and dry areas. Thus, it would be conservative to assume that evapotranspiration equals pan evaporation near the lao Aquifer System.

The most recent estimate of average evapotranspiration for the entire system is 40 in/yr, or 34 mgd (Yuen, 1990). This is the most conservative value for evapotranspiration, in terms of computing infiltration, compared to other past studies and actual evaporation measurements.

Using the isoheytal interval method the CWRM estimates that evapotranspiration for the entire lao Aquifer System is 27.1 mgd. This value lies within previous estimates. Given the factual data, review of previous analyses and literature, and CWRM analysis an annual evapotranspiration estimate of 27.1 mgd is reasonable for the lao Aquifer System.

3.4.7. Ground-Water Recharge

Ground-water recharge is that amount of water, applied in any manner to the ground surface (i.e., natural or irrigation), which infiltrates into and becomes part of the saturated formations of an aquifer. Recharge to the system takes place over the high-level, basal, and caprock aquifers. This report is mainly concerned with recharge to the dike and basal water bodies in the lao Aquifer System. Recharge to the caprock is negligible, especially to the potable supply and is therefore not considered. In the past, estimates of recharge were taken as conservative percentages of rainfall. Presently, hydrologists use the mass water balance method to estimate ground-water recharge, as illustrated in Figure 5 and summarized in Table 2.

The WRPP (Yuen and Assoc., 1990), estimated mean recharge to be 15 mgd. This official CWRM recharge is averaged over the lao Aquifer System using water balance algorithms. This estimate of recharge is 19 percent of total rainfall. This is conservative when compared to the average recharge estimate of 33 percent of total rainfall by other researchers (Table 2).

Unofficial updates to the estimate of lao Aquifer System recharge have been provided since the adoption of the 1990 WRPP. In 1991, Mink (1991, Appendix to 1977 report) revised his assessment of recharge based upon new modeling calculations in conjunction with observations from the Waiehu Deep Monitor Well and concluded that average infiltration lies between 20 and 23 mgd. In a September 9, 1995 memorandum to CWRM, Mink again recalculated recharge to be 31.57 mgd. In 1997, the USGS (Shade, 1997) estimated recharge to be 29 mgd with a small amount of return irrigation. Although these later estimates indicate a higher recharge rate for lao, none of these recharge estimates have been officially adopted by the CWRM through the WRPP process.

3.4.8. Ground-Water Pumpage

Within the lao Aquifer System there are 48 listed wells, test holes, and tunnels (CWRM well database). Of the 48 sources there are 13 municipal wells operated by the MDWS, 10 observation wells, 10 irrigation wells operated by the County of Maui and Wailuku Sugar, and 6 unused sources. Staff field investigated to verify the status of non-DWS wells on July 16, 2002. The status summary of all wells in lao is listed in Table 4.

lao Aquifer System pumpage began in 1948 with the operation of Wailuku Shaft 33 (5330-05). Prior to the onset of pumpage, ground-water use was limited to tunnel water from 8 tunnels. Four of these tunnels (5330-01,02; 5332-03; and 5530-01) developed water from alluvium of lao Stream, and in the case of 5530-01, in older alluvium at the mouth of Waiehu Stream (Stearns and Macdonald, 1942, pp. 197-198). The other 4 tunnels (5332-01,02; 5333-01,02) developed water from the dike complex and dikes within the caldera complex exposed in upper lao Valley. According to Stearns and Macdonald (1942, p.197) these tunnels divert water that was already percolating into lao Stream as springs. Therefore, tunnel flows are not considered pumpage from the aquifer and are accounted for in runoff quantities. Construction of these tunnels occurred decades before Wailuku Shaft 33 was constructed and developed, thus tunnel flows were at steady-state by the time the shaft was constructed.

Wailuku Shaft 33 (5330-05) was constructed in 1946 to provide additional irrigation water to sugarcane. The shaft is actually three large wells drilled below the pump room, rather than a skimming infiltration gallery that is more typical. The shaft began operations in 1948, and is the only operational source south of lao Stream. In 1953 the average output was 9.7 mgd, though the installed capacity was 21.75 mgd. Pumpage from the shaft peaked in 1971 when the average pumpage was 11.7 mgd (Mink, 1986, p. 4). The Mokuahu Wells (Nos. 5330-09, 10, 11) constituted the first major well field developed in the lao Aquifer, north of lao Stream. Mokuahu Wells 1 and 2 were drilled in 1953 and Mokuahu 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. These sources are north of lao Stream. The Commission tracks the 12-month moving average (MAV) of pumpage statewide. The 12-MAV is used since it incorporates a full climatic cycle at any given time.

Table 4. List of wells in the lao Aquifer System

Well	Well No.	owner/ user	type of use	date drilled	average production 12-MAV (mgd)	initial chloride (mg/L)	elevation at bottom of well (ft)	initial head (ft)	initial temp (deg F)
Waikapu 1	5130-01	State DOWALD	unused	1961	0	20	-206	12.0	69.8
Waikapu 2	5130-02	State DOWALD	unused	1974	0	13	-502	10.3	69.8
Waikapu Mauka	5131-01	Maui DWS	municipal	1999	0		-106	18.4	71.0
Waiale Prototype	5229-01	A&B (MAUI LANI)	lost	1978	0		-305		

Table 4. List of wells in the Iao Aquifer System (continued).

Well	Well No.	owner/ user	Type of use	date drilled	average production 12-MAV (mgd)	initial chloride (mg/L)	elevation at bottom of well (ft)	initial head (ft)	initial temp (deg F)
Ka Hale A Ke Ola	5230-01	Maui Econ Con	irrigation	1997	0.006	30	-51	4.1	73.0
Memorial Gym	5329-04	Maui Pks & Rec	irrigation	<1971	0.060		-30		
Baldwin High Sch	5329-05	Maui Pks & Rec	irrigation	<1971	0.070				
Baldwin High TH	5329-06	Maui County	unused	1939	0	152	-11	5.9	
Maui Stadium	5329-14	Maui DPW	irrigation	1970	0.100	285	-8		
Wailuku Arm	5329-17	U S Army	unused	1969	0		58		
Iao Tunnel	5330-01	Wailuku Sugar	irrigation	1900					
Iao Tunnel	5330-02	HC & S Co	irrigation	1900					
Field 63	5330-03	Wailuku Sugar	observation	1945	0		-20	30.6	
Wailuku Mill TH	5330-04	Wailuku Sugar	observation	1945	0	22	-525	16.4	
Wailuku Shaft 33	5330-05	Hawaii Land And Farming	Irrigation (municipal)	1946	5.025			26.0	
Mokuhau TH 1	5330-06	Maui DWS	geologic	1950	0	280	-121	27.3	
Mokuhau TH 2	5330-07	Maui DWS	geologic	1951	0		-101	23.7	
Mokuhau TH 3	5330-08	Maui DWS	geologic	1952	0		-102		
Mokuhau 1	5330-09	Maui DWS	municipal	1953	1.396	16	-247	23.3	
Mokuhau 2	5330-10	Maui DWS	municipal	1953	0	16	-247	21.5	
Mokuhau 3	5330-11	Maui DWS	municipal	1967	2.599	30	-251		
Puuohala TH-C	5330-12	Wailuku Sugar	unused	1975	0		-212	16.7	
Iao Valley TH	5331-01	Wailuku Sugar	observation	1940	0		-21	32.9	
Black Gorge Tunnel	5332-01	Wailuku Sugar	irrigation	1926					
Iao Tunnel	5332-02	Maui DWS	municipal	1939					
Field Gorge Tunnel	5332-03	Wailuku Sugar	sealed	<1942	0				

Table 4. List of wells in the Iao Aquifer System (continued).

Well	Well No.	owner/ user	Type of use	date drilled	average production 12-MAV (mgd)	initial chloride (mg/L)	elevation at bottom of well (ft)	initial head (ft)	initial temp (deg F)
Kepaniwai TH	5332-04	State DOWALD	observation	1973	0		459	675.0	
Kepaniwai	5332-05	Maui DWS	municipal	1974	0.795	25	413	677.0	69.8
Iao Needle Tunnel	5333-01	Wailuku Sugar	irrigation	<1942					
Iao Needle Tunnel	5333-02	Wailuku Sugar	sealed	<1942	0				
De Lara 1	5429-01	De Lara J	lost	1947	0	528			
Papohaku Park	5429-02	Maui Pks & Rec	irrigation	1991	0.050	60	-55	24.7	
Waiehu Hts 1	5430-01	Maui DWS	municipal	1975	0.195	52	-338	18.0	
Waiehu Hts 2	5430-02	Maui DWS	municipal	1975	1.095	20	-206	18.0	
Waiehu TH-E	5430-03	Wailuku Sugar	observation	1976	0		-165	14.4	
Waiehu TH-D	5430-04	State DOWALD	observation	1975	0		-108		
Waiehu Deep Monitor	5430-05	State CWRM	observation	1982	0		-1020		
Waiehu TH-B	5431-01	Wailuku Sugar	observation	1974	0	15	-66	16.6	
Waihee 1	5431-02	Maui DWS	municipal	1976	0.563		-182	13.6	72.5
Waihee 2	5431-03	Maui DWS	municipal	1976	1.641	189			71.6
Waihee 3	5431-04	Maui DWS	municipal	1981	2.772		-156	14.7	71.1
Waiehu TH	5529-01	U S G S	geologic	1935	0	32	-8	2.0	
Waiehu Golf	5529-02	Maui Pks & Rec	irrigation	1967	0.110		-66	3.6	73.9
Waiehu Tunnel	5530-01	Wailuku Sugar	observation	<1942					
Waiehu TH	5530-02	Wailuku Sugar	geologic	1933	0		-97	65.0	
Waiehu G C 1	5530-03	Maui Pks & Rec	unused	1995	0				
Waiehu G C 2	5530-04	Maui Pks & Rec	unused	1995	0		-73	8.4	73.9
Waihee TH A1	5631-01	Wailuku Sugar	observation	1974	0		-52	16.6	

Since 1991, the shaft has been operated by the MDWS at an average rate of $4.6 \pm$ mgd. Figure 12 reflects the addition of new sources and shows a high of about 16 mgd in 1978. With changing irrigation methods in the early 1980's there was a reduction in pumpage from Wailuku Shaft 33, so that the average total aquifer was 10 mgd. Pumpage in the lao Aquifer System steadily increased from $10 \pm$ mgd the early 1980's to over 20 mgd in 1997. Since 1997, total 12-MAV aquifer pumpage has been reduced to about $16 \pm$ mgd.

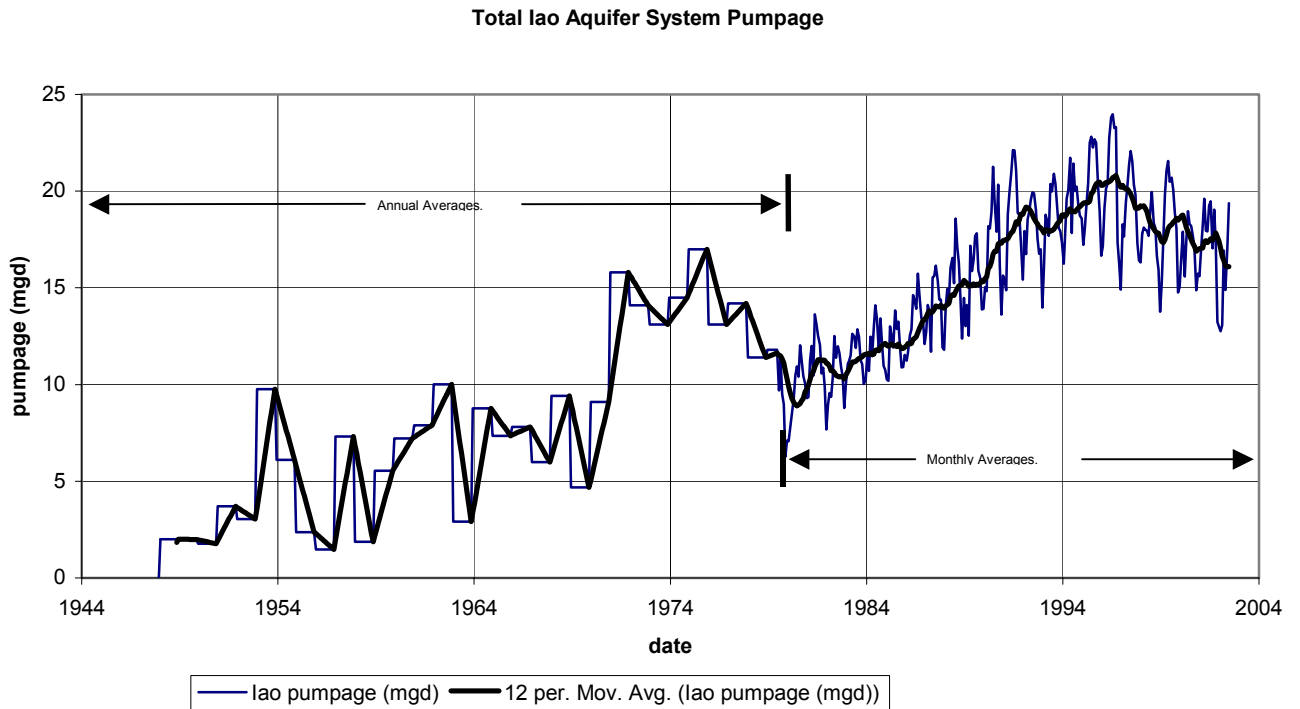


Figure 12. Total historical lao Aquifer System pumpage

3.4.9. Water Levels

Water-level data collection in the Lao Aquifer System began in 1947 and is sporadic during its first 35 years of data collection. Since 1983, water-level data has been collected on a more regular basis from non-pumping observation wells. Since 1996 occasional water-level readings from pumped wells Wailuku Shaft 33 (5330-05) and Mokuhaul 2 (5330-10) have been collected.

Water levels within a basal aquifer in steady-state are described by the Ghyben-Herzberg principle. This principle recognizes the 1:40 ratio where fresh water (at an average specific gravity of 1.000) floats on salt water (at an average specific gravity of 1.025). For every foot of fresh water above mean sea level (MSL), the distance to the mid-point of the transition zone extends approximately 40 feet below MSL under steady-state. Under natural pre-development conditions, it is assumed that the aquifer is in a steady-state condition. Therefore, water levels under natural pre-development conditions are governed by the Ghyben-Herzberg principle, geological boundaries, aquifer formation properties, recharge, and leakage. Coastal caprock formations are a geologic boundary that are less permeable than the basaltic formations and reduce leakage to the sea and, thus, generate relatively higher basal water levels and deeper fresh water lenses than areas with no caprock.

Water levels under developed, or pumping, conditions are governed by the Ghyben-Herzberg principle, geological boundaries, aquifer formation properties, recharge, leakage, and pumpage. However, in the short-term, pumpage is the primary governing factor that determines water-level elevations, not the transition zone mid-point elevation. Hydrologists know such a reaction as a "cone of depression" where water levels are drawn down in a fashion that extends outward from the pumping well (see Figure 18). When pumping ceases, localized pumping stresses only found in the pumping well (i.e. turbulence losses, well bore storage, etc.) dissipate and the water level will rise to match the Ghyben-Herzberg principle in relation to the location of the transition zone mid-point. Likewise, in the vicinity of a pumping well, water levels will rise to match the Ghyben-Herzberg principle in relation to the location of the transition zone mid-point. This rise will occur immediately after cessation of pumpage and continue over time at a slower rate. To illustrate this, Wailuku Shaft 33 was shut down for seven to eight months and water levels were continuously measured by the USGS (Figure 17 in Meyer and Presley, 2001). Data show that measured recovery at Wailuku Shaft 33 (5330-05) occurred over a four month period when the shaft was shut down. The water levels rose from $9\pm$ feet, MSL to $16.5\pm$ feet, MSL. Additionally, the MDWS, USGS, Mink, and CWRM conducted an aquifer-wide recovery test in January 2000 by turning off all pumping that showed water levels in the 3 Lao wells observed would recover within three months if pumping were shut-off completely. Therefore, these tests show that water levels in both pumping and observation wells will recover relatively rapidly and are not indicative of the overall condition of the aquifer.

All of the water-level data presented in this report are accurate measurements but other factors may affect its utility and quality. Ideally water-level data should be collected continuously with a data-recording device. Often continuous data collection is not practical and water level data is collected periodically. "Potential drawbacks to periodic monitoring are that hydraulic responses to short-term stresses may occur between measurements and may be missed, extreme water-level fluctuations cannot be determined with certainty, and apparent trends in water levels potentially are biased by the choice of measurement frequency." (Taylor and Alley, 2001, box B) The location of water-level observation wells can also affect the utility of the data. Observation wells located too close to pumping centers may be heavily influenced by local drawdown. These wells would not accurately represent the regional conditions in the aquifer.

Water levels in the southern portion of Iao illustrate that the overall condition of the aquifer is better than what it appears to be based solely on water levels north of Iao Stream. The new Waikapu Mauka well (5131-01) at the southern end of the Iao Aquifer System recorded a water level of 18.35 feet MSL in December 1999 and 16.9 feet MSL in June 2002. Another new deep monitor well has been funded by the State (to begin construction in 2003) and will be drilled in the southern portion of Iao will help confirm the depth of the transition zone and the health of the southern portion of the Iao Aquifer System.

The most important water-level data is the initial measurement made in 1948, where the first measured basal water level in the Iao Aquifer was $28 \pm$ feet MSL (Mink, 1977) at Wailuku Shaft 33. This pre-development water level represents the initial steady-state water level at this point in the Iao Aquifer. Under this initial condition the thickness of the lens at Wailuku Shaft 33 should have been $-1120 \pm$ feet taken to the mid-point of the transition zone (chloride concentration of 9,500 mg/L or 50 percent isochlor). This is the water level used in estimating sustainable yield using the robust analytical model (RAM; WRPP, 1990).

Figure 13 presents the majority of measured basal water-level data in the Iao Aquifer System for three observation test holes and Waiehu Deep Monitor Well. These observation well sites are on the north side of Iao Stream, and within the influence of the major pumping sources of the Mokuahau, Waiehu Heights, and Waihee Wells. Figure 13 clearly shows that the water levels behave similarly over time. Figure 14 shows water level measurements at Wailuku Shaft 33 and Mokuahau Well 2. Except for some measurements in the early 1970's, the period of record is relatively short. Both of these wells are in pumping stations, they represent localized drawdown. In order to determine whether the water levels are influenced more by pumpage or by climatic conditions, Test Hole A-1 was chosen to plot with rainfall and pumpage (Figures 15 and 16).

Water-Levels in lao Aquifer System

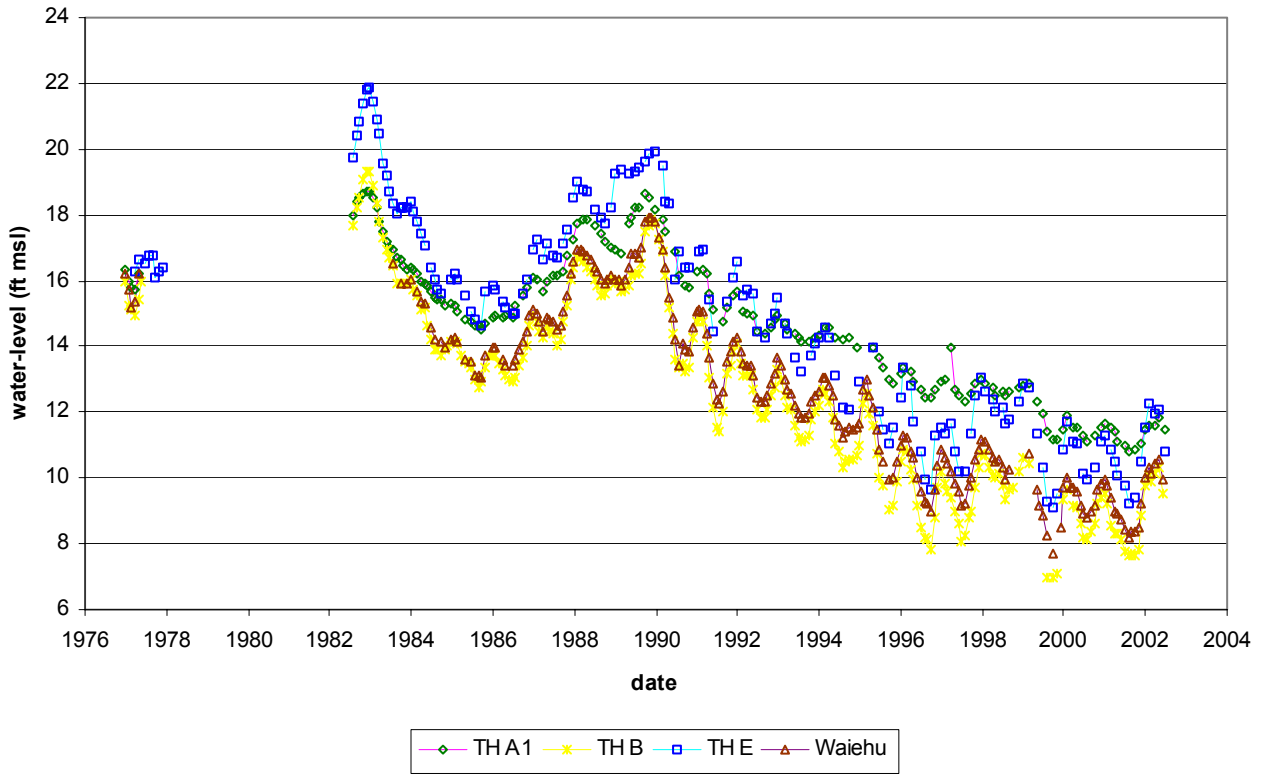


Figure 13. Water-Level comparison for the lao Aquifer System

Wailuku Shaft 33 and Mokuhau Well 2 Water Levels

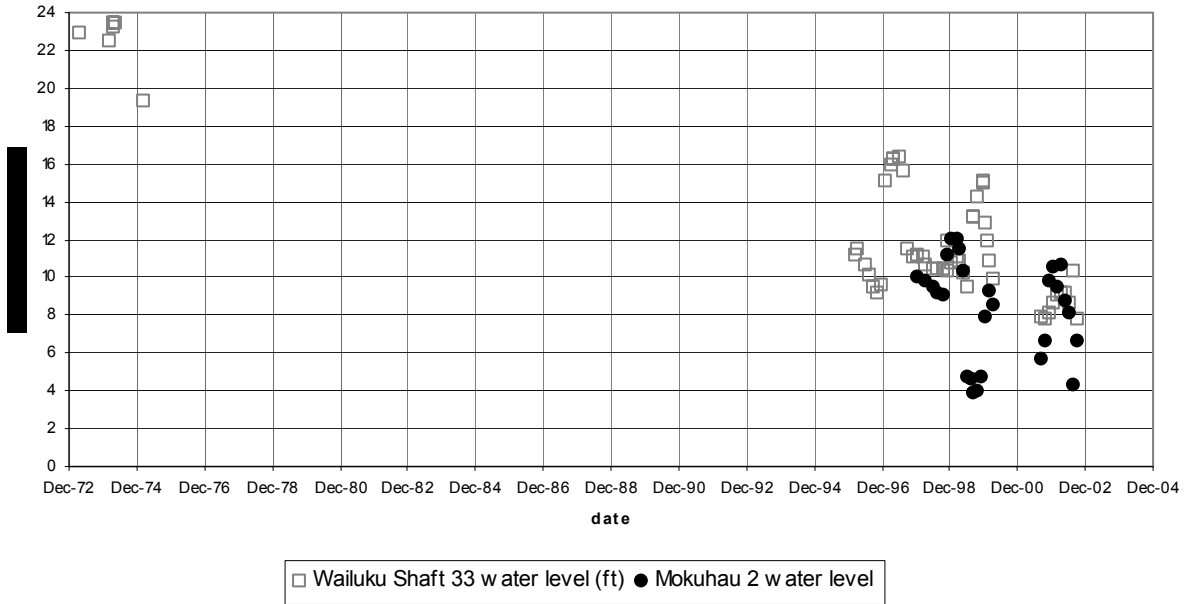


Figure 14. Water-Level measurements at Wailuku Shaft 33 and Mokuhau Well 2

Figure 15 plainly illustrates that water levels closely track and are very sensitive to rainfall patterns. Therefore, it appears that rainfall correlates with all observation well water levels in the lao Aquifer Systems (Figure 13).

Water-Levels, Pumpage and Rainfall in lao Aquifer System

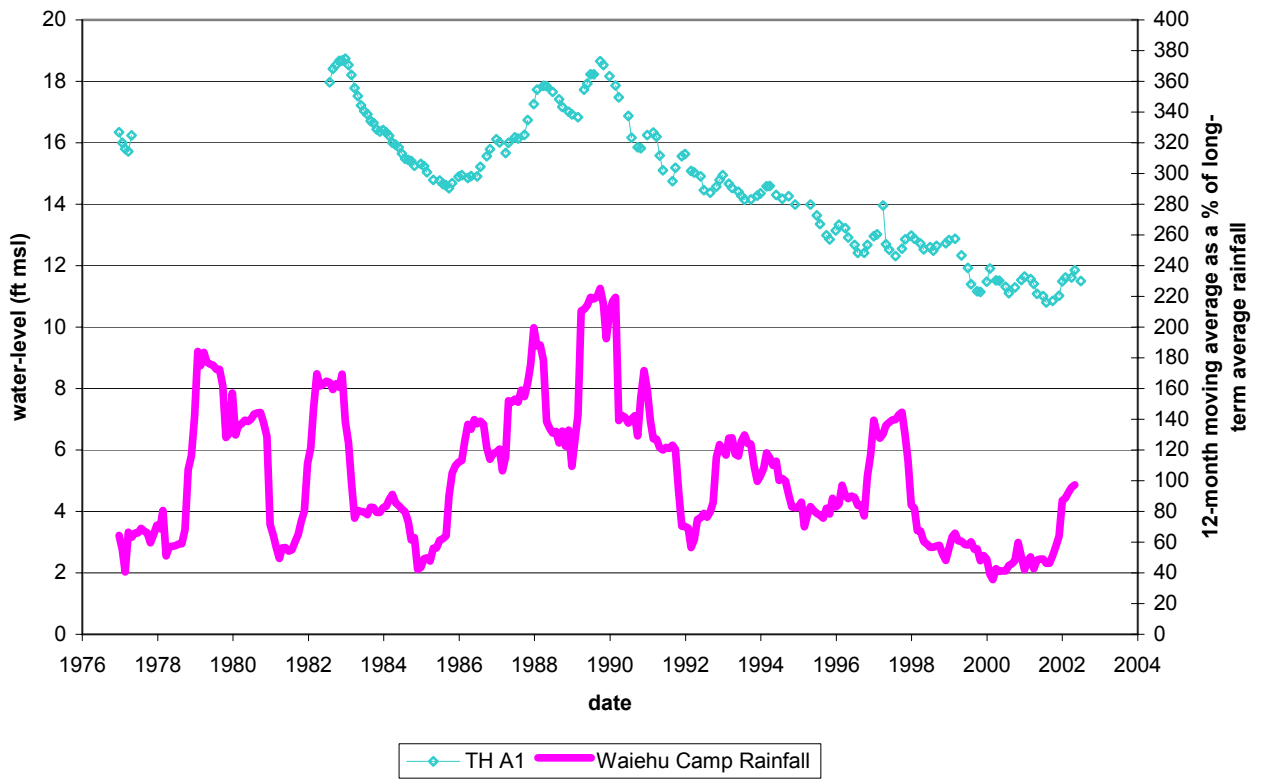


Figure 15. Rainfall and water-level comparison for lao Aquifer System

Water-Levels, Pumpage and Rainfall in lao Aquifer System

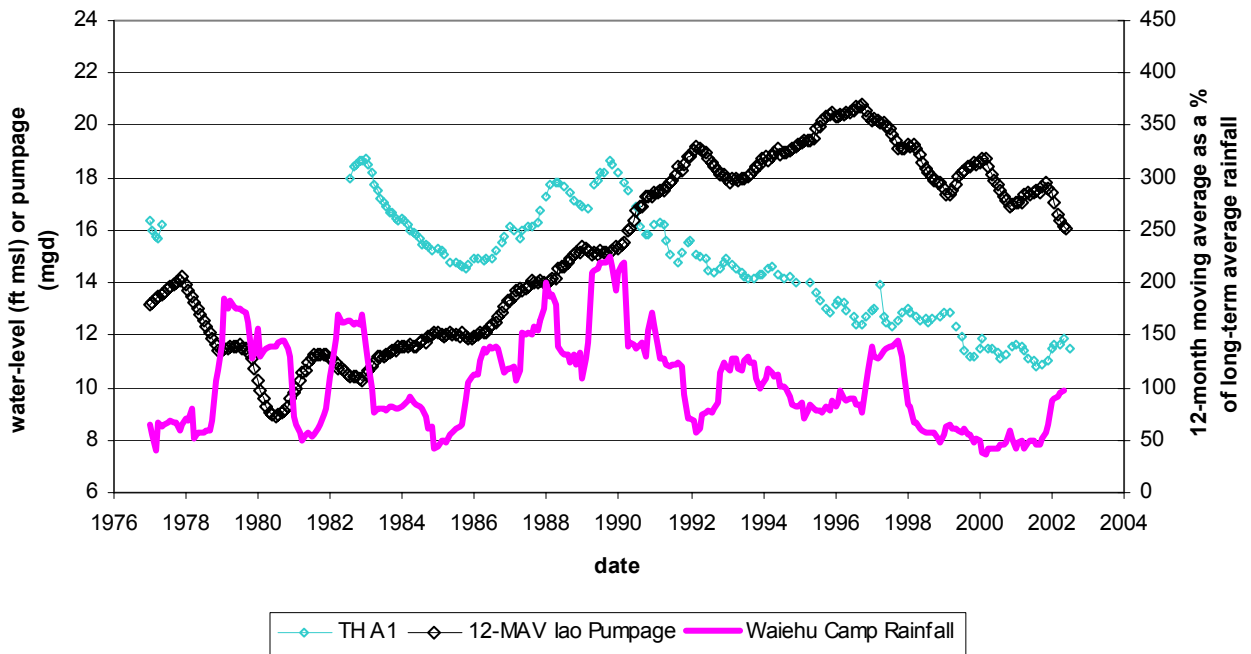


Figure 16. Rainfall and water-level comparison for lao Aquifer System

Graphically comparing rainfall, pumpage, and water-level response patterns, it appears that water levels follow rainfall patterns closer than pumpage. Figure 16 illustrates these relationships. From 1986 to 1990, water levels rose in response to increased rainfall **and** increasing pumpage. This indicates that rainfall has a stronger influence than pumpage over observation well (i.e. aquifer) water levels. From 1997 to the present, water levels declined in response to severe drought and decreasing pumpage. This, again, shows rainfall having a stronger influence than pumpage over water levels. Indeed, correlation coefficients between rainfall and water levels (0.44) and pumpage and water levels (0.27) show that rainfall has a better correlation to water levels than pumpage in lao. The USGS also recognizes that water levels are sensitive to rainfall (Meyer and Presley, 2001).

Figure 17 shows that water levels react more quickly to pumpage and rainfall than the transition zone mid-point. The inferred water level (equilibrium head) from the transition zone mid-point based on Ghyben-Herzberg at the Waiehu Deep Monitor Well is superimposed on Figure 17 to illustrate this point.

Iao Aquifer System, Maui Water Levels and Pumpage

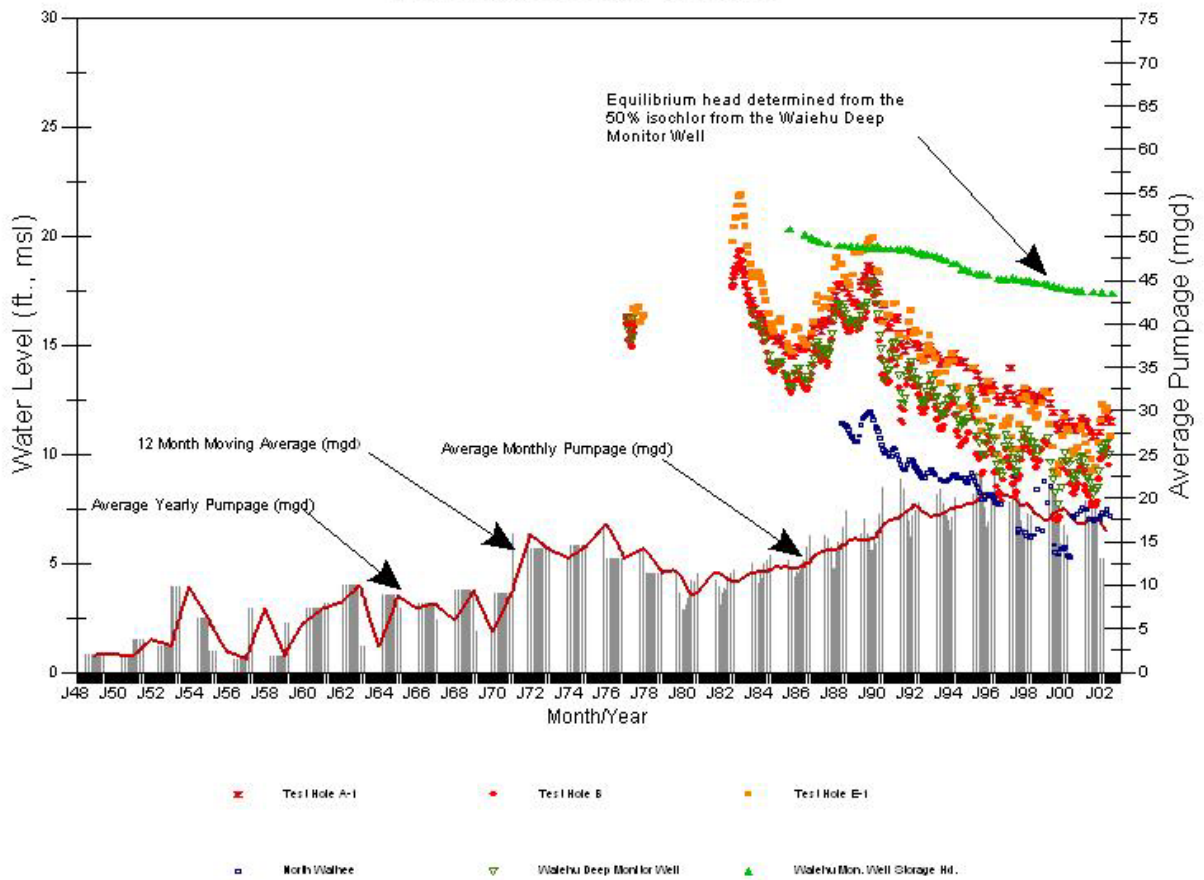


Figure 17. Water levels at the Waiehu Deep Monitor Well and test holes

(Source: CWRM, State of Hawaii)

In addition to the lag of the transition zone mid-point relative to water levels, the transition zone appears to be thinning according to data collected from the Waiehu Deep Monitor Well (5430-05). Figure 18 illustrates this phenomenon.

Waiehu Deep Monitor Well, Iao Aq. Sys. Movement of TZ Mid-Point & TTZ

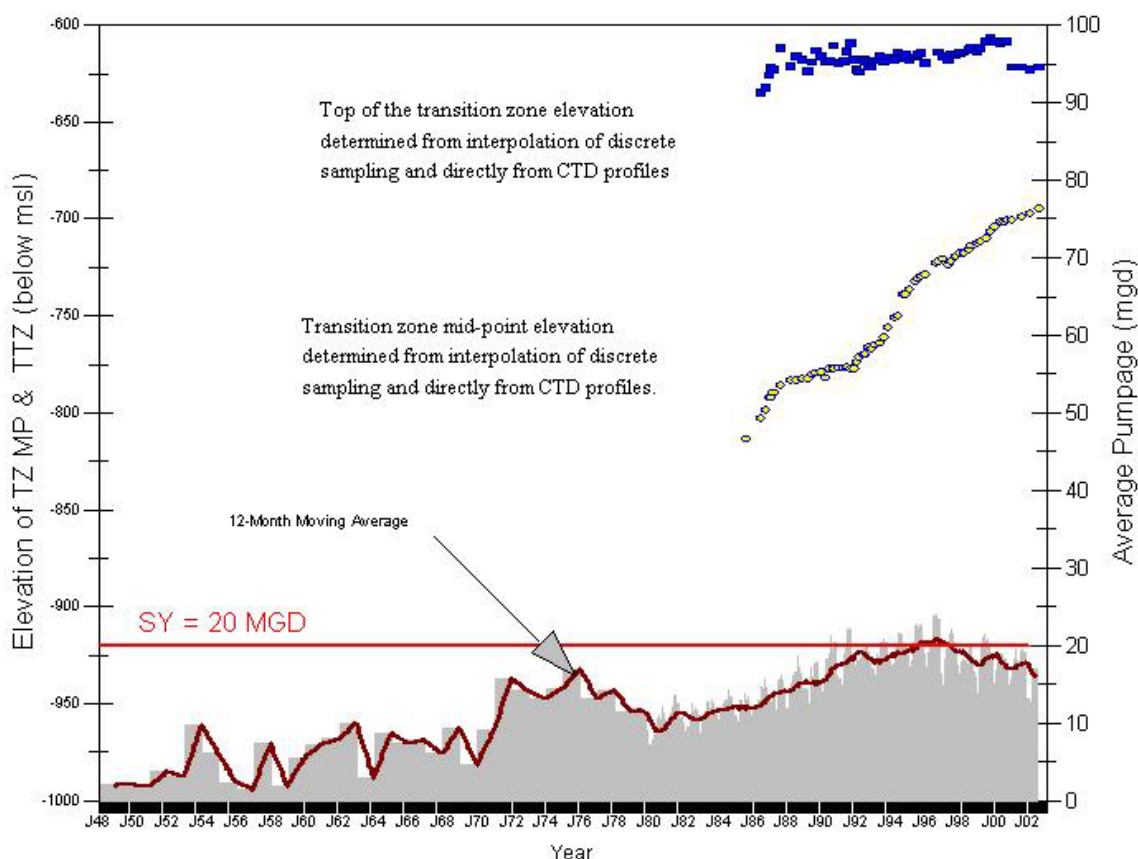


Figure 18. Waiehu Deep Monitor Well – transition zone data
(Source: CWRM, State of Hawaii)

The top of the transition zone is defined by the 250 mg/L chloride content (approximately 1000 $\mu\text{mhos/cm}$, or 2 percent seawater) and has been relatively stable from 1985 to the present, while the mid-point has risen $121 \pm$ feet over the same period. The thickness from the mid-point to the top of the transition zone is thus presently 73 feet. By comparison, similar aquifers in Oahu have transition zone thicknesses between 250 and >500 feet at pumpages near their sustainable yields. The reason for this thinning phenomenon is uncertain, although both the USGS (Meyer and Presley, 2001, p.48) and CWRM are attempting to gather more data to address this issue. The rate of rise in the transition zone is currently 4.75 ft/year since 1998. At 4.75 ft/year, the mid-point of the transition zone would encroach on the well bottoms of Mokuhau and Waiehu Heights 1 wells within 94 and 75 years, respectively.

3.4.10. Water Quality

3.4.10(a) Chlorides

The chloride ion concentration is a measure of salinity used to indicate the potential potability of the resource. U.S. EPA guidelines suggest that the 250 mg/L chloride concentration is a taste standard and should be the upper limit for water supply systems. This secondary

contaminant limit is based on aesthetics, rather than health reasons, and is not mandatory. Normally, the counties' water supply purveyors further endeavor to keep the delivered supply at 160 mg/L or less. Additional factors influencing chloride concentrations within individual wells in basal aquifers, such as Waihee, include geology, hydrologic properties of the aquifer, and well infrastructure (such as well depth, pump capacity, pumping schedules, etc.) and produce observable long-term trends.

Chlorides differ depending on hydrogeologic conditions. Dike-impounded sources, such as the Waihee Valley Tunnels, have high water levels and no known evidence of contact with seawater, which results in low chloride concentrations. However, no data has been collected to confirm that salt water underlies high-level aquifers, which would require drilling a well thousands of feet deep. Basal sources are more susceptible to changes in chloride concentrations because the Ghyben-Herzberg lens floats on denser salt water and, therefore is in direct contact with salt water. The contact between fresh and salt water is not sharp but rather diffuse in a zone of mixing, also known as the transition zone (See Figure 4 showing cross section). These transitions zones vary in thickness from aquifer to aquifer.

Chlorides are also impacted by well infrastructure. Localized chloride increases can be due to upconing effects resulting from high pumpage rates of individual wells, a well's depth, and aquifer properties in the vicinity of the pumping station. Within well batteries, such as Mokuhau, well spacing and location are also important when examining chloride trends in the individual wells of the battery. Localized chloride increases can be due to upconing effects resulting from high pumpage rates of individual wells, a well's depth, and aquifer properties in the vicinity of the pumping station. Figure 19 shows a possible conceptual diagram of upconing in DWS well fields that parallel the coast.

Figure 20 shows another conceptual diagram of upconing on a cross-section perpendicular to the coast. This may be happening at Mokuhau. Mokuhau well field has exhibited upconing, and as a result, Mokuhau Well No. 2 (located in the middle of the well field) has not been pumped, even intermittently, since 1997 due to excessively high chloride ion concentrations. In addition to localized upconing, well infrastructure can be affected by aquifer-wide shrinkage of the basal lens, which would increase chloride trends in all well sources. Deep wells, wells with large pump capacities, and wells closest to the ocean would be the first to experience higher chlorides.

Iao Aquifer

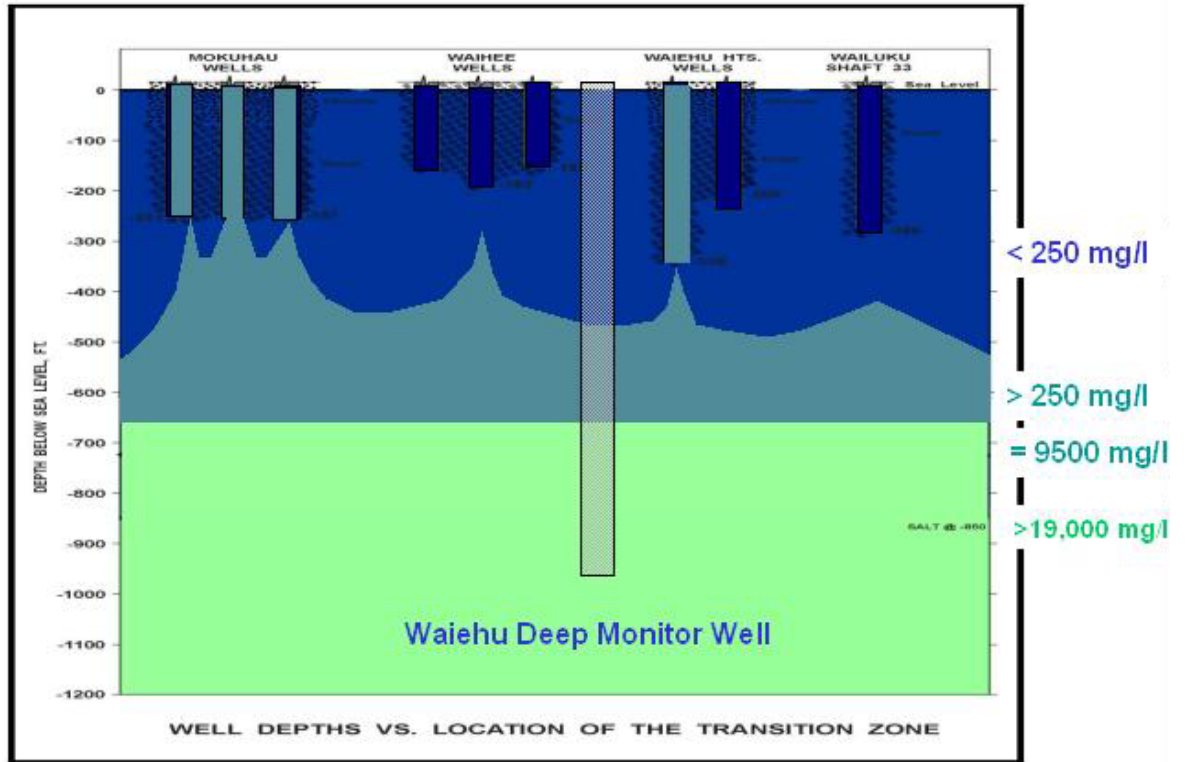
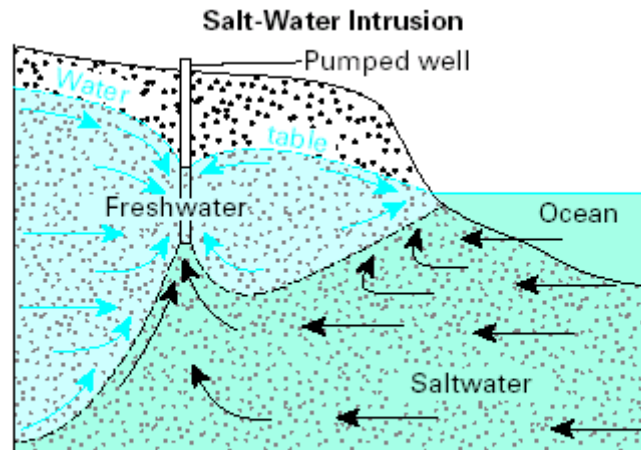


Figure 19. Localized upconing effects in Iao



How intensive ground-water pumping can cause salt-water intrusion in coastal aquifers.

Figure 20. Conceptual diagram of upconing (adopted from the USGS webpage)

Chlorides differ depending on hydrogeologic conditions. Dike-impounded sources, such as the Kepaniwai Well and Iao Tunnel, have high water levels and no known evidence of contact with seawater, which results in low chloride concentrations, only slightly greater than rainwater. Basal sources are more susceptible to changes in chloride concentrations because the Ghyben-Herzberg lens floats on denser salt water and, therefore is in direct contact with salt water. The contact between fresh and salt water is not sharp but rather diffuse in a zone of mixing, also known as the transition zone (See Figure 4 showing cross section). These transition zones vary in thickness from aquifer to aquifer.

Deep monitor wells help us distinguish between localized upconing and aquifer-wide hydrogeologic conditions affecting salinity. Fortunately, salinity and temperature profiles conducted in the Waiehu Deep Monitor Well provide knowledge of regional changes, not only within the transition zone, but the fresh water core that is the potable portion of the basal lens. Figure 21 shows the most recent conductivity profile data collected by CWRM from Waiehu Deep Monitor Well.

Waiehu Deep Monitor Well No. 5430-05
CTD Logged August 22, 2002
Serial No. 425

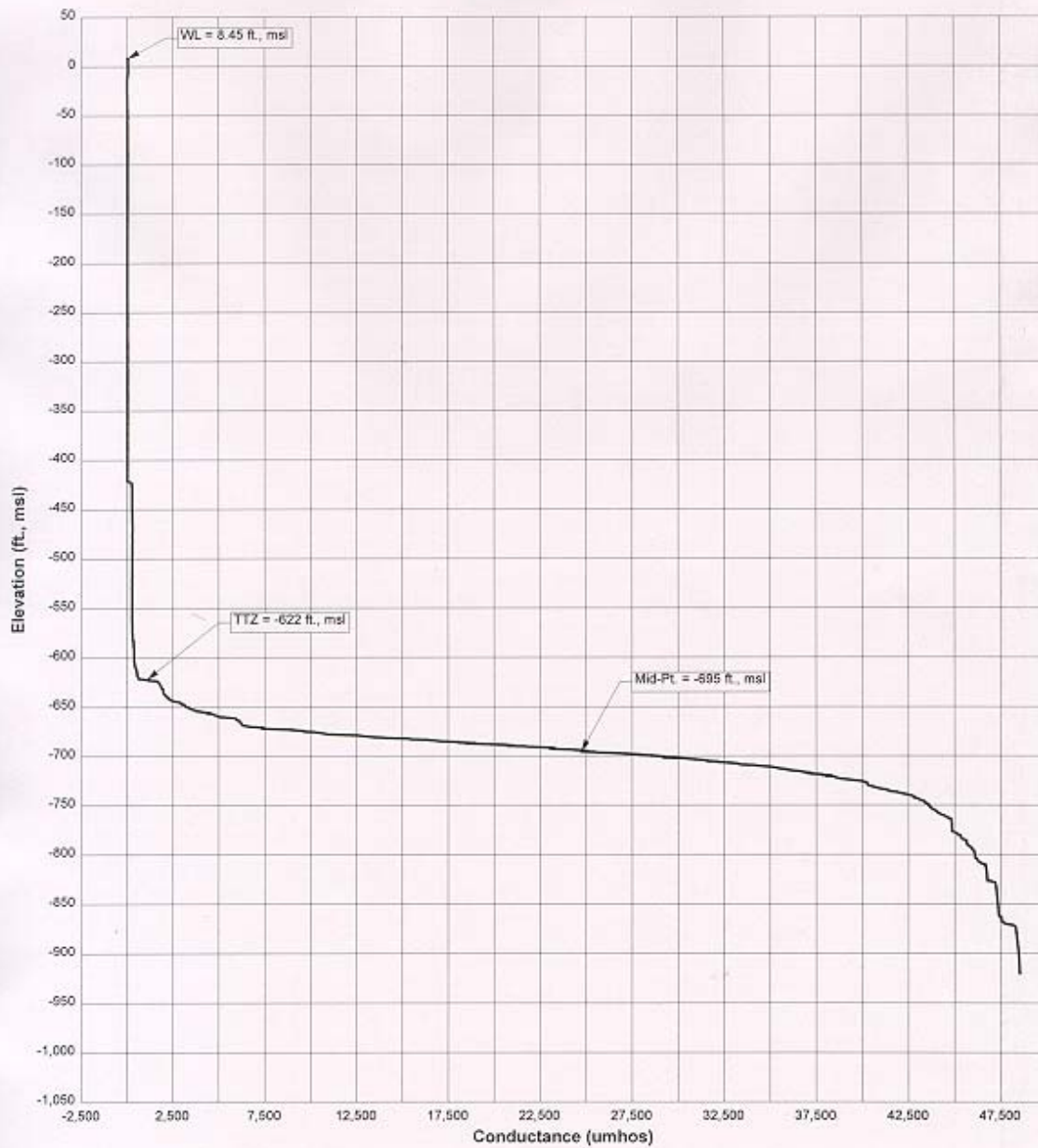


Figure 21. Conductivity profile of Waiehu Deep Monitor Well, logged August 22, 2002.

Table 5 lists the initial chloride concentrations when current active wells in Iao Aquifer were first drilled and tested and provides a starting point to measure chloride trends in Iao.

Table 5. Initial chloride concentrations

WELL NAME	INITIAL CHLORIDE (MG/L)	YEAR (DRILLED)
Wailuku Shaft 33	NA	1946
Mokuhau 1	16	1953
Mokuhau 2	16	1953
Mokuhau 3	30	1967
Waiehu Hts. 1	52	1975
Waiehu Hts. 2	20	1975
Waihee 1	15	1976
Waihee 2	NA	1976
Waihee 3	189	1981
Waiehu Deep Monitor Well	NA	1982

Initial chloride values for Wailuku Shaft 33, Waihee 2, and the Waiehu Deep Monitor Well are unavailable but it is assumed that those concentrations were less than 30 mg/L. Waihee 3 initial chloride is believed to be an error since current chloride concentrations are much less.

Table 6 presents the average annual maximum chloride values for each of the Iao sources. Maui DWS samples each source weekly. The maximum chloride concentration represents the conservative view of a well's performance over time.

Year	Table 6. Average annual maximum chlorides in Iao basal wells								
	Waihee1	Waihee2	Waihee3	Mokuhau1	Mokuhau2	Mokuhau3	Waiehu1	Waiehu2	Sh33
1983	13	16	N/A	N/A	222	121	83	50	N/A
1984	15	16	N/A	N/A	171	104	92	49	N/A
1985	18	16	N/A	123	188	114	86	35	N/A
1986	17	16	N/A	114	161	148	82	52	N/A
1987	23	24	N/A	112	160	131	95	65	N/A
1988	38	30	N/A	76	205	150	92	90	N/A
1989	37	29	N/A	90	207	158	89	88	N/A
1990	39	21	35	114	377	184	76	65	N/A
1991	35	38	34	117	293	129	103	54	N/A
1992	29	46	30	125	141	101	93	47	45
1993	35	34	22	106	217	97	101	47	40
1994	41	42	35	102	279	128	113	55	48
1995	32	45	38	109	283	157	114	64	53
1996	23	36	19	85	334	140	123	47	40
1997	25	45	20	114	N/A	176	98	55	40
1998	29	57	20	139	N/A	93	78	53	42
1999	32	65	24	150	N/A	118	128	47	45
2000	46	53	N/A	198	N/A	135	174	58	46
2001	26	45	25	195	N/A	139	170	63	48

There are observable trends in the data presented in Table 6. Chloride concentrations in Waihee 2, the Mokuhau Wells, and Waiehu Heights 1 have trended upwards since 1983. Other wells show no trend since 1983. However, there is variability between wells within the same well field that can be the result of differences in well infrastructure (well depth, casing depth, the amount of open hole exposed), pumping schedules (that is, which wells are pumped longer or are rested more often, or are turned on and off more often), pump efficiency, and localized heterogeneity of aquifer properties.

The following sections present chloride data for the individual basal wells. These data are limited prior to 1975. Figures 22 through 31 present available monthly maximum chloride data for individual wells from USGS and MDWS, total average lao monthly pumpage, total average station pumpage, total average well pumpage plotted over time.

Mokuhau Wells

The Mokuhau Wells (Nos. 5330-09, 10, 11) constituted the first major well field developed in the lao Aquifer. Mokuhau Wells 1 and 2 were drilled in 1953 and Mokuhau 3 was completed in 1967. Initial chloride values are presented in Table 5. These chloride values are low due to the low aquifer pumpage at the time (<10 mgd total). The Mokuhau Wells bottom hole elevations range from -247 feet, MSL to -251 feet, MSL. Installed capacity at the Mokuhau Wells has two wells at 2,800 gpm (4 mgd each; Mokuhau 1 and 2) and one well at 4250 gpm (6 mgd; Mokuhau 3).

Mokuhau Well No. 1, lao Aquifer System
Max. Monthly Chloride and Pumpage

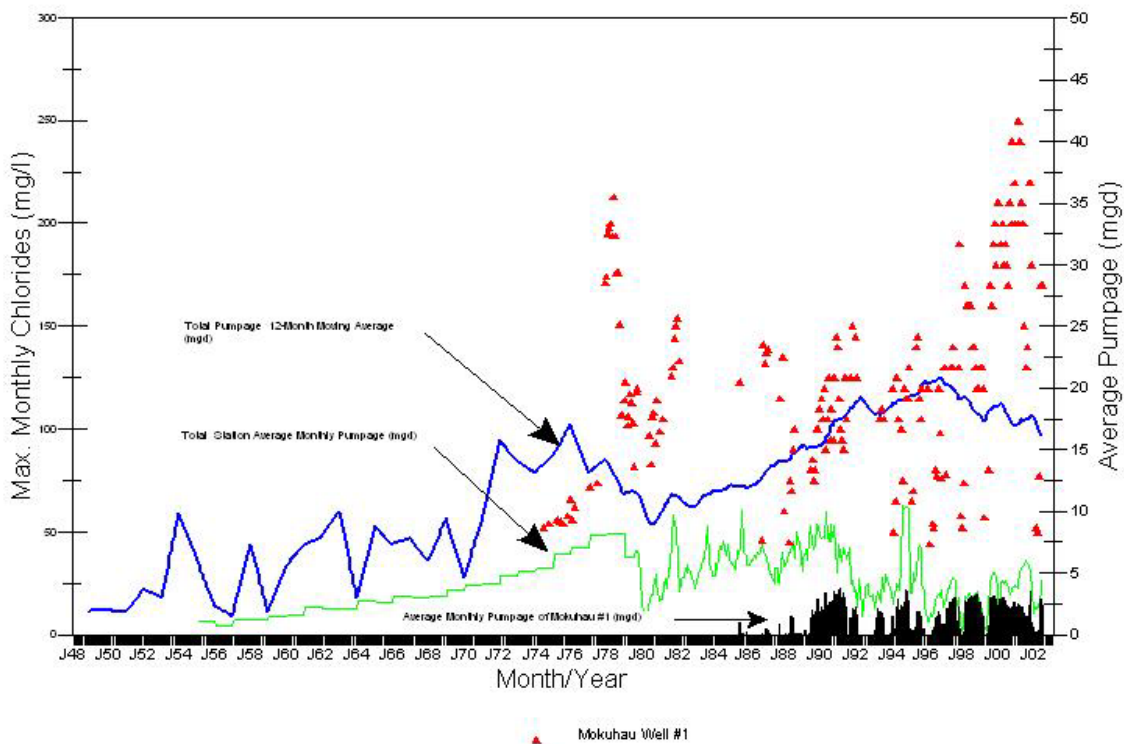


Figure 22. Maximum monthly chloride and pumpage at Mokuhau 1.

Figure 22 shows increasing maximum chloride concentrations in the late 1970's to early 1980's when the Waiehu Heights and Waihee Wells were put online, even though total pumpage from the Mokuhau station had decreased from 8.3 mgd in 1977 (Mink, 1986) to <5 mgd. During the mid-1980's through the mid-1990's the average monthly maximum chloride value remained < 150± mg/L. In the late 1990's to present, the chloride concentration from this well increased, partly as a response to the drought conditions and partly to increased sustained pumping because of Mokuhau 2 being taken offline.

Mokuhau Well No. 2, Iao Aquifer System
Max. Monthly Chloride and Pumpage

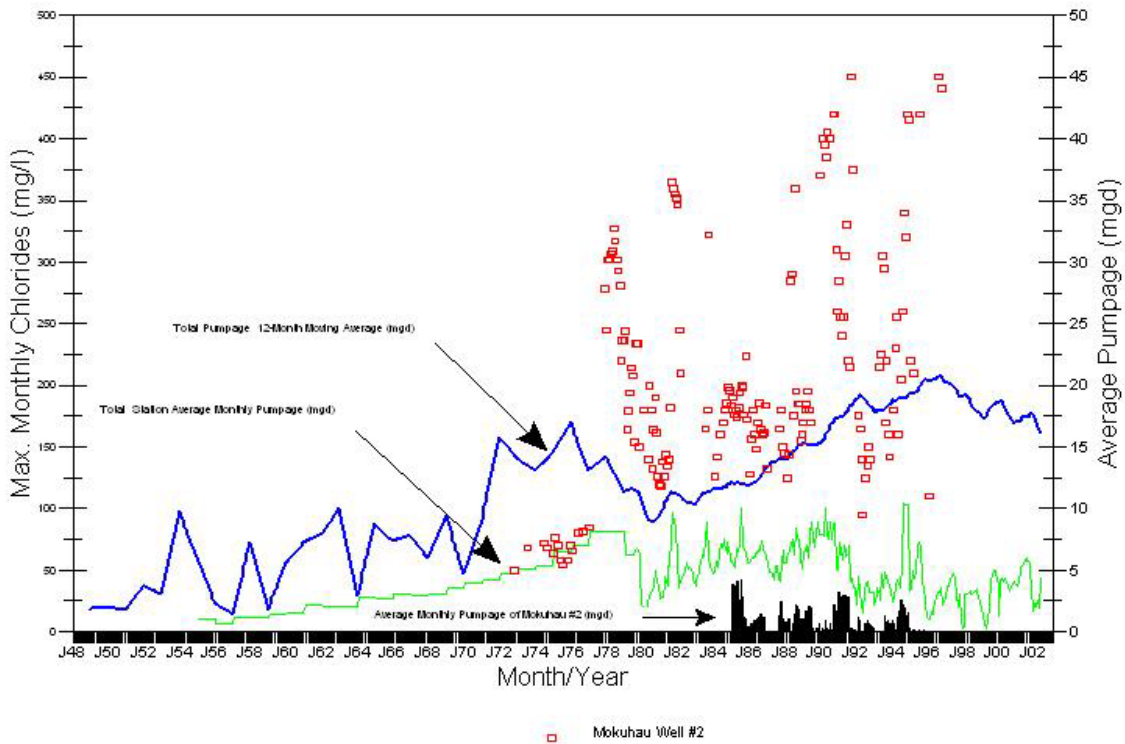


Figure 23. Maximum monthly chloride and pumpage at Mokuhau 2

Figure 23 indicates that Mokuhau 2 chloride concentration maintained 50-75 mg/L for the first years of operation, and increased significantly when the Waiehu Heights and Waihee stations began to operate. The location of Mokuhau 2 in the middle of the well field has increased the severity of the saltwater intrusion (Mink, 1986). The Mokuhau well field is set in a relatively confined area, with Mokuhau 2 located 50 feet from Mokuhau 1 and 45 feet from Mokuhau 3 (Mink, 1986, p.9). Mokuhau 2 has been effectively non-operational since 1995, even though samples were collected through 1997. Wailuku Shaft 33 has been brought online to alleviate some of the stress in the Mokuhau Well field, but reduced pumpage at Mokuhau has not overcome upcoming problems.

Mokuhau Well No. 3, Iao Aquifer System
Max. Monthly Chloride and Pumpage

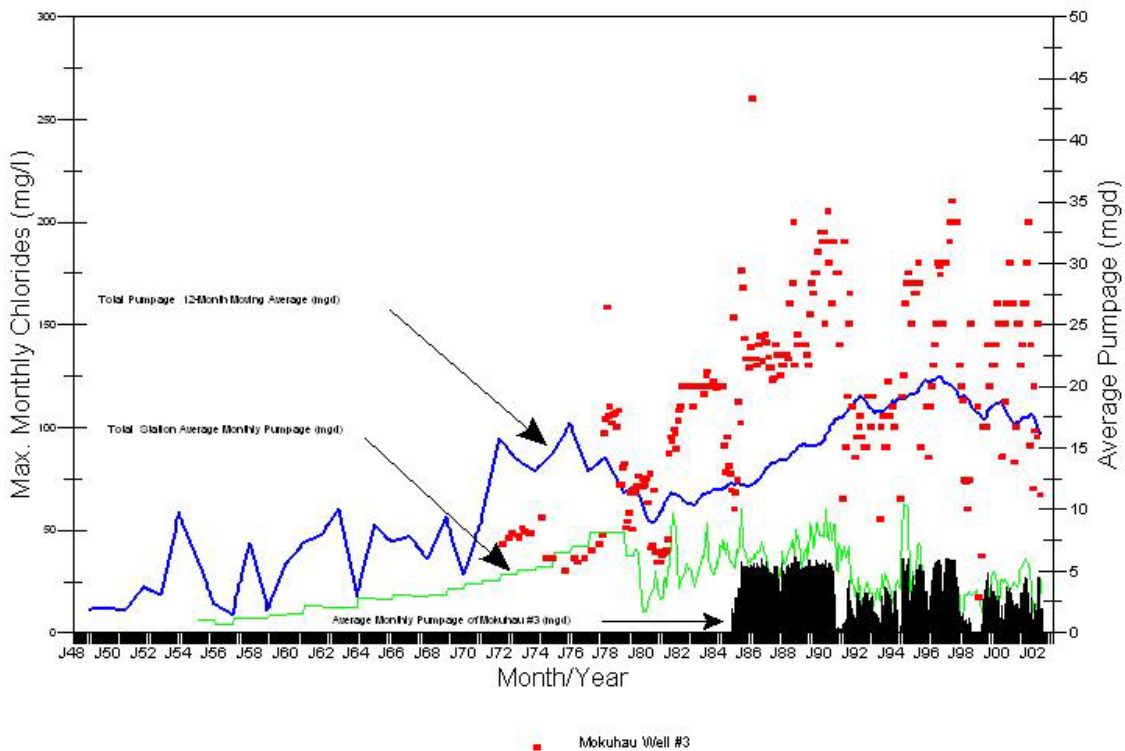


Figure 24. Maximum monthly chloride and pumpage at Mokuhau 3

Mokuhau 3 has an installed capacity of 6 mgd, and as can be seen in Figure 24, pumps the majority of the water from the Mokuhau well field. The chlorides have increased over time; however, in recent years, the average maximum monthly values range $100\text{ to }200\pm\text{ mg/L}$. The higher values could be related to when the sample is collected vis-à-vis the pumping schedule.

Waiehu Heights Wells

The Waiehu Heights Wells (well nos. 5430-01,02) were drilled in 1975. Pump test results indicated that these wells were successful and were outfitted with 1.79 mgd pumps (1250 gpm) each. Waiehu Heights Well 1 (5430-01) is drilled deep having a bottom hole elevation of -338 feet, MSL. Waiehu Heights Well 2 (5430-02) has a bottom hole elevation of -206 feet, MSL. Table 5 shows that the initial chloride value for Well 1 was 52 mg/L and for Well 2 was 20 mg/L, which is a reflection on the disparity of their bottom hole elevations.

Figures 25 and 26 present available monthly maximum chloride data for the Waiehu Heights Wells from USGS and MDWS, total average Iao monthly pumpage, total average station pumpage, total average well pumpage plotted over time.

Waiehu Hts. No. 1, Iao Aquifer System Max. Monthly Chloride and Pumpage

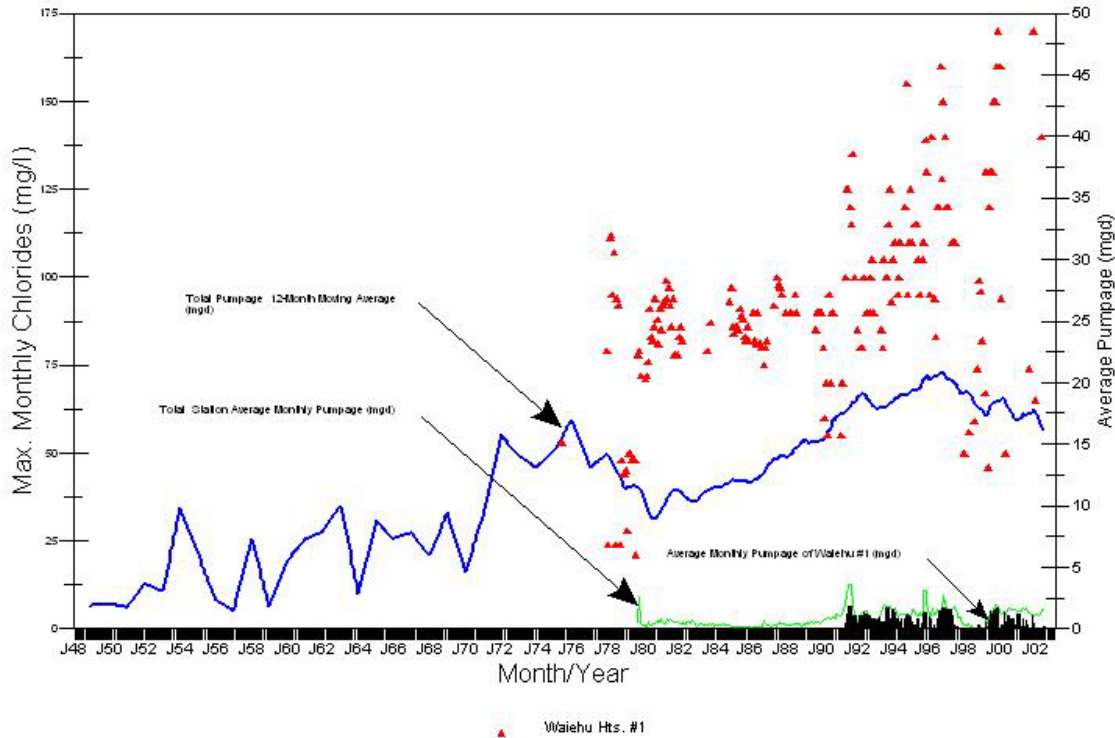


Figure 25. Maximum monthly chloride and pumpage at Waiehu Heights 1.

Figure 25 shows the total Waiehu Heights well field draft to be less than 2.5 mgd. Well 1 producing the majority of the station's output until the last several years. Because this well is so much deeper than Well 2, the average maximum monthly chloride values have been increasing since 1980, and increased significantly since the early 1990's when total aquifer pumpage increased to 15 mgd. This station is in the vicinity of the Mokuahau and Waihee well fields. However, as in the case of Mokuahau 3, the average maximum values fluctuate between $50 \pm$ mg/L and $175 \pm$ mg/L. The degree of fluctuation could be related to sampling schedules as described previously.

Waiehu Hts. No. 2, Iao Aquifer System

Max. Monthly Chloride and Pumpage

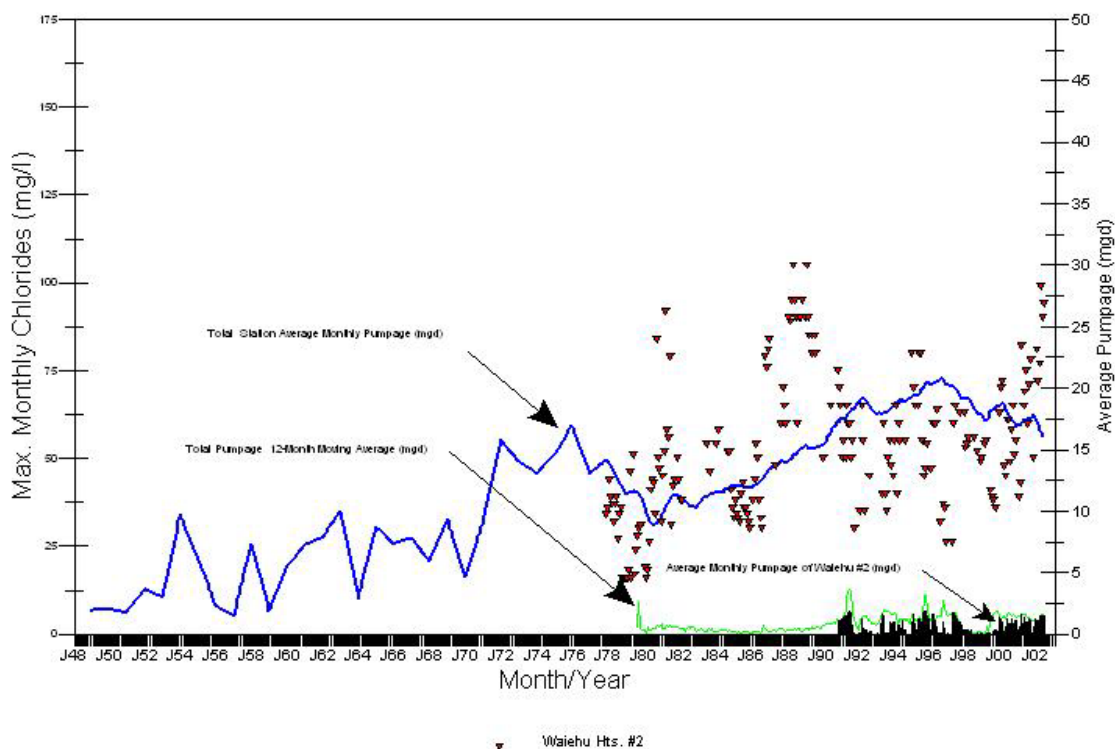


Figure 26. Maximum monthly chloride and pumpage at Waiehu Heights 2.

From Figure 26, Waiehu Well 2, though having an identical installed capacity as Well 1, produces better quality water because its bottom elevation is much shallower. Even though there are fluctuations in monthly maximum values, the chlorides range from slightly $>100\pm$ mg/L to $25\pm$ mg/L. Again, monthly fluctuations are the result of sampling versus the runtime of the pump.

Waihee Wells

The Waihee Well field (5431-01,02,04) was drilled at about the same time as the Waiehu Heights wells. Two of the wells have an installed (5431-01,02) capacity of 2800 gpm each (4 mgd) and well no. 5431-04 has an installed capacity of 3480 gpm (5 mgd). These wells are shallower than those at Mokuahu and Waiehu Heights. The deepest is Waihee 1 at -182 feet, MSL. The shallowest is Waihee 3 at -156 feet, MSL.

Table 5 shows that the initial chloride values range considerably. Waihee 1 was 20 mg/L, while Waihee 3 was 189 mg/L (again, this value is thought to be an error). There is no initial chloride value for Waihee 2.

Figures 27 through 29 present the data for the individual wells within the well field. Total station output is about 7 mgd. However, since about 2001, the station produces about 5 mgd.

Waihee Well No. 1, Iao Aquifer System

Max. Monthly Chloride and Pumpage

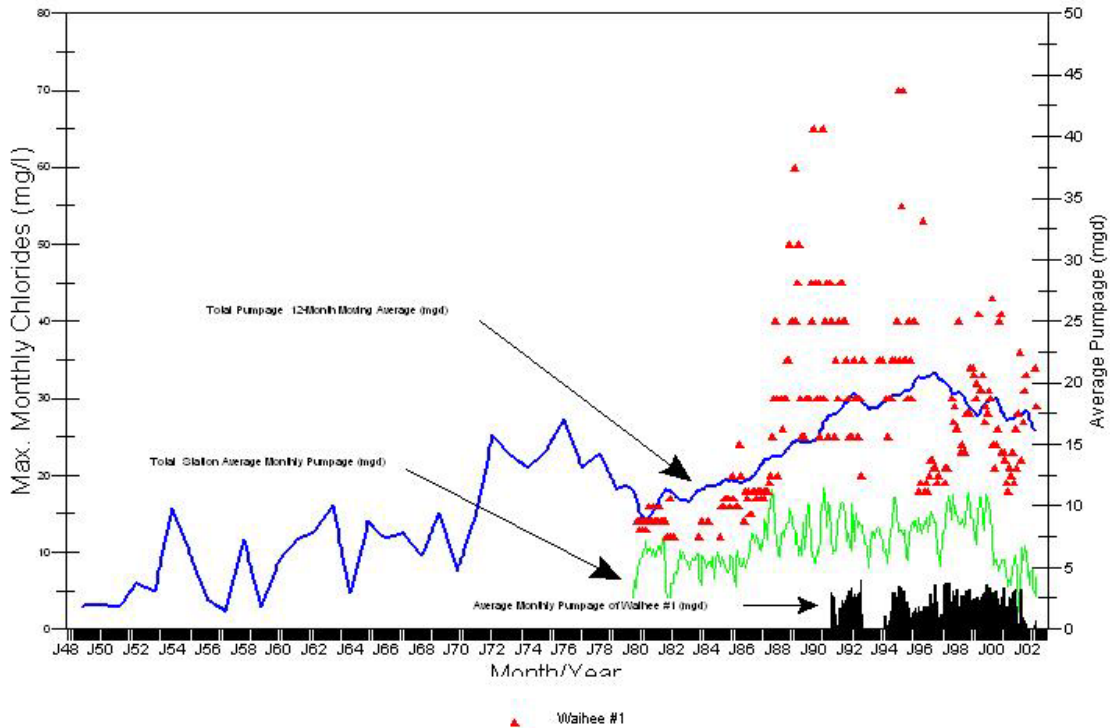


Figure 27. Maximum monthly chloride and pumpage at Waihee 1.

Waihee 1 produces about a third of the total withdrawal, or about 2.5 mgd average pumpage. In the late 1980's through the mid 1990's the average maximum monthly chlorides ranged from <20 mg/L to a high of 70 mg/L. Since 1997, the fluctuations of chloride concentrations are tighter, and are generally between 20 to 40 mg/L.

Waihee Well No. 2, Iao Aquifer System

Max. Monthly Chloride and Pumpage

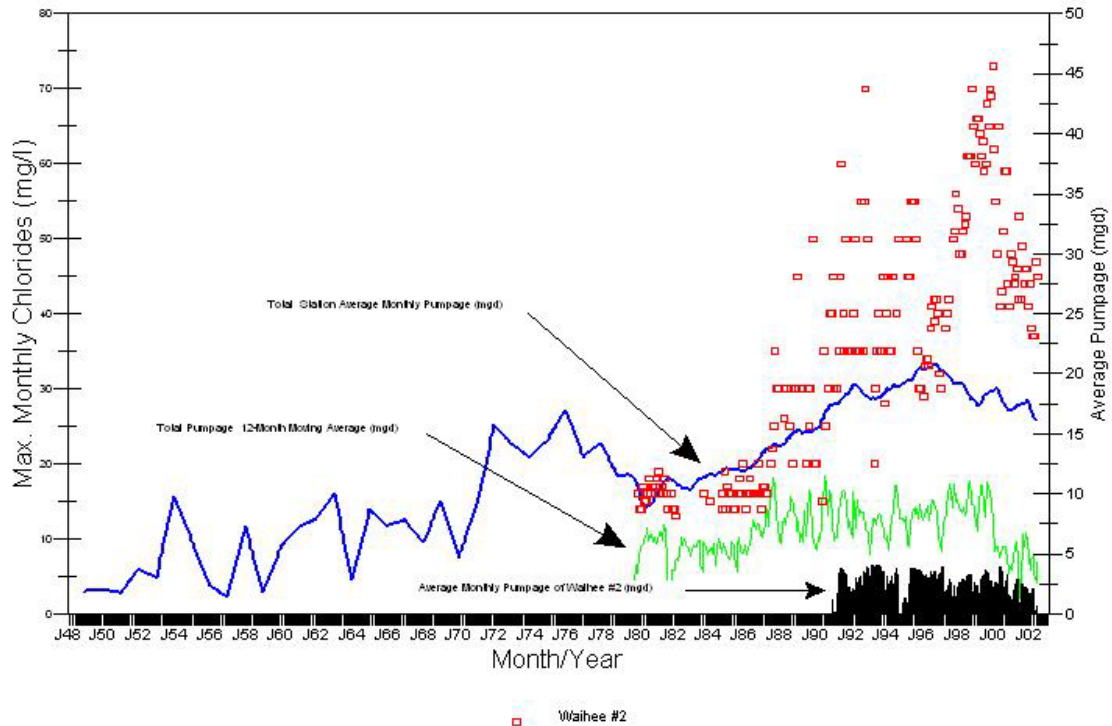


Figure 28. Maximum monthly chloride and pumpage at Waihee 2.

Waihee 2 also produces about one third of the station's water. Despite the early low concentrations during the 1980's chlorides have risen as total aquifer pumpage increased throughout the 1990's until the production at the station decreased to 5 mgd in the year 2001. Maximum monthly chloride values dropped to $40 \pm$ mg/L as a result of low pumpage.

Waihee Well No. 3, Iao Aquifer System

Max. Monthly Chloride and Pumpage

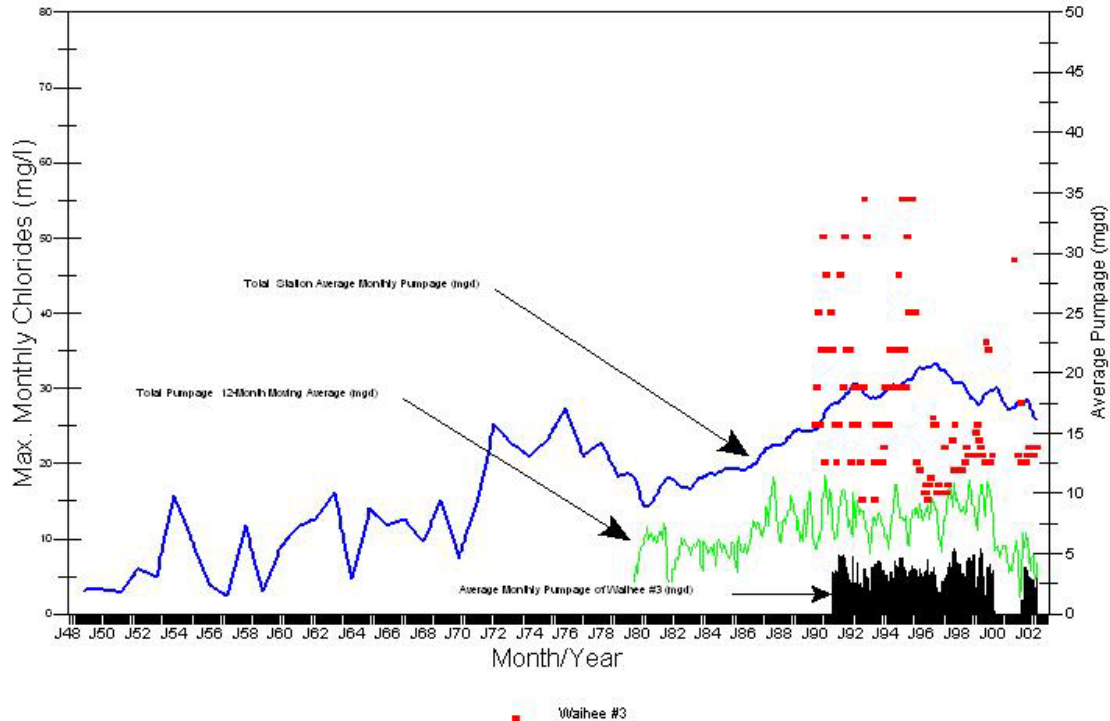


Figure 29. Maximum monthly chloride and pumpage at Waihee 3.

Waihee 3 has the largest installed capacity at the well field and also exhibited the greatest fluctuation of chloride concentrations over the period of high total aquifer pumpage. Although the maximum chloride values did not exceed 60 mg/L, there was a dramatic decrease in the late 1990's as MDWS cut back total Iao pumpage. Even though the station cut back in 2001, the chlorides have remained steady at about 20± mg/L since 1997. There are a few months where the sample maximum value jumped between 35-50± mg/L, but these data anomalies do not seem to reflect what is the station norm. Therefore, this well field has not been experiencing chloride behavior that suggests excessive upconing.

Wailuku Shaft 33

Wailuku Shaft 33 (5330-05) was constructed in 1946 to provide additional irrigation water to sugarcane. The shaft is actually three large wells drilled below the pump room, rather than a skimming infiltration gallery that is more typical. The shaft began operations in 1948, and is the only operational source south of Iao Stream. In 1953 the average output was 9.7 mgd, though the installed capacity was 21.75 mgd. Pumpage peaked in 1971 where the average pumpage was 11.7 mgd (Mink, 1986, p. 4). Since MDWS began to operate the shaft in 1991, the average pumpage is 4.6± mgd. Figure 30 presents the chloride and pumpage history of this source.

Wailuku Shaft 33, Iao Aquifer System
Max. Monthly Chloride and Pumpage

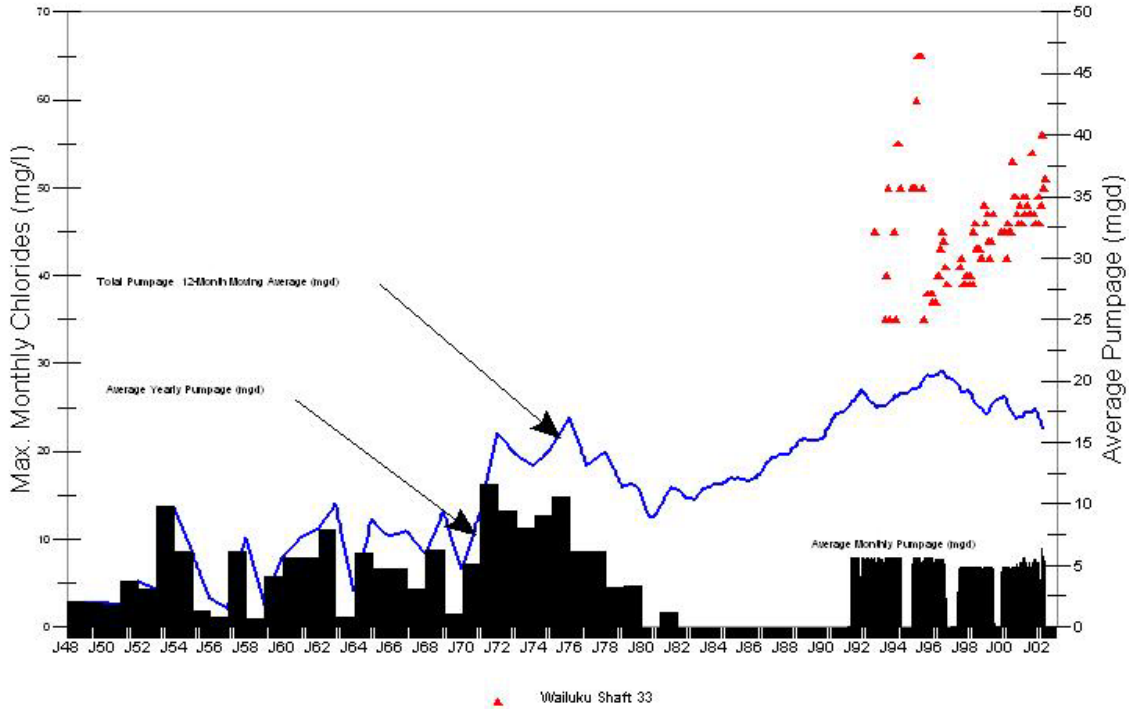


Figure 30. Maximum monthly chloride and pumpage at Wailuku Shaft 33.

Since Wailuku Shaft 33 was put back into operation in 1991, the maximum monthly chloride concentration has increased from 35± mg/L to 55± mg/L. Despite pumping almost 5 mgd, the water quality remains excellent.

Kepaniwai Well

The Kepaniwai well (5332-05) is located within the high-level dike-impounded portion of the Iao Aquifer System. The well was drilled in 1974 at an elevation of 713 feet, MSL and encountered water at an elevation of 676± feet, MSL. The well is 300 feet deep, and because of the high drawdown encountered during the testing phase of construction, the 1 mgd (700 gpm) pump is set at 179 feet below the surface. Average pumpage is 0.67 mgd. Figure 31 presents the chloride and pumping history of this source.

Keponiwai Well, Iao Aquifer System

Max. Monthly Chloride and Pumpage

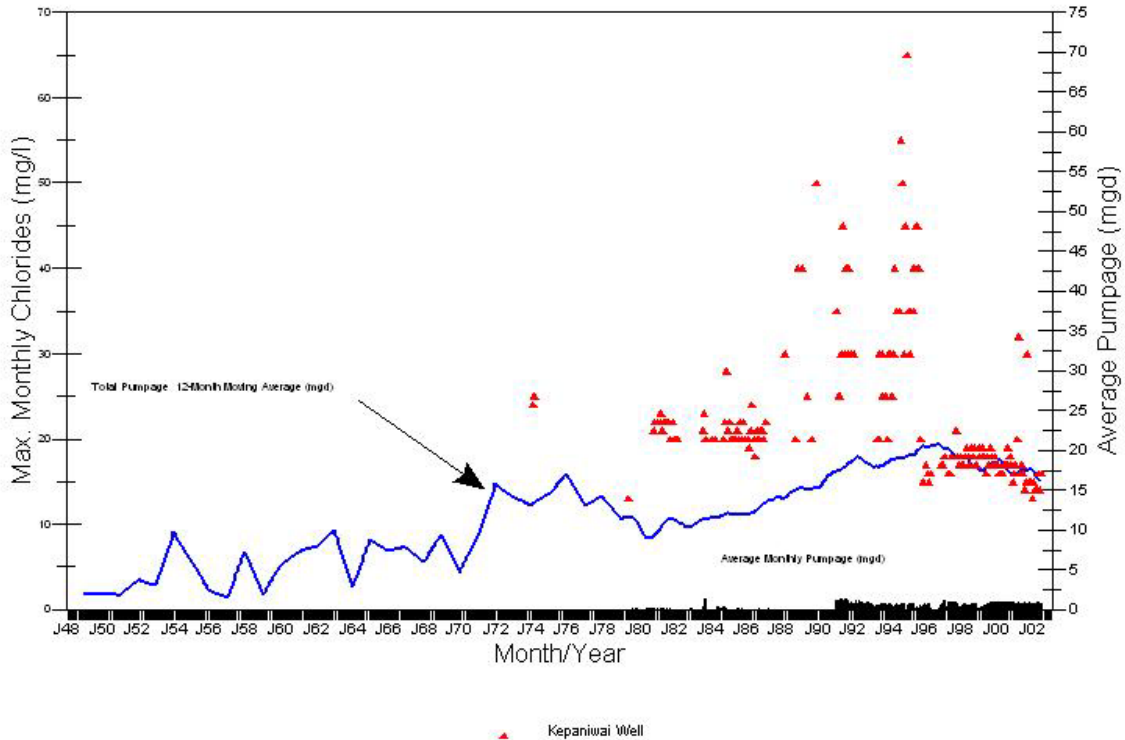


Figure 31. Maximum monthly chloride and pumpage at Keponiwai Well.

The chloride data generally show typical dike-impounded values between 10 and 20 mg/L. However, anomalously high values are shown in the data set. One anomalous measurement of 135 mg/L was reported in September 1991. The anomalous values may be either caused by sampling/analytical error or by some other mechanism (e.g. geothermal convection). More research will be needed to determine if the high chloride values are natural or the result of error.

3.4.10(b) Temperature

Visher and Mink (1964, p. 122) report that the temperature of water recharging the Koolau aquifer averages 67.5° F, while ground-water temperatures in Honolulu average about 70° F (21.1° C). Mink (1977, pp. 17-18) notes that ground-water temperatures ranging from 71° F (21.6° C) to 72.5° F (22.5° C) pumped from Wailuku Shaft 33, the Mokuhaui Wells, and the Waihee Wells are warmer than expected. Given the elevation and cooler temperature of the recharge area, estimated at 67° F (19.5±°C), ground-water temperatures should be cooler. The Keponiwai Well, drilled into a dike compartment, produces water at 69.8° F (21.0° C). He concludes that the anomalous basal water temperatures could be from the following:

- 1) Recharge originating at low elevations.
- 2) Return irrigation water providing for a large portion of recharge. With the reduction of agriculture irrigation since the mid 1990's over the Iao Aquifer, return irrigation water is no longer a major component of recharge.

3) Ground-water temperatures are in balance with the geothermal gradient; therefore, the ground-water flow is sluggish and total recharge limited.

Continual temperature profiling of the Waiehu Deep Monitor well by CWRM is shown as Figure 32. This profile is essentially identical to the first temperature log completed in 1999. The profile shows that temperature at the surface is 21.9° C (71.4° F) and steadily decreases to 20.8° C (69.4° F) at elevation -425± feet, MSL, where a cold water zone that is 19.5° C (67.1° F) extends to -570± feet, MSL. The cold water zone represents recharge from the higher mountainous interior of West Maui. Below the cold water zone, temperatures increase with increasing salinity. The transition zone mid-point temperature is 20.3±° C (68.5° F), while the bottom temperature is 22.9±° C (73.2° F) at -925 feet, MSL.

Waiehu Deep Monitor Well No. 5430-05
CTD Logged August 22, 2002
Serial No. 425

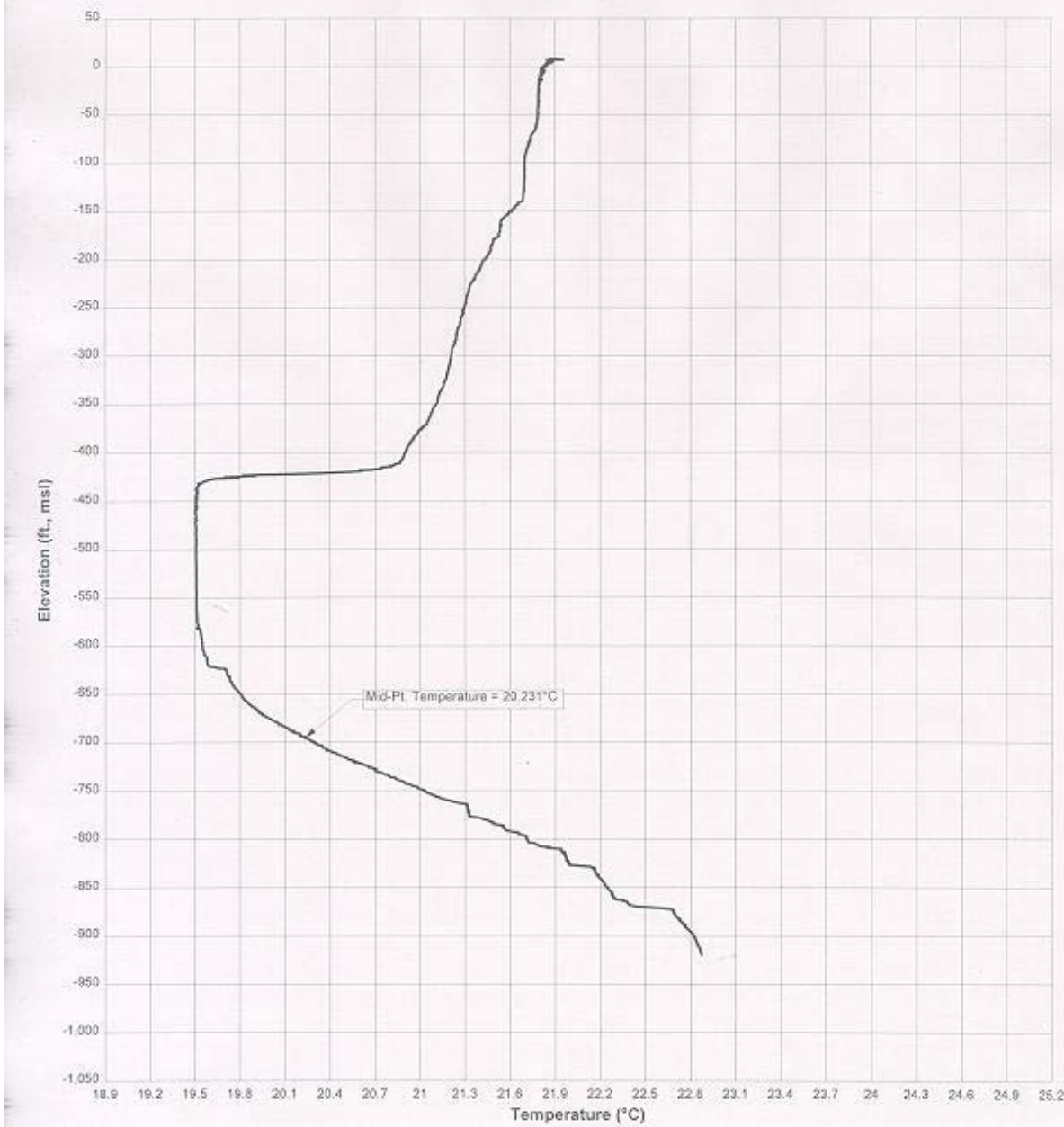


Figure 32. Temperature profile through Waiehu Deep Monitor Well.

3.4.10(c) Contaminants

The Department of Health (DOH) Safe Drinking Water Branch (SDWB) has tested all Iao drinking water wells for organic compounds and inorganic contaminants. SDWB did not detect any

organic contaminants. However, SDWB did detect inorganic contaminants; chromium and fluoride in concentrations well below EPA maximum contaminant levels (MCL).

3.4.11. Sustainable Yield

Under the State Water Code, sustainable yield is defined as follows:

HRS §174C-3 - *"Sustainable yield means the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the commission."*

In determining sustainable yields, the Commission distinguishes between optimal potential development of an aquifer and the man-made limitation on withdrawals imposed by existing infrastructure. Under the WRPP, sustainable yields are derived by the RAM and address the optimal potential development perspective for planning and managing purposes. RAM was never intended to address constraints imposed by actual infrastructure perspective. Indeed, USGS Report WRI 00-4244 (Oki and Meyer, 2001) shows that predicted spatial distribution of water levels in an optimal development model such as RAM will differ from the predicted water-level distribution of a model that accounts for sub-optimal infrastructure. To address the infrastructure perspective, a regional numerical model is required. Also, it should be understood that there is no single optimal configuration of infrastructure given the need to balance economic vs. hydrologic constraints.

The Commission has revised sustainable yields when 'acceptable' numerical models have been developed **and** there has been competition amongst large users (e.g. Ewa-Kunia, Waipahu-Waiawa, and Kualapuu Aquifer Systems). There has been another numerical model developed to address infrastructure constraints to sustainable yield (e.g. Lanai, Ewa Caprock) but the Commission did not revise the WRPP sustainable yields. In the case of Lanai, sustainable yield was not revised due to the lack of competition between large users. In the case of the Ewa Caprock, the Commission determined to use chloride limits to non-potable individual wells to manage and protect the aquifer. Therefore, given the facts that the MDWS is the sole large user in lao and no numerical model exists for lao, it would seem more appropriate to use the optimal potential development perspective at this time. However, the county is pursuing the development of a 4.5-year, \$1 million dollar numerical modeling project, that includes lao, to be done by the USGS (June 28,2002 letter from USGS to MDWS). Once this project is done, the Commission may then consider revising lao aquifer sustainable yield from the infrastructure perspective.

The current official CWRM sustainable yield estimate for lao is 20 mgd, as adopted through the WRPP. However, the original official recharge estimate of 15 mgd is less than the sustainable yield of 20 mgd. Since 1995, revised estimates for recharge have been presented for lao (see Table 2) but not officially adopted through the WRPP procedures. These studies suggest that recharge in the WRPP is too low and suggest that the current sustainable yield is appropriate.

Ultimately, actual field data should reconcile and verify that pumping at a sustainable yield estimate is not endangering the aquifer. Currently, data suggest that pumping at 20 mgd will not endanger the aquifer but may reduce the utility of some of the deeper MDWS sources (Mokuhau, Waiehu 1). The current 12-MAV is 16±mgd (80 percent of sustainable yield) is much less than that seen during the last Commission designation decision and may improve conditions at some pumping wells.

3.5. Waihee Aquifer System Hydrology

3.5.1. Ground-Water Occurrence

Ground water in the Waihee Aquifer System occurs in two areas of the Wailuku Volcanics: 1) upper regional high-level dike confined water, 2) lower regional basal water (Figure 4). There are also small-perched aquifers in high rainfall areas of the Honolua Formation (Stearns and Macdonald, 1942 p 175). Potable ground water in the Waihee Aquifer System is found in both the high-level and basal portions of the system. Only the basal aquifer is currently used for potable water. The basal water zone extends about a mile inland from the coast (Meyer and Presley, 2001; Yamanaga and Huxel, 1970 p. 25).

The Waihee River forms the southern boundary of the basal aquifer. The low-permeability valley fill of the streambed forms a partial barrier to ground-water flow (Mink, 1997). See Figure 2 map of Iao and Waihee boundaries. Therefore, the valley fill delineates the aquifer system from the Iao Aquifer System. The northern boundary of the Waihee Aquifer System is defined by Kahakuloa Stream. The delineation of aquifers further inland is probably less pronounced. It appears from the streamflow data that the deeply entrenched Waihee River probably intercepts dike-impounded aquifer flow from other aquifer systems.

3.5.2. Rainfall

The Waihee Aquifer System receives a substantial amount of rainfall but with great geographical variation. Mean annual rainfall within the system varies from about 40 inches over the relatively dry coastal region to almost 350 inches at the head of the aquifer system (Giambelluca and others, 1986, report R76). Table 7 lists rain gauge stations and the average rainfall for Waihee Aquifer System. Rainfall data over the aquifer system is very sparse. For this reason we have included data from Eke and Puu Kukui rain gauges as examples of interior rain gauges for the Waihee Aquifer System. However, an isohyetal map can be constructed using existing West Maui rainfall data. Figure 8 shows the distribution of mean yearly rainfall over the region and the location of rain gauges. Previous estimates of total rainfall in million gallons per day are tabulated in the water balance table (Table 8).

Table 7. Summary of rainfall station data in or near the Waihee Aquifer System

Station	Station No.	Gage Elevation (ft)	Mean Annual Rainfall (in)	Median Annual Rainfall (in)	Period of Record or Reference	Note
Waihee Valley	482	300	43.2	41.3	1936-2002	
Eke	481.3	4602	255.7	251.3	1913-1933	not in Waihee
Puu Kukui	380	5788	391.6	381.0	R76, p 202	not in Waihee
Puu Kukui	380	5788	380.9	n/a	1928-2002	not in Waihee
Kahakuloa Mauka	482.3	650	37.72	34.5	1967-1983	

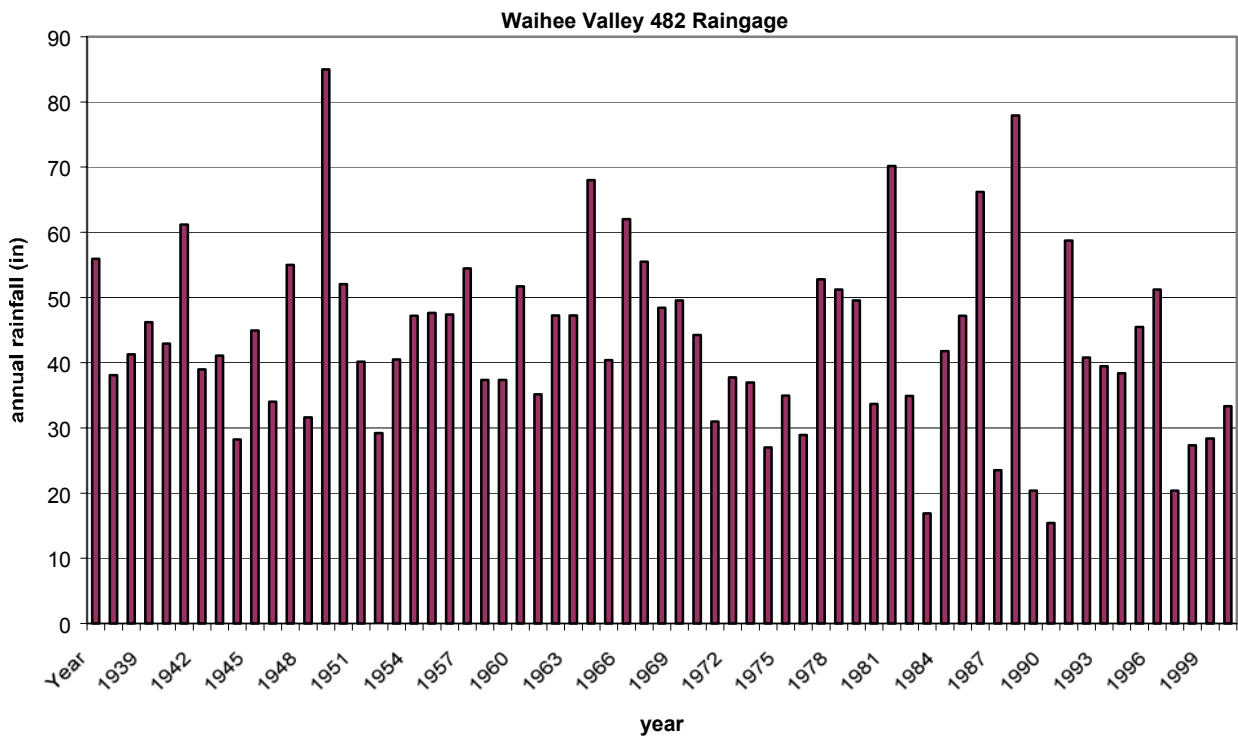


Figure 33. Annual rainfall at station no. 482 in Waihee Aquifer System

Station No. 482 in Waihee Valley recorded the most continuous daily record of rainfall within the aquifer system. Figure 33 shows annual rainfall data at Station No. 482 over the entire period of record.

Figure 34 illustrates another way of looking at rainfall data from Station No. 482. Annual rainfall is taken as a percentage of long-term historical average mean for this gage. Therefore, rainfall percentages greater than 100 percent represent a wet year and rainfall percentages less than 100 percent represent dry years. Over the length of record there have been six major drought periods. The most recent drought began in 1998 and continues to the present time.

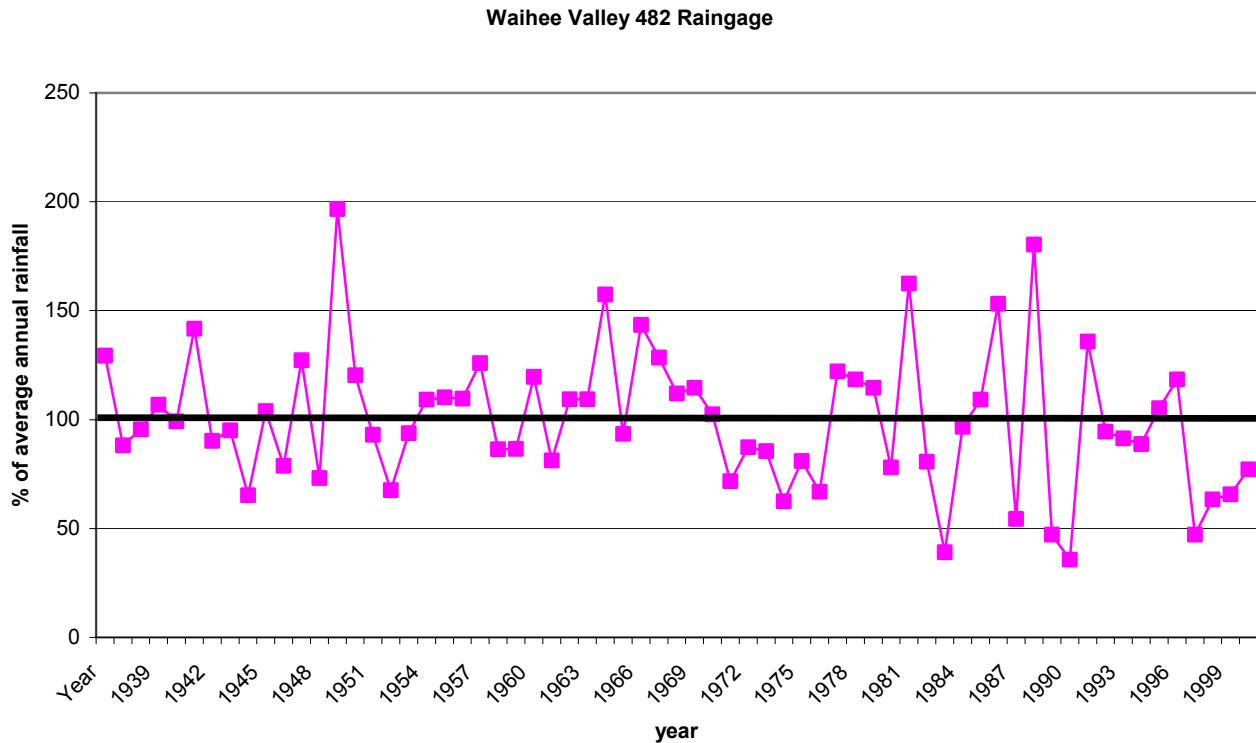


Figure 34. Annual rainfall as a percent of the mean, station no. 482 in Waihee Aquifer System

Figure 35 illustrates a third method of looking at rainfall data from Station No. 482. Annual rainfall is expressed as the 12-month Standard Precipitation Index (McKee, and others, 1993). The Honolulu National Weather Service Forecast Office adopted these SPI data for use in Hawaii. The SPI is also used by the National Drought Mitigation Center and the Western Regional Climate Center. A dry period occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less. The dry period ends when the SPI becomes positive. The graph shows that it was moderately to severely dry at Waihee from May 1998 to November 2001.

Figure 36 shows the percent of average annual rainfall at Puu Kukui 380 Rain Gage. There is missing data, but the graph indicates that 2000 and 2001 were low rainfall years while 1999 and 1998 were average or above average.

Waihee Valley Raingage 12-Month SPI

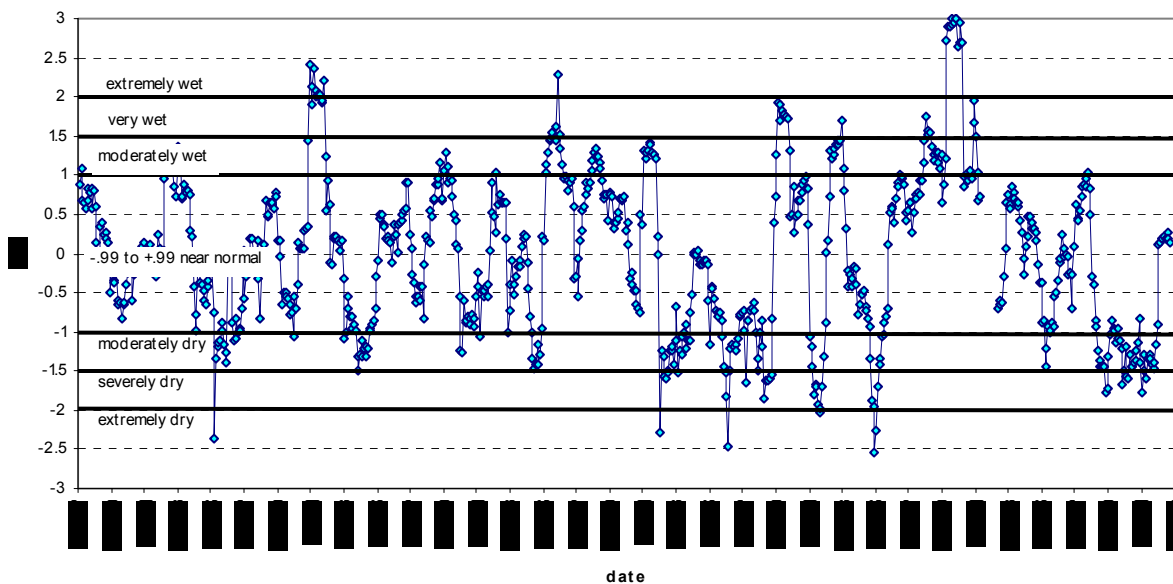


Figure 35. Annual rainfall expressed as an 12-month SPI, station no. 482 in Waihee Aquifer System (data from Honolulu National Weather Service Forecast Office, 2002)

Puu Kukui 380 Raingage Percent of Annual Average

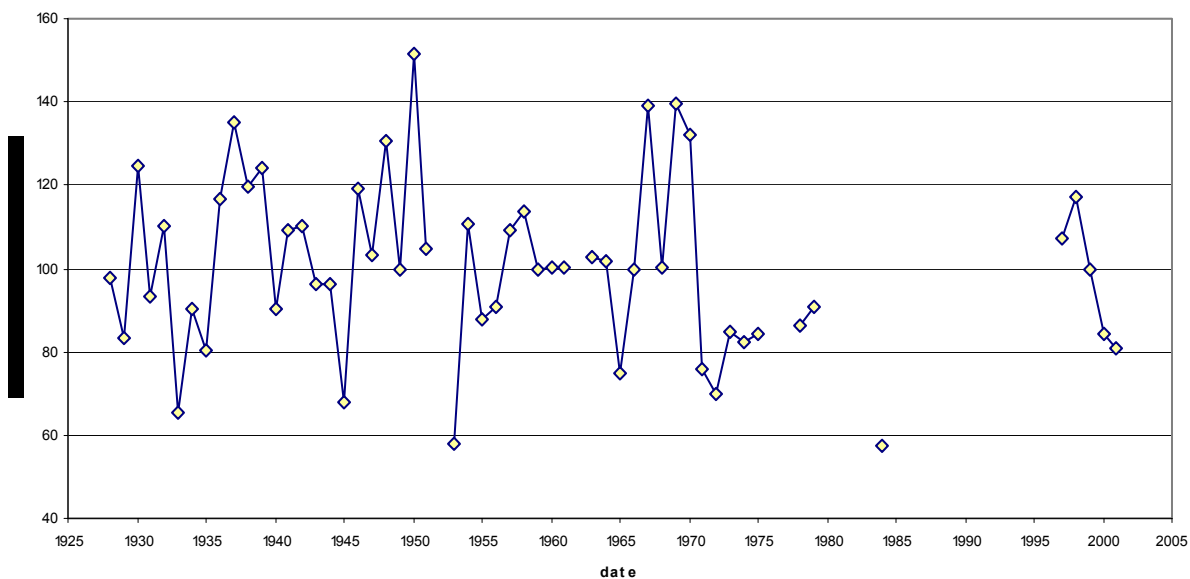


Figure 36. Rainfall as a percent of the long-term annual average at Puu Kukui 380 Rain Gage

Table 8. Relevant water balances for Waihee Aquifer System.

Note that these estimates refer to different areas and may not be directly comparable.

Region	Report	Area	Rainfall		Runoff		ET		Recharge			SY
			square miles	mgd	mgd/mi sq	mgd	% of rainfall	mgd	% of rainfall	mgd	% of rainfall	
Iao Aquifer	Shade (1997)	16.15	87	5.39	40	46%	18	21%	29	33%	1.8	
Lahaina District	Shade (1996) natural cond	96	330	3.44	95	29%	90	27%	145	44%	1.51	
Waihee Aquifer System	Mink (1995)	11.87	63	5.31	14.62	23%	23	37%	25.5	40%	2.15	
Waihee Aquifer System	WRPP (Yuen and Assoc., 1990)	11.87	63	5.31	28	44%	23	37%	12	19%	1.01	8
Wailuku	Takasaki (1978)	NA	370		175	47%	130	35%	65	18%		
Lahaina District	State of Hawaii 1977 (R54)	60	265	4.42	53	20%	119	45%	93	35%	1.55	
Maalaea to Waihee	DLNR, 1970 (R38)	32.8	230	7.01	120	52%	50	22%	60	26%	1.83	
Iao	DLNR, 1970 (R38)	9.2	95	10.33	50	53%	10	11%	35	37%	3.8	
northwest Maui (Honokohau to Honokeana)	Belt Collins 1969 (R33)	NA	122		40	33%	53	43%	29	24%		
Iao Valley	Caskey 1968	6.02	53	8.8	39	74%	12	23%	2	4%	0.33	
West Maui	Stearns and Macdonald 1942 p 43	140	580	4.14					145	25%	1.04	
	Average (not weighted)					42%		29%		29%	1.75	

3.5.3. Fog Drip

In addition to rainfall, fog drip is a significant contributor to recharge in the Waihee Aquifer System. Fog drip is water vapor and precipitation that is caught by vegetation and then drips to the ground. Earlier fog drip studies on the islands of Hawaii and Lanai indicate that fog drip is a significant contributor to ground-water recharge on those islands (Anderson, 1984; Ekern 1978; Ekern, 1964; Mink, 1983). Water balance estimates in West Maui and the Waihee Aquifer System have not incorporated fog drip as a separate parameter.

Estimations of fog drip have not been made for the Waihee Aquifer System. Ekern (1978, p.3) notes that at an elevation of about 5,000 feet, fog drip is about 33 percent of rainfall. As the elevation increases above 5,000 feet the proportion of fog drip to rainfall also increases, though total precipitation is substantially less. The elevations of most ridges surrounding Waihee Valley are high but less than 5,000 feet. Therefore, fog drip in Waihee may be something less than 33 percent of rainfall.

3.5.4. Return Irrigation

Large-scale irrigation does not exist in Waihee. Therefore, return irrigation is negligible in the Waihee Aquifer System.

3.5.5. **Runoff**

Runoff is the average total stream flow for the aquifer system. It includes the direct runoff from rainfall and base-flow runoff derived from dike zone ground water. Runoff is estimated from existing stream flow data in the aquifer system and similar aquifer systems (Yuen and Assoc., 1990).

There are two perennial streams in the aquifer system: Waihee River and Makamakaole Stream (Yamanaga and Huxel, 1970). There are also several other streams with intermittent runoff. Presently, the U.S. Geological Survey maintains a streamgage on Waihee River. The USGS also collected stream flow data on Makamakaole Stream from 1939 to 1952. Table 9 summarizes stream discharge data and statistical parameters for Waihee River and Makamakaole Stream. Unfortunately, there are no reliable estimates of runoff from the remainder of the aquifer system. Kahakuloa Stream is on the northwest boundary of the aquifer system but is considered to be in the Kahakuloa Aquifer System.

Table 9. Waihee Aquifer System gaged streams		
	Waihee Stream	Makamakaole Stream
station number	16614000	16617000
drainage area	4.20 square miles	0.40 square miles
elevation of gage (ft)	605	1500
period of record	11/1/1983 to 6/19/2002	7/1/1939 to 6/30/1952
Q average (mgd)	50.0	1.89
Q50, median (mgd)	34.9	1.10
Q90 (mgd)	24.6	0.59
Q min (mgd)	14.2	0.43
Q max (mgd)	749.7	56.87
average discharge per area (mgd/sq mile)	11.9	4.71

Although stream flow data is limited, several studies give estimates of total runoff from the Waihee Aquifer System or similar areas in West Maui (Table 8). The WRPP estimates average total runoff for the aquifer system as 50 in/yr over 11.87 square miles or 28 mgd.

The Waihee River data suggest that the 28 mgd estimate of total runoff may be too low (Table 9 streams data). The total streamflow from Waihee River alone at the 605-foot elevation averages 50 mgd. This is far more than the total estimated aquifer system runoff of 28 mgd. The Waihee River Valley has cut deeply into the dike complex. It is probably intercepting dike-impounded water that originates from other aquifer systems. This could account for the higher measured runoff. Figure 37 shows historical runoff information. Since 1982, measured stream discharge as the 12-MAV appears stable.

Waihee River Average Monthly Flow

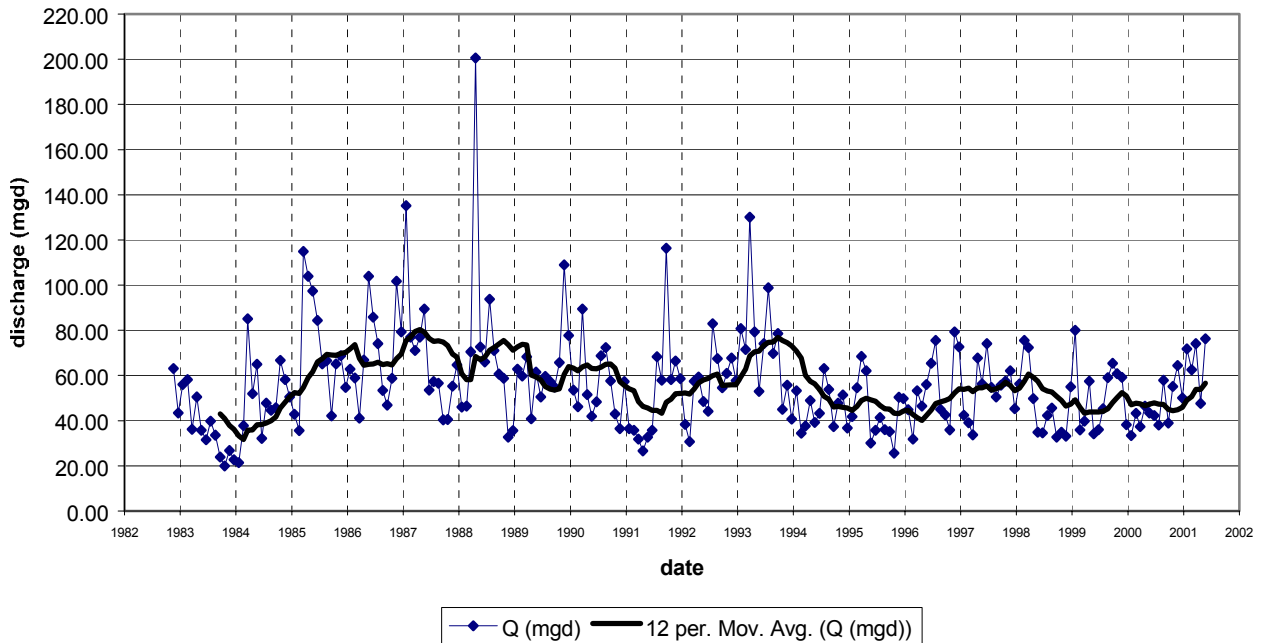


Figure 37. Waihee River average monthly flow at USGS gage 16612000

Makamakaole Stream originates from springs in clinker beds of the trachyte of the Honolua Formation (Stearns and Macdonald, 1942, p 201). These springs in the Honolua Formation are perched water springs that are not substantially affected by basal pumping. Runoff in Makamakaole Stream was stable during the period of record. A graph of monthly discharge in Makamakaole Stream from 1939 to 1952 is shown below (Figure 38).

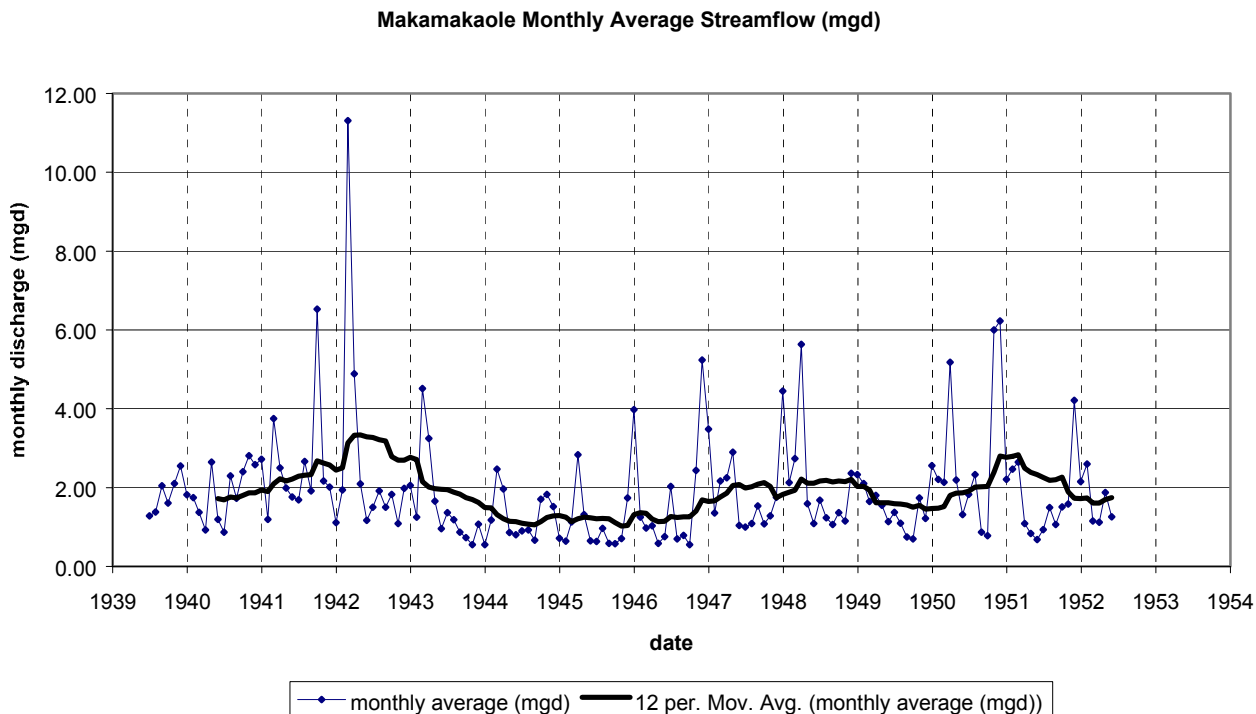


Figure 38. Makamakaole Stream average monthly flow at USGS gage 16617000

Waihee Tunnels 1 and 2 were constructed in 1909 to develop high-level water for irrigation purposes (Stearns and Macdonald, 1942; Yamanaga and Huxel, 1970). These tunnels discharge water into Waihee River that is later captured by ditch intakes. The current status or discharges of these tunnels are unknown due to their remote location (Garret Hew, personal communication, 2002). Stearns and Macdonald (1942) reported that streamflow at the intakes was not increased by the tunnels. Therefore, most of the water developed by the tunnels must have formerly discharged into the stream as springs along the stream below the tunnels and above the intakes. The net effect is these tunnels simply redirect spring flow along the reach of Waihee River and do not increase runoff.

Despite the unknown factors in the estimation of runoff, the WRPP (Yuen and Assoc., 1990) estimate of runoff as a percentage of total rainfall is consistent with other estimates of runoff in West Maui (Table 8).

3.5.6. Evapotranspiration

Evapotranspiration is the surface and subsurface water released to the atmosphere through direct evaporation and by transpiration through plants (Todd, 1980 p 361). Evapotranspiration can be estimated from pan evaporation data. Evapotranspiration has been estimated in previous studies and results are tabulated in the water balance table (Table 8).

There is no known pan evaporation data from the Waihee Aquifer System. The nearest reported pan evaporation data found in State Report R74 (Ekern and Chang, 1985), come from evaporation pan stations, State Key No. 385, near Wailuku. Report R74 shows that adjusted annual evaporation near Kahului is 81 inches per year. Maximum pan evaporation in the Waihee

System is about 70 inches/year (R74). There is no pan evaporation data from central West Maui, but if we extrapolate from other mountainous areas in Hawaii below the trade wind inversion we can estimate the minimum pan evaporation at about 20 to 30 inches/year.

Pan evaporation will generally be greater than actual ET because it is based upon an unlimited supply of water to evaporate. The WRRP estimate of average actual evapotranspiration for the entire system is 40 in/yr, or 23 mgd (Yuen and Assoc., 1990). This is a relatively high value for evapotranspiration compared to other past studies and actual evaporation measurements, which would result in less recharge.

3.5.7. Ground-Water Recharge

The primary objective in calculating the water balance for Waihee is to determine recharge. Ground-water recharge is that amount of water, applied in any manner to the ground surface (i.e., natural or irrigation return), which infiltrates into and becomes part of an aquifer. Recharge to the system takes place over both the high-level, basal, and caprock aquifers. This report is concerned with recharge to the dike and basal water bodies. This report uses the water balance method in determining recharge, as illustrated in Figure 5 and summarized in Table 8.

The WRPP (Yuen and Assoc., 1990) estimated mean recharge in the Waihee Aquifer System to be 12 mgd. This estimate of recharge is 19 percent of total rainfall. This is conservative when compared to the average recharge estimate of 29 percent of total rainfall by other researchers (Table 8). CWRM staff believes that we should continue to use conservative estimates of recharge until the size of the resource is verified by long term pumping experience.

3.5.8. Ground-Water Pumpage

There are 16 well within the Waihee Aquifer System (Table 10). Pumpage is primarily from MDWS wells (North Waihee 1 and 2, Kanoa 1 and 2,) and minor pumping from 4 private wells. Tunnel flows are intercepted spring flow in Waihee River, and therefore are not counted as pumpage.

Table 10. Waihee Aquifer System well list

Well	Well No.	owner/ user	type of well	date drilled	average pumpage 12 MAV (mgd)	Initial chloride (mg/L)	elevation at bottom of well (ft)	initial head (ft)	Initial temp (deg F)
North Waihee 1	5631-02	Maui DWS	municipal	1981	1.419	14	-105	9-10	
North Waihee 2	5631-03	Maui DWS	municipal	1981	1.424	15	-105	9-10	
Kanoa 1	5731-02	Maui DWS	municipal	1999	0.752	25	-51	9.32	69
Kanoa 2	5731-04	Maui DWS	municipal	2000	1.245	25	-52		
Kanoa Monitor TH-1	5731-05	USGS	monitor		0			12.4	
Kupa'a	5731-03	Maui DWS	inactive municipal	1999	0	25	-50	6.75	71

Table 10. Waihee Aquifer System well list (continued)

Well	Well No.	owner/ user	type of well	date drilled	average pumpage 12 MAV (mgd)	Initial chloride (mg/L)	elevation at bottom of well (ft)	initial head (ft)	Initial temp (deg F)
Kahakuloa Acres	5832-03	Island Shores	irrigation	1994	0.015	29	-20	6.84	70
Wailena	5832-02	Island Shores	irrigation	1985	standby to Kahakuloa	28		6.4	71
Waihee Marino 1	5631-05	Marino D	domestic	1991	0.072 (1)	25	-56	8.3	70
Waihee Marino 2	5631-06	Marino D	domestic	1991	0.072 (1)	25	-50	7.5	70
Mendes	5731-01	Medes E	not in use		0				
Obyrne	5832-01	Obyrne	domestic		unknown				
Waihee	5631-04	Marino- Lamanti	domestic	1985	very little (1 home)		9		
Waihee Tunnel 1	5434-01	HC & S	flowing tunnel	1909	4.6 (2)		1625 (3)		
Waihee Tunnel 2	5434-02	HC & S	flowing tunnel	1909	1.0 (2)		1650 (3)		

(1) pump size

(2) tunnel flow measured August 1933 (Stearns and Macdonald, 1942 p 213)

(3) portal elevation

Large-scale pumpage began in Waihee in 1997. Currently, the 12-MAV is just under 5 mgd. Figure 39 illustrates the historical pumpage data in the Waihee Aquifer System. The primary ground-water user is MDWS and pumpage is concentrated in the southern part of the aquifer system. The MDWS is planning to drill a new well (Maluhia Well) 750 feet north of Makamakaole Stream (C. Takumi Engineering, letter to CWRM dated August 30, 2002). If successful, this well will take advantage of recharge in the northern part of the Waihee Aquifer System

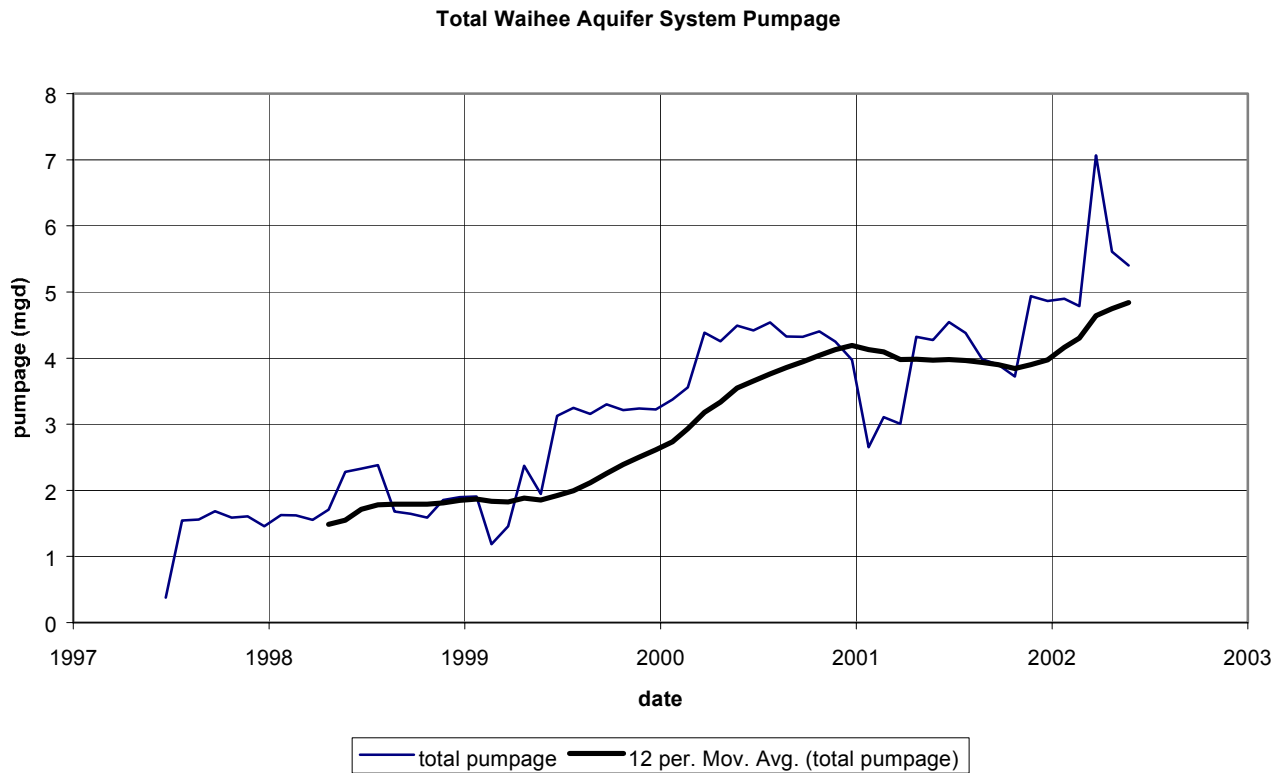


Figure 39. Total historical Waihee Aquifer System pumpage

3.5.9. Water Levels

The collection of water-level data in the Waihee Aquifer System began in 1981. Regular water-level collection did not begin until 1988.

Water levels within a basal aquifer in steady-state are described by the Ghyben-Herzberg principle. This principle recognizes the 1:40 ratio where fresh water (at an average specific gravity of 1.000) floats on salt water (at an average specific gravity of 1.025). For every foot of fresh water above mean sea level (MSL), the distance to the mid-point of the transition zone extends approximately 40 feet below MSL under steady-state. Under natural pre-development conditions, it is assumed that the aquifer is in a steady-state condition. Therefore, water levels under natural pre-development conditions are governed by the Ghyben-Herzberg principle, geological boundaries, aquifer formation properties, recharge, and leakage. Coastal caprock formations are a geologic boundary that are less permeable than the basaltic formations and reduce leakage to the sea and, thus, generate relatively higher basal water levels and deeper fresh water lenses than areas with no

caprock. The Waihee Aquifer System does not have a coastal caprock but the Honolua Formation behaves like a caprock because of its low permeability.

Water levels under developed, or pumping, conditions are governed by the Ghyben-Herzberg principle, geological boundaries, aquifer formation properties, recharge, leakage, and pumpage. However, in the short-term, pumpage is the primary governing factor that determines water-level elevations, not the transition zone mid-point elevation. Such a reaction is known as a cone of depression. Water levels are drawn down in a fashion that extends outward from the pumping well (see Figures 19 and 20). When pumping ceases, localized pumping stresses only found in the pumping well (i.e. turbulence losses, well bore storage, etc.) dissipate and the water level will rise to match the Ghyben-Herzberg principle in relation to the location of the transition zone mid-point. Likewise, in the vicinity of a pumping well, water levels will rise to match the Ghyben-Herzberg principle in relation to the location of the transition zone mid-point. This rise will begin to occur immediately after cessation of pumpage and continue over time at a slower rate.

The most important water-level data is the initial measurement made in 1981, where the first measured basal water level in the Waihee Aquifer System was 9.35 feet MSL at North Waihee 2. This pre-development water level represents the initial steady-state water level at this point in the Waihee Aquifer System. Under this initial condition the thickness of the lens at North Waihee 1 should have been $374 \pm$ feet taken to the mid-point of the transition zone (chloride concentration of 9,500 mg/L or 50 percent isochlor). This is the point used in estimating sustainable yield using RAM (WRPP, 1990).

Like lao, it appears that rainfall has greater influence than pumpage over observation well (i.e. aquifer) water levels in the Waihee Aquifer System. Figure 40 shows water levels in the Waihee and lao Aquifer Systems and rainfall at the Waihee Valley raingage. When comparing rainfall, pumpage, and water-level response patterns, it seems very clear that water levels follow rainfall patterns much more closely than pumpage in both aquifer systems.

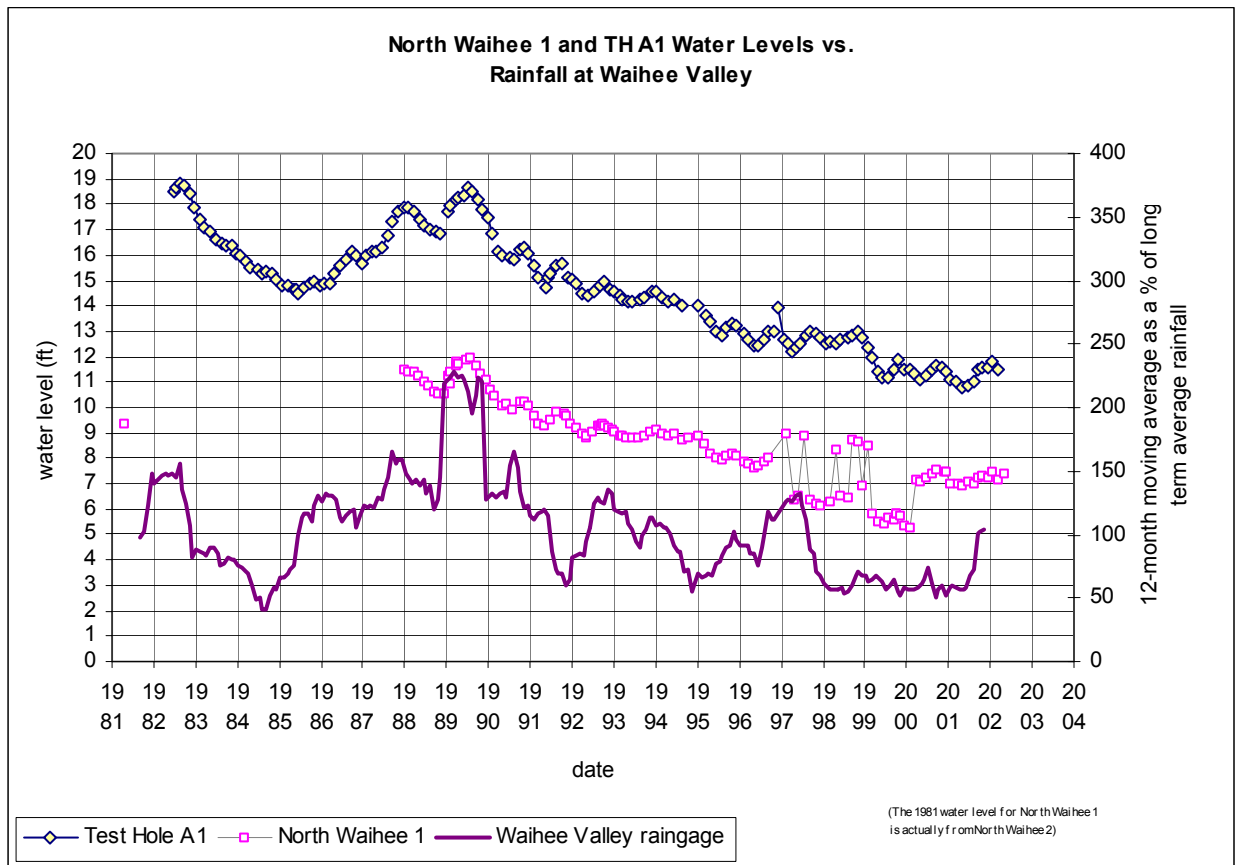


Figure 40. Water levels at North Waihee and TH A1 graphed with rainfall at Waihee Valley.

The water-level information presented in Figure 40 shows the reaction of water levels in the basal aquifer to pumping stresses over the past 13 years in both the Iao and Waihee Aquifer Systems. Water levels in Waihee declined from about 11.5 feet to 7 feet from 1989 to 2002. From 1981 to 1988 water levels increased from 9.35 feet to 11.5 feet. During this period there was minimal pumpage and no municipal pumpage.

Development of the Waihee Aquifer basal ground-water changed the equilibrium conditions within the aquifer as pumpage reduced natural leakage by an equal amount. Pumpage will reduce the volume of the basal lens and lower the initial steady-state water level. As the head becomes lower, the leakage from the aquifer will decrease. Eventually, the head levels will reach a new equilibrium based upon the new pumping conditions.

From 1989 to 2002, average pumpage from the aquifer system increased from negligible to over 5 mgd. Municipal pumping started at the North Waihee Wells in July 1997. During this period, it can be seen that the maximum measured operating head levels at North Waihee Well 1 decreased from about 8 feet to 7 feet above MSL. This drop in head is partially

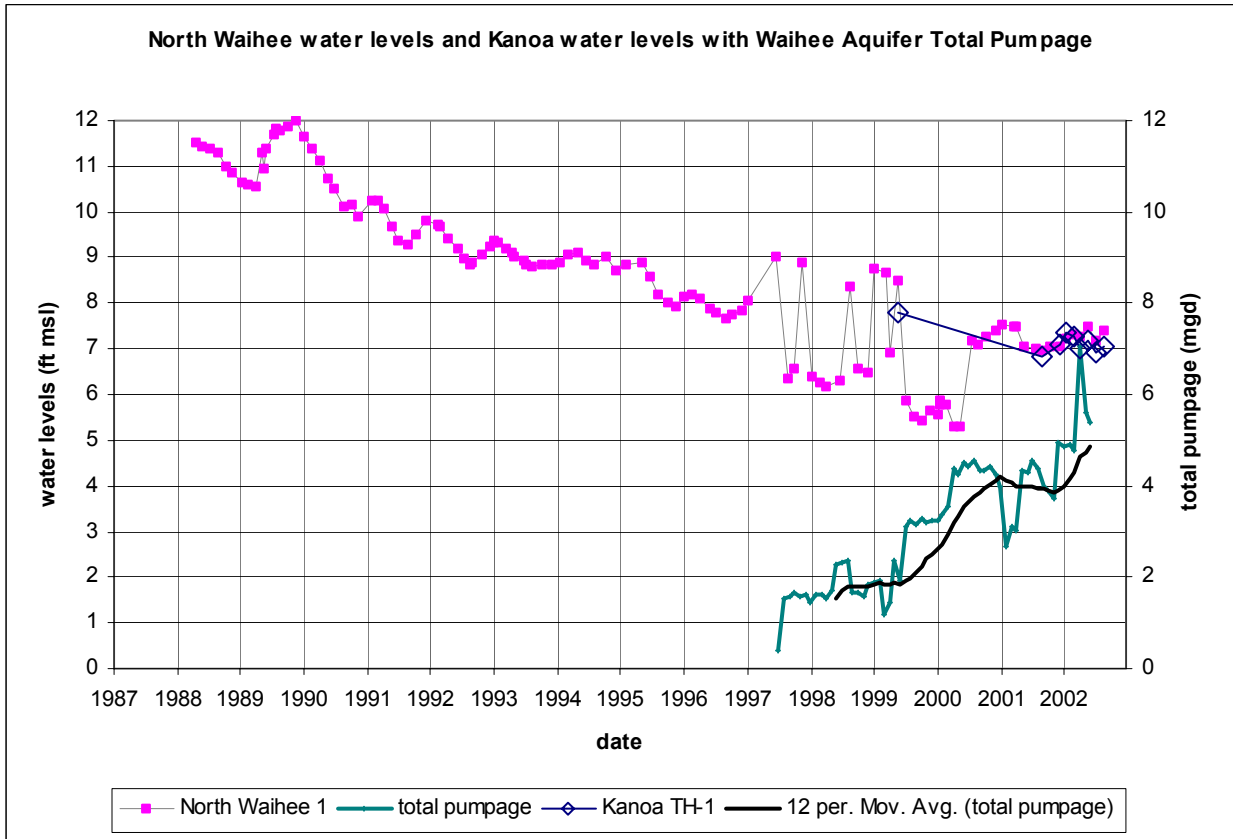


Figure 41. Water levels at Waihee and total aquifer system pumpage.

attributable to the fact that the well used for monitoring is a pumping well. The well is also at the center of the cone of depression caused by the North Waihee Wells' pumpage. Water levels have essentially been stable since July 2000 despite the fact that pumpage in the aquifer has increased. The recent period of low rainfall appears to have had a greater affect on water levels than pumpage. However, correlation coefficient analyses results are not valid due to the short period of record and the close proximity of pumping.

The USGS has recently begun measuring water levels at an observation well near the Kanoa Wells (Figure 41). This well is also within the cone of depression of the Kanoa Wells, but its measurements are not influenced by drawdown in the pumping well. The water level before pumping at Kanoa Well was 7.81 feet (Mink, 1999). Currently the water level is about 7 ft. The water levels measured at Kanoa are essentially identical to the water levels at North Waihee and are difficult to distinguish on the graph.

The recovery of water levels towards steady-state conditions can be observed when aquifer pumping is temporarily shut off. In January 2000, wells in Waihee and Iao were briefly shut off to attempt to measure water-level recoveries. Mink (Mink and Yuen memorandum February 8, 2000), calculated that water levels at the North Waihee Wells in the Waihee Aquifer System would recover to their full equilibrium storage heads within three weeks.

3.5.10. Water Quality

3.5.10(a) Chlorides

The chloride ion concentration is a measure of salinity used to indicate the potential potability of the resource. U.S. EPA guidelines suggest that the 250 mg/L chloride concentration is a taste standard and should be the upper limit for water supply systems. This secondary contaminant limit is based on aesthetics, rather than health reasons, and is not mandatory. Normally, the counties' water supply purveyors further endeavor to keep the delivered supply at 160 mg/L or less. Additional factors influencing chloride concentrations within individual wells in basal aquifers, such as Waihee, include geology, hydrologic properties of the aquifer, and well infrastructure (such as well depth, pump capacity, pumping schedules, etc.) and produce observable long-term trends.

Chlorides differ depending on hydrogeologic conditions. Dike-impounded sources, such as the Waihee Valley Tunnels, have high water levels and no known evidence of contact with seawater, which results in low chloride concentrations. However, no data has been collected to confirm that salt water underlies high-level aquifers, which would require drilling a well thousands of feet deep. Basal sources are more susceptible to changes in chloride concentrations because the Ghyben-Herzberg lens floats on denser salt water and, therefore is in direct contact with salt water. The contact between fresh and salt water is not sharp but rather diffuse in a zone of mixing, also known as the transition zone (See Figure 4 showing cross section). These transitions zones vary in thickness from aquifer to aquifer.

Chlorides are also impacted by well infrastructure. Localized chloride increases can be due to upconing effects resulting from high pumpage rates of individual wells, a well's depth, and aquifer properties in the vicinity of the pumping station. In addition to localized upconing, well infrastructure can be affected by aquifer-wide shrinkage of the basal lens, which would increase chloride trends in all well sources. Deep wells, wells with large pump capacities, and wells closest to the ocean would be the first to experience higher chlorides.

Deep monitor wells help us distinguish between localized upconing and aquifer-wide hydrogeologic conditions affecting salinity. There is no deep monitor well in the Waihee Aquifer System.

Table 10 (see Ground-Water Pumpage Section) lists the initial chloride concentrations when current active wells in Waihee Aquifer were first drilled and tested. Chloride levels in the North Waihee Well field have remained level since production began in July 1997. Chloride levels in the Kanoa Well field have increased steadily since production began in March 2000. The chloride levels in Kanoa are still well within acceptable levels. The water from all four wells has relatively low chloride concentrations for a basal water source (see Figure 42). Despite the relatively low chloride concentrations, we recommend that the upward trend of chloride in the Kanoa Wells be monitored.

Waihee Aquifer Chloride Concentrations

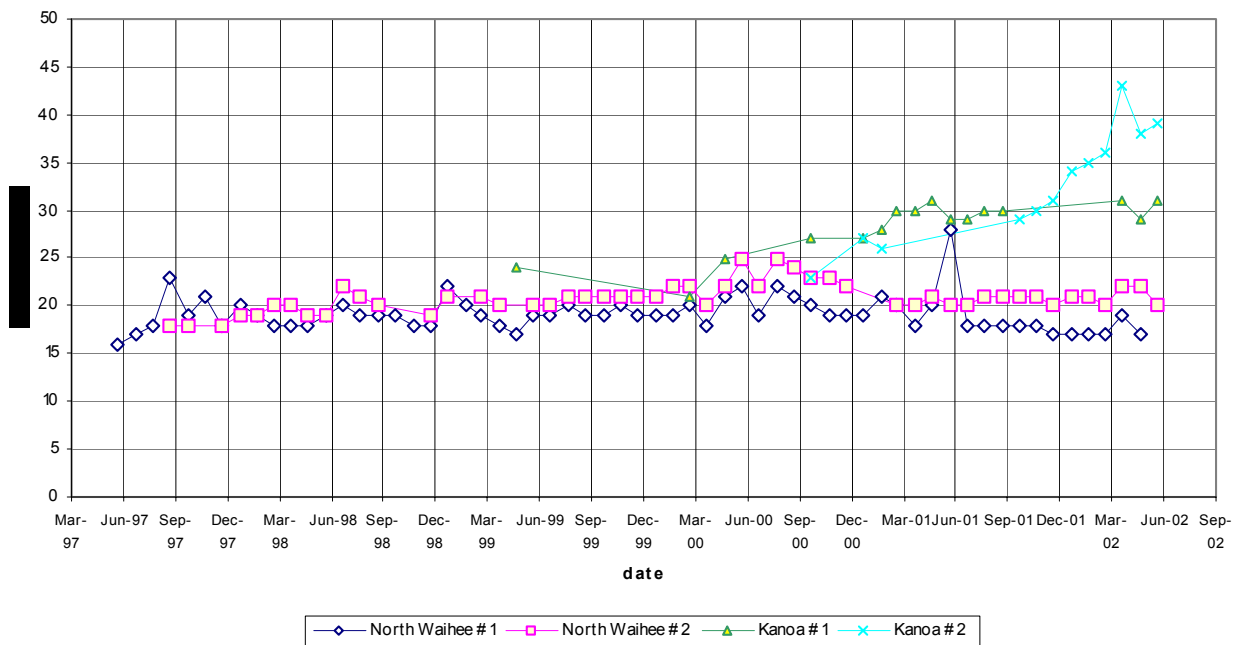


Figure 42. Graph of chloride concentrations at the North Waihee and Kanoa Well fields

3.5.10(b) Temperature

Visher and Mink (1964, p. 122) report that the temperature of water recharging the Koolau aquifer averages 67.5 °F, while ground-water temperatures in Honolulu average about 70 °F. Water temperatures in the North Waihee and Kanoa Wells are about 70 °F. There is no vertical profiling of temperature in the Waihee Aquifer System, because a deep monitor well has yet to be drilled in the area.

3.5.10(c) Contaminants

According to the Department of Health, Safe Drinking Water Branch, there have been no detectable organic or inorganic contaminants found in Waihee Aquifer System potable water wells.

3.5.11. Sustainable Yield

Under the State Water Code, sustainable yield is defined as follows:

HRS §174C-3 - *"Sustainable yield means the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the commission."*

In determining sustainable yields, the Commission distinguishes between optimal potential development of an aquifer and the man-made limitation on withdrawals imposed by existing infrastructure. Under the WRPP, sustainable yields are derived by the RAM and address the optimal potential development perspective for planning and managing purposes. RAM was never intended to address constraints imposed by actual infrastructure perspective.

To address the infrastructure perspective, a regional numerical model is required. The Commission has revised sustainable yields when 'acceptable' numerical models have been developed **and** there has been competition amongst large users (e.g. Ewa-Kunia, Waipahu-Waiawa, and Kualapuu Aquifer Systems). There has been another numerical model developed to address infrastructure constraints to sustainable yield (e.g. Lanai, Ewa Caprock) but the Commission did not revise the WRPP sustainable yields. In the case of Lanai sustainable yield was not revised due to the lack of competition between large users. In the case of the Ewa Caprock, Commission determined to use chloride limits to non-potable individual wells to manage and protect the aquifer. Therefore, given the facts that the MDWS is the sole large user in Waihee and no numerical model exists for Waihee, it would seem more appropriate to use the optimal potential development perspective at this time. However, the county is pursuing the development of a 4.5-year \$1 million dollar numerical modeling project, that includes Iao and Waihee, to be done by the USGS (June 28, 2002 letter from USGS to MDWS). Once this project is done, the Commission may then consider revising Iao aquifer sustainable yield from the infrastructure perspective.

The current official CWRM sustainable yield estimate for Waihee Aquifer System is 8 mgd, as adopted through the WRPP. The official recharge estimate is 12 mgd. The current 12-MAV is 4.8 mgd and is 60 percent of sustainable yield. Ultimately, actual field data will be needed to verify that pumping at 8 mgd is not endangering the aquifer. The actual data show that the current pumpage of 5 mgd is not endangering the aquifer at this time, although this cannot be verified without deep monitor well data. Additionally, the integrity of the infrastructure may be at risk, as suggested by Mink (1981 & 2002), in that the southern half of this aquifer should be limited to pumping only 4-5 mgd.

Given the past methodologies and estimates for sustainable yield shown in Table 10 it appears that 8 mgd is reasonable. The CWRM estimate of sustainable yield uses 19 percent of total rainfall. This is conservative compared to other estimates of sustainable yield in West Maui. Presently, this estimate has been approved by the CWRM and adopted by Maui County for planning purposes. The reaction of the basal aquifer system to present pumping conditions and stresses seems to indicate that the aquifer is in no danger at this time.

3.6. Future Development and Projected Water Use

Figure 43 shows that the Iao and Waihee Aquifer Systems are the sole sources for the potable municipal Central Maui Service Area (CMSA), which sprawls from Waihee and Wailuku to Kahului and Paia, to Kihei, Wailea, and Makena. The map is a composite of Maui aquifer systems and the CMSA infrastructure. The Iao and Waihee Aquifers Systems are shaded, while the service area is marked by a dashed line.

Potable water delivered through this municipal system serves both potable and non-potable needs. Figure 44 is a schematic of the main potable CMSA. There is another segment of demand for irrigation water that is met through effluent reuse, administered by the County of Maui, Public Works, and individual well systems. However, upon asking the County for a delivery breakdown of potable vs. non-potable needs, the County indicated they could not differentiate between these major categories of use.

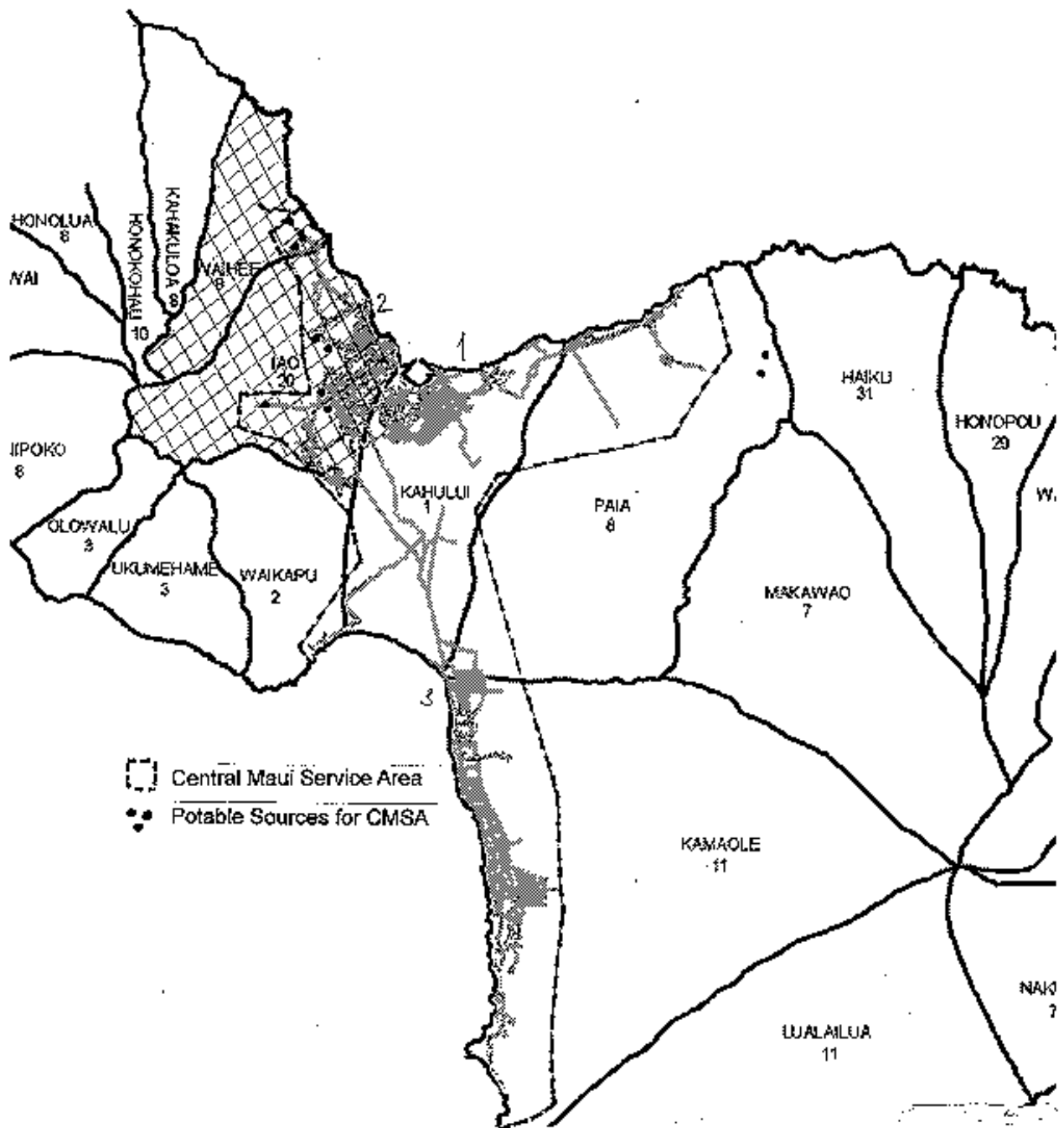


Figure 43. Central Maui Water (Wailuku) System

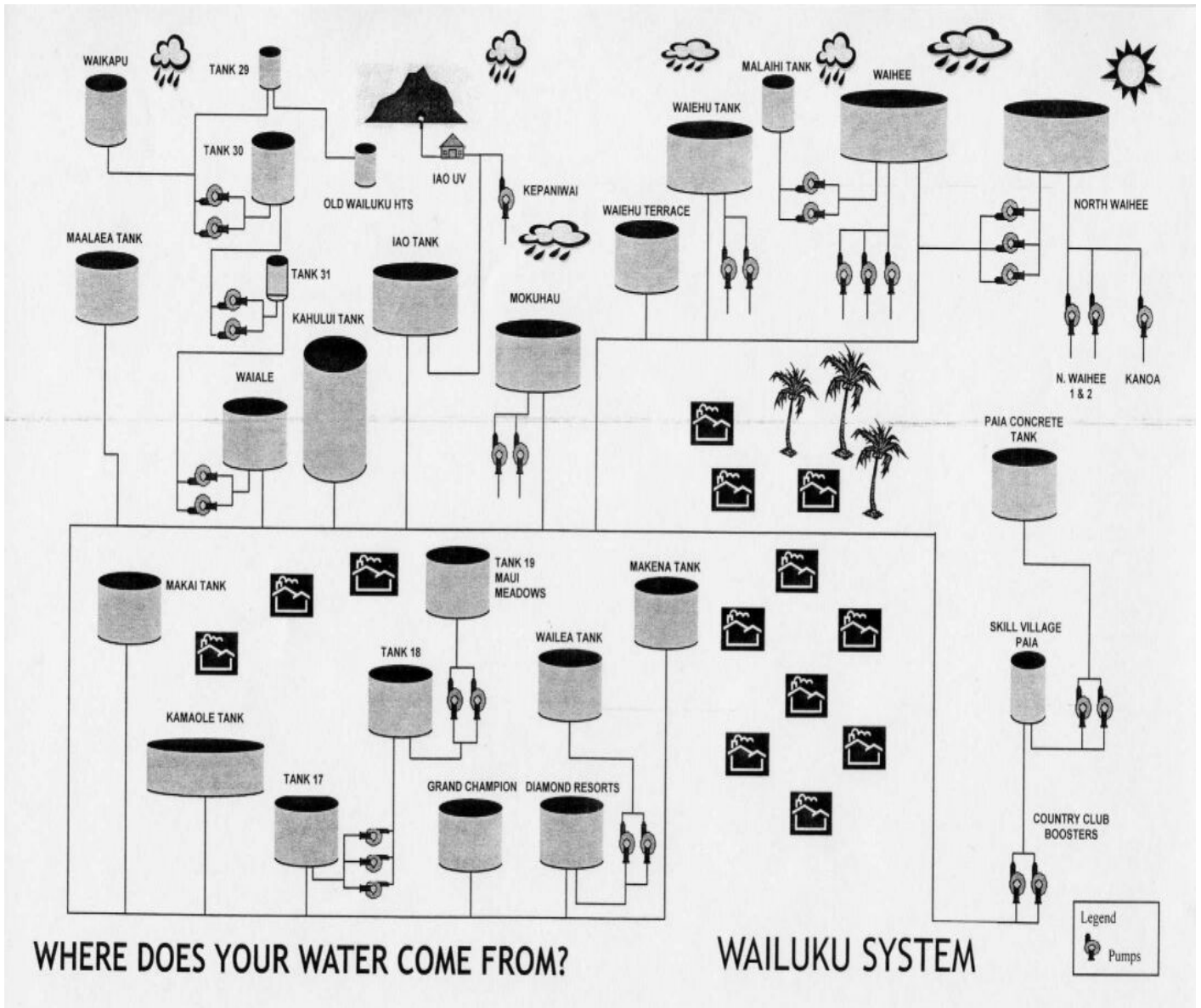


Figure 44. Central Maui Water (Wailuku) System
 (Source: Maui Department of Water Supply web page, <http://mauiwater.org/>)

3.6.1. Growth of Demand served by Iao and Waihee.

3.6.1(a) Current Demands

Total water use in the CMSA increased about 19 percent from 1994 to 2001 (from 18.318 mgd to 21.762 mgd, according to MDWS figures). Despite an uneven sequence of growth in three major areas, after eight years the distribution between three different areas has remained essentially unchanged:

Waihee -Wailuku	19 %
Kahului-Spreckelsville	25
Kihei-Makena	<u>56</u>
	100 %

Total current 12-MAV (through June 2002) source production for the Central Maui Service Area is currently as follows:

Iao Aquifer Wells	16.084 mgd*	
Waihee Aquifer	4.840 mgd*	* counted against sustainable yield
Iao Tunnel	<u>1.116 mgd</u>	
Total	22.040 mgd	

The difference between 21.762 mgd reported by the County in 2001 and the 22.040 mgd reported by CWRM in 2001 reflects a significant reduction in Iao pumpage due to new pumpage from two new wells in Waihee.

Unaccounted for water represents system losses and cannot be measured directly. The losses are determined by the amount of water supplied to all the customers (metered at the property line) divided by the amount of water metered at the sources. MDWS estimates the unaccounted for water in the CMSA is 5 to 6 percent (Kraftsow, 2002, personal communication).

3.6.1(b) Projected Demands

Projected year 2010 water production requirements for the CMSA were estimated at 31.1 mgd in the 1990 Maui County Water Use and Development Plan (WUDP). The current ultimate demand, based on current plans, is 29.19 mgd. Current 2002 projections of potential new use from discussions with Maui County since initiation of this designation proceeding are listed and compared with the 1990 WUDP and 1996 FOF values in Table 11 below:

Table 11. Total projected demand

Description	1990	'96 FOF mgd	2002 mgd
Existing water commitments ¹ (Water System Development Fee Rule)		0.410	0.411
Approved building permits w/o commitments		0.480	NA

Pending and approved building permits ²		0.476	6.736
Central Maui Joint Venture (contractual obligation)		6.750 to 7	NA ³
Additional demand total		8.116 to 8.366	7.147
12 –MAV pumpage for CMSA for calendar year	15.4	20.35	22.040
Total projected use	31.1 ⁴	28.5 to 28.7	29.2

Notes:

- 1) *Source: Maui DWS: Existing water commitments are a moving number, month by month, as commitments are made and projects are connected and taken off this list.*
- 2) *Source: Maui DWS: The 2002 figure for pending projects simplifies “projects without commitments” to include projects with approved permits, and those with approval still pending; and it includes many projects which were part of the Central Maui Joint Venture (JV) commitment. The list used to estimate amounts omits 20 to 30 very small projects totaling less than 0.25 mgd.*
- 3) *Because the projects on the list have such a long time frame (some have been on hold since the 1980’s), any additional amount following a resolution of the JV commitment are commensurate with the total build out by 2020.*
- 4) *Source: County of Maui WUDP.*

The 1996 Findings of Fact reflected the County’s estimates of new development in four categories and the County updated the 2002 values for these same categories as close as possible. These 1996 and 2002 projections do not have a specific time frame. It seems that total projected demands for the CMSA have increased by about 0.5± mgd since 1996.

Added to current use of 22.0± mgd, current projections thus reach 29.2± mgd. This is roughly 2 mgd less than that projected by the 1990 WUDP. Given current water sources in the Iao and Waihee Aquifer Systems, the projected demand exceeds the combined sustainable yield total of 28 mgd by 1.2± mgd.

3.6.2. Growth of CMSA Supply

Since the 1996 Commission decision not to designate Iao, there has been significant growth in the CMSA infrastructure. North Waihee Wells 1 and 2 (5631-02 and 03) were being brought on-line in 1997, and in 2000 the Kanoa Wells (5731-02 and 04) were put into service. These active sources provide an average of 5± mgd. Two additional wells (Waikapu Mauka (5131-01) and Kupaa (5731-03)) have been drilled but are not in service at this time. MDWS also has plans to drill another well in Waihee (Maluhia, north of Makamakaole Stream).

The new Waikapu Mauka Well (5131-01) is scheduled to come on line shortly. This well is located in the Iao Aquifer System but at its southern boundary, and will supply up to 2 mgd. Its purpose is not to increase pumpage but rather to redistribute current pumpage within Iao.

It is unknown when the new Kupaa Well (5731-03) will come on line. It has been drilled in the Waihee Aquifer System south of Makamakaole Stream and its purpose is to distribute existing pumpage within the Waihee Aquifer System.

Outside Iao and Waihee

The East Maui Water Development Plan (EMWDP) shows the intent to supply the CMSA from sources in the Haiku Aquifer System (Aquifer 60401). The sustainable yield for this aquifer is 29 mgd. The EMWDP will produce an average of 9.3 mgd from eight new wells. This amount should cover the current projected 1.2 mgd deficit for the CMSA and, presumably, newer developments in Haiku and or other areas serviced by the CMSA. The Maui WUDP is currently being updated and should provide better information on the projected demands in these other areas. In 1997, the EMWDP was stalled in court for lack of an adequate EIS. A Supplemental EIS has now been completed and accepted by the MBWS on October 15, 2002. **and must now be reviewed and cleared by the Court.** Until the EMWDP moves forward, the demand on the Iao and Waihee Aquifer Systems will exceed their combined estimated sustainable yields by 1.2 mgd.

Although initially part of the EMWDP, Hamakuapoko Wells 1 and 2 in the Paia Aquifer System (Aquifer 60302 SY = 31 mgd) are currently used to supplement the Upcountry water system. These wells supply an additional 1.5 mgd.

Additionally, the Kihei-Makena Community Plan (1998) projects resident population growth for the area between 22,830 and 24,514 residents by 2010 as compared to the 1990 population of 15,365. The visitor population is not taken into account in these figures, but is estimated to be large. The plan states that water supply increases will be concurrent with planned growth, and supports the projected development of the Central and East Maui water systems. However, using County water demand standards of 600 gal/day per single family unit, and assuming 4 residents per unit, this population growth would translate to an increase of 1.25 mgd. This number cannot be reconciled with Table 11 above.

3.6.3. Iao Water Management Rule

On March 5, 1999, the Maui BWS approved the Iao Water Management Rule, Title 16, Chapter 9 of the Maui County Administrative Rule (See Appendix F). In general, this rule is intended to prevent over pumpage of the Iao Aquifer System and in a manner that seeks to prevent conditions that would meet some of the designation criteria set out under the Water Code.

In terms of implementing the rule, maximum absolute 3-MAV chloride limits have exceeded limits defined in the Rule on many occasions apparently without any declaration of such conditions. In 2001, Waiehu Heights 1 and Mokuahau 1 and 3, had exceeded the 200 mg/L, 3-MAV limit of the "Critical Low Ground Water Conditions", but there is no evidence of notification given to the public, the County Council, or the CWRM, nor follow-up actions as is required under §16-9-5. Therefore, this management rule has not been enforced.

3.7. County and Public Testimony

Testimony has been compiled through the petition, solicitation of comments, CWRM meetings, and public hearings as required under the designation process. Original comments are found in Appendices B and D and are summarized in Table 12 as follows:

Table 12. Summary of testimony

Sector	Name	Pos	Comment
Petitioner	James Williamson	Y	<ul style="list-style-type: none"> • Aquifer shown marked deterioration since 1997: rising chlorides, lower water levels • lao and Waihe'e Aquifers have no physical boundary between them, are same aquifer, w/ SY 20 total • lao Management Rule not being enforced • New development being approved w/o regard for water availability; should declare moratorium on new meters • Need new wells outside "lao" – 3-4 mi North of Waihe'e Stream • Need deep monitor well in south part of aquifer • Planning & financing water development inadequate
County	Mayor Kimo Apana	N	<ul style="list-style-type: none"> • Reduced pumping in lao Aquifer • Pumpage spread to Waihe'e, surface sources • Enactment of lao Management Rule • Charter Commission considering structural change to empower BWS
County	Council		<ul style="list-style-type: none"> • No comments offered. Only questions asked of CWRM concerning hydrology and designation.
County	MDWS	N	<ul style="list-style-type: none"> • County has a responsibility to manage resources • DWS monitors water and chloride levels • Water levels reflect lengthy low-rainfall period • Waiehu well too deep, can be pumped less • Mokuahu well too deep, not pumped now • Central Maui Joint Venture agreement should not invite CWRM involvement • DWS will continue developing sources in Waihe'e Aquifer • Water level recovery after pumping shows similarity to long-term average • BWS enacted lao Management Rule • DWS is primary aquifer user and can control management of use • BWS is convening special review of alternate sources • underlying question is whether designation would improve resource protection

Table 12. Summary of Testimony (continued)

Sector	Name	Pos	Comment
County	MDWS	N	<ul style="list-style-type: none"> • following solutions would be more effective than designation: <ul style="list-style-type: none"> – better coordination on land use permit approvals, observing DWS caveats about water availability and imposing reporting requirements on permittees – clarify county charter to give DWS jurisdiction over all water resources in county, not just under Board development – require county well permits (in addition to CWRM permits) to assure construction to county specs, proper reporting – improve coordination between “quantity” (CWRM) and “quality” (DOH) issues within DWS – initiative to fill gaps in information by temporary staff or grant funding – clarify discrepancies between published documents and operating knowledge/policy, e.g. Haiku SY=31 or 15? – Clarify CWRM support for county positions reserving water for municipal use, e.g. EMWDP – coordinate pumpage guidelines w/ CWRM, USGS & UH/WRRC – rely on community-based WUDP to resolve conflicts • current efforts at lao: source development to spread pumpage within and outside lao; land purchase of watershed lands; free distribution of low-flow fixtures; leak detection, pressure monitoring, etc. • CWRM would have to engage time-consuming water use permitting process
County	Board of Water Supply	N	<ul style="list-style-type: none"> • Reduced pumping from lao • Collecting data, drilling new deep monitor well
County	Michael Nobriga	N	<ul style="list-style-type: none"> • Drought has caused problem • lao Management Rule sets automatic and mandatory actions • Board does not allow new development w/o providing necessary supply • Board pro-active in securing additional resources • Water Use and Development Plans will provide a clearer picture
Hydrologist	William Meyer	na	<ul style="list-style-type: none"> • Sustainable yield for lao <20 mgd; cannot be realized with existing infrastructure • RAM model used to estimate SY under predicts water level declines, cannot represent spatial variables • Withdrawals from caprock should be counted against SY • lao and Waihe'e connected; Waihe'e well configuration is sub optimal • CWRM should require “safe water levels”, disallow “intrusion water levels” • WRPP does not specify optimum well spacing or depth guidelines, is insensitive to aquifer interconnectedness • WRPP does not commit CWRM to program of upgrading information and theoretical foundations
Hydrologist	John Mink	na	<ul style="list-style-type: none"> • Resource integrity should be determined by examining depth of lens, not water level above sea level; drawing conclusions about aquifer depth from localized water levels in pumping wells overestimates effect of pumpage • Critique of RAM model suffers from misunderstanding of storage head, ignoring salinity-depth curves, and willful ignoring of ordinary field observations; model accurately predicts empirical contraction. • Some connectedness of lao and Waihe'e misses strong impedance and separate calculations based on groundwater-generating factors in Waihe'e: divide Waihe'e SY at Makamakaole

Table 12. Summary of Testimony (continued)

Sector	Name	Pos	Comment
Hydrologist	Gordon Tribble	na	<ul style="list-style-type: none"> Regulatory level of sustainable yield should be distinguished from potential withdrawals of existing infrastructure No single value for SY – dependent on distribution of pumpage, dynamic ground-water flow, and climatic change RAM model ignore variability Interconnectedness of aquifers means pumpage from one aquifer influences another Focus should be on how to determine best yield from aquifers
			•
Public	Warren Suzuki	N	<ul style="list-style-type: none"> reduced pumping rate spreading pumping locations
Public	Don Fujimoto	N	<ul style="list-style-type: none"> DWS the only user, has reduced pumping intervention adds to bureaucracy petition is by anti-growth activists to stop development
Public	Bobbie Becker & Jace Hobbs	Y	<ul style="list-style-type: none"> dropping water levels questions about recharge, aquifer boundaries, drought effect
Public	Barbara & Michael Reed Gach	Y	<ul style="list-style-type: none"> want responsible planning; Kihei development beyond infrastructure capacity
Public	Randy Ching	Y	<ul style="list-style-type: none"> no one knows how much is there, is being withdrawn, or how quickly it's recharged
Public	Andrea & Christopher Dean	Y	<ul style="list-style-type: none"> no consensus on amount in the aquifer, amount used
Public	Hugh Starr	Y	<ul style="list-style-type: none"> professionals record deterioration
Public	Isaac Harp	Y	<ul style="list-style-type: none"> poor condition of supply developers lobby for increased allocation
Public	Elaine Wender	Y	<ul style="list-style-type: none"> aquifers may already have suffered permanent damage
Public	Maile Lu'uwai	Y	<ul style="list-style-type: none"> escalating development need to protect resource
Public	Kapua Sproat	Y	<ul style="list-style-type: none"> "Please consider (Maui News article) Makena Rezoning Decision Delayed (02 Feb 02) lao is at its limit
Public	Jeffrey B. Parker	Y	<ul style="list-style-type: none"> county agencies are mired in "develop – no matter what the costs" mentality, continue to approve projects w/o regard for impacts
Public	Steve Slater	Y	<ul style="list-style-type: none"> lost money because denied meter, but large landowners have no problem getting meters
Public	Jesse Slater	Y	<ul style="list-style-type: none"> too much water going to big developers, disregarding needs of community
Public	Rebecca & Godwin Pelissero	Y	<ul style="list-style-type: none"> with spiraling growth, we need to find out if there's enough water
Public	Roy Smith & Diana Dahl	Y	<ul style="list-style-type: none"> development is competing w/ farming; we need a study to determine if there's enough water
Public	Martha E. Martin	Y	<ul style="list-style-type: none"> development proceeds w/o good planning to manage water we lack info on aquifer boundaries, recharge, the amount of withdrawals

Table 12. Summary of Testimony (continued)

Sector	Name	Pos	Comment
Public	Stefano Segre	Y	<ul style="list-style-type: none"> with spiraling growth, is there enough water?
Public	Greg & Masako Cordray Westcott	Y	<ul style="list-style-type: none"> rising saltwater levels
Public	Daniel Grantham	Y	<ul style="list-style-type: none"> Sierra Club supports long history of dependence on lao, and overestimating its SY declining water levels, rising salinity on probation since 1997 conditions meet several criteria overpumping continues despite deterioration we fail to account for private pumping in lao, Waihe'e, Kahului
Public	Christina Hemming	Y	<ul style="list-style-type: none"> USGS Exhibit 10 (14 Nov 01) says amount of long-term pumping depends on several factors: distribution of pumpage, dynamic ground-water flow, climatic variability, current values based on model not addressing these MBWS does not have authority to manage – just a utility to supply water all criteria met hotel/vacation rentals use disproportionate amounts (spa examples) West Maui taro growers have lost water
Public	Lucienne de Naie	Y	<ul style="list-style-type: none"> Ka Wai Ola project updates info CWRM should also look at Kahului withdrawals: institutional – parks, assisted living, homeless shelter some not on CWRM's database are sending in reports Ka Hale Ola told (?) they could get permit because not in lao, but boundary says they are lao withdrawals could affect Kanaha Pond lao appears to be connected to Waihe'e, Kahului, and Waikapū too much poor research and piecemeal planning
Public	Megan Powers	Y	<ul style="list-style-type: none"> paid-off politicians and untruthful analysis have led to overcommitment of water for development next area to be overused could be East Maui, where streams are already dry, people have no access to water
Public	Chris Baz	Y	<ul style="list-style-type: none"> continuing growth, but enough water?
Public	Terry Reim	Y	<ul style="list-style-type: none"> Maui Tomorrow's Ka Wai Ola project updates database: not all users counted
Public	David Leece, Anne Pierce, Astrid Watanabe, Yolanta Marché Rob Story Jacob and Mary Anne Doane Mau	Y	<ul style="list-style-type: none"> No specific comment

In addition to government agencies there were 42 individual testimonies submitted. The majority of interested public testifiers support designation. It is interesting to note that the Maui County Council has not submitted comments to date but instead has only asked questions about the hydrology and designation process.

3.8. Criteria For Designation

Chapter 174C, HRS, presents a listing of criteria that the CWRM must consider in determining the designation of a ground-water management area. These criteria are listed in Table 13.

Table 13. Ground-water designation criteria

1. **[§174C-44(1)]** *Whether an increase in water use or authorized planned use may cause the maximum rate of withdrawal from the ground-water source to reach ninety percent of the sustainable yield of the proposed water management area;*
2. **[§174C-44(2)]** *There is an actual or threatened water quality degradation as determined by the department of health;*
3. **[§174C-44(3)]** *Whether regulation is necessary to preserve the diminishing ground-water supply for future needs, as evidenced by excessively declining ground-water levels;*
4. **[§174C-44(4)]** *Whether rates, times, spatial patterns, or depths of existing withdrawals of ground water are endangering the stability or optimum development of the ground-water body due to upconing or encroachment of salt water;*
5. **[§174C-44(5)]** *Whether the chloride contents of existing wells are increasing to levels which materially reduce the value of their existing uses;*
6. **[§174C-44(6)]** *Whether excessive preventable waste is occurring;*
7. **[§174C-44(7)]** *Serious disputes respecting the use of ground-water resources are occurring; or*
8. **[§174C-44(8)]** *Whether water development projects that have received any federal, state, or county approval may result, in the opinion of the CWRM, in one of the above conditions.*

Each criterion is assessed in light of the existing data and analyses as follows:

3.8.1. lao Aquifer System Designation Criteria

CRITERION 1.

Whether an increase in water use or authorized planned use may cause the maximum rate of withdrawal from the ground-water source to reach ninety percent of the sustainable yield of the proposed water management area.

Discussion

In the past, MDWS has exceeded 90 percent of sustainable yield. Presently, water use is 80 percent of sustainable yield. The projected additional demand from the CMSA of 7.147 mgd is assumed to meet the definition of authorized planned use. Therefore, it may be necessary to pump lao at 90 percent of sustainable yield or greater, if other alternative sources outside of the lao and Waihee Aquifer Systems do not augment the CMSA.

Conclusion: **CRITERION 1 MET**

CRITERION 2.

There is an actual or threatened water quality degradation as determined by the Department of Health.

Discussion

No evidence has been presented by the Department of Health, Safe Drinking Water Branch, during the preparation of these findings of fact that indicates this criterion has been met at this time.

Conclusion: **CRITERION 2 NOT MET**

CRITERION 3.

Whether regulation is necessary to preserve the diminishing ground-water supply for future needs, as evidenced by excessively declining ground-water levels.

Discussion

Since the last known peak in 1982, water levels have declined significantly. However, this decline is not excessive for the following reasons:

1. Water levels have been stable for the past three years despite drought conditions;
2. Transition zone behavior indicates that while some individual well water-levels are of concern but are not declining excessively aquifer-wide;
3. Pumpage and water-level data are concentrated north of lao stream and ignores the southern portions of the aquifer. The new lao Deep Monitor Well will help to determine if aquifer water levels are satisfactory.

Conclusion: **CRITERION 3 NOT MET**

CRITERION 4.

Whether rates, times, spatial patterns, or depths of existing withdrawals of ground water are endangering the stability or optimum development of the ground-water body due to upconing or encroachment of salt water.

Discussion

Evidence presented indicates this criterion is met at this time.

Under present withdrawal rates, depths and spatial patterns, water-level and chloride data indicate there is an upconing problem at the Mokuahau and Waiehu Heights well fields. It is no coincidence that the upconing occurs at these sites as they are the deepest, have the largest pumps, and are not spread out within the well fields. These may continue to endanger optimum development of lao due to salt water encroachment unless modifications to these sources are made.

Conclusion: **CRITERION 4 MET**

CRITERION 5.

Whether the chloride contents of existing wells are increasing to levels which materially reduce the value of their existing uses.

Discussion

There have been significant increases in chloride concentrations in Mokuahau and Waiehu Heights Wells. Mokuahau 2 is the only well that is exceeding the EPA 250 mg/L guideline. This well has been taken out of service. Chloride levels in other wells are rising but are within the EPA guidelines.

Recent management efforts by MDWS have occurred in an attempt to ease the chloride concerns before a significant number of sources reach levels that met this criterion. These efforts include:

1. Reduction of pumpage at Mokuahau;
2. Reduction of overall lao pumpage;
3. Maui BWS approval of lao Water Management Rule.

Although the first two actions have occurred, chloride limits have been exceeded under the MDWS lao Water Management Rule and enforcement actions have not been implemented.

However, recent declines in chloride concentration in sensitive wells show some improvement since early 2001. Ultimately chlorides are still acceptably below EPA guidelines that help define the utility of existing sources.

Conclusion: **CRITERION 5 NOT MET**

CRITERION 6.

Whether excessive preventable waste is occurring.

Discussion

At this time, there is no evidence that there has been excessive waste.

Conclusion: **CRITERION 6 NOT MET**

CRITERION 7.

Serious disputes respecting the use of ground-water resources are occurring.

Discussion

Since nearly all the water developed from the Iao Aquifer System is by MDWS, actual serious disputes between existing water users are not occurring. However, the Maui Meadows petitioner has raised the issue that the sustainable yield is an inaccurate portrayal of ground-water conditions. The current sustainable yield based on optimum development is still considered a reasonable estimate at this time. Also, this dispute is more about Iao hydrology than between actual or planned end use of ground water.

Disputes regarding land use issues are not germane for the CWRM. The CWRM has no jurisdiction on land use approvals that are under the purview of the County of Maui and the State Land Use Commission.

Conclusion: **CRITERION 7 NOT MET**

CRITERION 8.

Whether water development projects that have received any federal, state, or county approval may result, in the opinion of the CWRM, in one of the above conditions.

Discussion

Future water development projects in lao that have recently received some sort of approval from government agencies are the Waikapu Mauka and lao Deep Monitor wells. The Waikapu Mauka Well will spread the pumpage south of lao Stream, but will not increase total overall pumpage for the aquifer. The planned lao Deep Monitor well will monitor conditions in the transition zone south of lao Stream. Both these wells should actually help avoid any one of the above designation criteria.

Conclusion: **CRITERION 8 NOT MET**

3.8.2. Waihee Aquifer System Designation Criteria

CRITERION 1.

Whether an increase in water use or authorized planned use may cause the maximum rate of withdrawal from the ground-water source to reach ninety percent of the sustainable yield of the proposed water management area.

Discussion

Use of the Waihee Aquifer System is only 62 percent of the sustainable yield. The projected additional demand for the CMSA of 7.147 mgd is assumed to meet the definition of authorized planned use. Therefore, it may be necessary to pump Waihee at 90 percent of sustainable yield or greater, if other alternative sources outside of the lao and Waihee Aquifer Systems do not augment the CMSA.

Conclusion: **CRITERION 1 MET**

CRITERION 2.

There is an actual or threatened water quality degradation as determined by the Department of Health.

Discussion

No evidence has been presented by the Department of Health, Safe Drinking Water Branch, during the preparation of these findings of fact that indicates this criterion has been met at this time.

Conclusion: **CRITERION 2 NOT MET**

CRITERION 3.

Whether regulation is necessary to preserve the diminishing ground-water supply for future needs, as evidenced by excessively declining ground-water levels.

Discussion

Water levels have declined since 1989 but not excessively and seem more related to rainfall patterns than pumpage. Ground-water levels have been stable since 2000.

Conclusion: **CRITERION 3 NOT MET**

CRITERION 4.

Whether rates, times, spatial patterns, or depths of existing withdrawals of ground water are endangering the stability or optimum development of the ground-water body due to upconing or encroachment of salt water.

Discussion

Present withdrawal rates, depths and spatial patterns, water-level and chloride behavior show there is no upconing problem at this time. However, a proper deep monitor well would provide data to further verify this conclusion.

Conclusion: **CRITERION 4 NOT MET**

CRITERION 5.

Whether the chloride contents of existing wells are increasing to levels which materially reduce the value of their existing uses.

Discussion

Chloride concentrations in Waihee Aquifer System sources are well within acceptable limits.

Conclusion: **CRITERION 5 NOT MET**

CRITERION 6.

Whether excessive preventable waste is occurring.

Discussion

At this time, there is no evidence that this criterion has been met.

Conclusion: **CRITERION 6 NOT MET**

CRITERION 7.

Serious disputes respecting the use of ground-water resources are occurring.

Discussion

Since nearly all the water developed from the Waihee Aquifer System is by MDWS, actual serious disputes between existing water users are not occurring. However, the Maui Meadows petitioner has raised the issue that the sustainable yield is an inaccurate portrayal of ground-water conditions. The current sustainable yield based on optimum development is still considered a reasonable estimate at this time. Also, this dispute is more about Waihee hydrology than between actual or planned end use of ground water.

Disputes regarding land use issues are not germane for CWRM. The CWRM has no jurisdiction on land use approvals that are under the purview of the County of Maui and the State Land Use Commission.

Conclusion: **CRITERION 7 NOT MET**

CRITERION 8.

Whether water development projects that have received any federal, state, or county approval may result, in the opinion of the CWRM, in one of the above conditions.

Discussion

Future water development projects in Waihee that have recently received some sort of approval from government agencies are the Kupaa and Maluhia wells. Both these well locations spread pumpage north within the aquifer and should actually help avoid any one of the above designation criteria.

Conclusion: **CRITERION 8 NOT MET**

4. CONCLUSION

At this time, the information available indicates that the Iao Aquifer System meets criterion §174C-44(1), and (4) while the Waihee Aquifer System meets criterion §174C-44(1) only under the State Water Code concerning designation of ground-water management areas. These criteria are:

1. *[§174C-44(1)] Whether an increase in water use or authorized planned use may cause the maximum rate of withdrawal from the ground-water source to reach ninety percent of the sustainable yield of the proposed water management area;*
2. *[§174C-44(4)] Whether rates, times, spatial patterns, or depths of existing withdrawals of ground water are endangering the stability or optimum development of the ground-water body due to upconing or encroachment of salt water.*

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APPENDIX A Petition for Designation

APPENDIX B Maui County Comments to Petition

APPENDIX C CWRM Action to Continue Designation

MINUTES
FOR THE MEETING OF THE
COMMISSION ON WATER RESOURCE MANAGEMENT

DATE: November 14, 2001
TIME: 9:00 am
PLACE: David Trask Bldg.
2145 Kaohu Street, Conf. Rm. 207
Wailuku, Maui, Hawaii

Chairperson Gilbert S. Coloma-Agaran called the meeting of the Commission on Water Resource Management (CWRM) to order at 9:10 a.m.

The following were in attendance:

MEMBERS: Mr. Gilbert S. Coloma-Agaran, Dr. Bruce Anderson, Mr. Brian Nishida, Mr. David Nobriga, Mr. Herbert Richards, Jr.

STAFF: Linnel Nishioka, Roy Hardy, Eric Hirano, Glenn Bauer, Charley Ice

EXCUSED: Mr. Robert Girald

COUNSEL: Edsel Yamada

OTHERS: Sally Raisbeck, David Craddick, Jonathan Starr, William Meyer, Dorothy Williams, James Williamson, Gordon Tribble, Steve Gingerich, Celeste King, Christina Hemming, Megan Powers, Glenn Shepherd, JoAnne Johnson, Paul Achitoff, Daniel Grantham, Lucienne deNave, Danny Agsalog, Sheri Morrison, Jock Yamaguchi, Manabu Tagomori, Harry Eager, Colleen Chang, Carl Freedman, Elliott K., Anders Frank Lyons, Susan Moikeha, Thelma Shimaoka, Richard T., Terri Reim

All written testimonies submitted at the meeting are filed in the Commission office and are available for review by interested parties.

1. Minutes of the October 17, 2001 meeting

MOTION: (RICHARDS/NISHIDA)
To approve the minutes.
UNANIMOUSLY APPROVED.

2. Old Business/Announcements by Deputy Director Linnel Nishioka

Clarification was made from the Commission meeting of October 17, 2001. Monies in the amount of \$300,000 is part of the Federal budget for our Agriculture Water Use and Development Plan.

Deputy Director Nishioka withdrew staff submittals Items 5, 6 and 8 from this meeting's agenda upon requests from the applicants who would like to provide staff with some additional information.

3. Maui Meadows Homeowners Association, C/o James Williamson, Vice President, Recommendation for Continuance on the Petition for Ground Water Management Area Action, Iao and Waihee Aquifer Systems, Wailuku, Maui

ORAL AND POWERPOINT PRESENTATION OF SUBMITTAL: Roy Hardy

AMENDED RECOMMENDATIONS:

That the Chairperson recommend to the Commission:

1. ~~Deny the continuance of~~ Continue the Petition to designate both Iao and Waihee Aquifer Systems.
2. To continue with its August 13, 1997 decision that requires automatic designation of the Iao Aquifer System should the 12-month moving average reach 20 mgd.

Mr. Roy Hardy gave a powerpoint presentation on the designation process and some background of Iao. He talked about both the Iao and Waihee Aquifers in their past and current hydrologic conditions noting the significance of the current 4-year drought, behavior of the transition zone, the limitations the well infrastructure is placing on the aquifers and new alternative sources that have come online in the past 4 years since the last designation proceedings. It would appear conditions are improving since the last Commission action although perhaps not as fast as some people would like to see. Attached to these minutes is a copy of Mr. Hardy's powerpoint presentation.

From U.S. Geological Survey (USGS), Mr. Gordon Tribble, District Chief and Steve Gingerich, Groundwater Specialist for Hawaii provided technical information on the Iao and Waihee Aquifer Systems through a powerpoint presentation. They did not give testimony for or against designation. One of the main points that Mr. Tribble raised was that there is no single fixed value for sustainable yield. The current pumping levels may also not be sustainable over the long term. Because these two aquifers are not independent, the pumping from the Waihee Aquifer is affecting the water levels in the Iao Aquifer. Given the importance of this area as a source of groundwater and municipal supply for the Island of Maui and the extent to which it is being utilized, it may be prudent for all to consider increasing the sophistication of collecting hydrologic data and the tools used to collect these data.

Mr. Steve Gingerich talked about the input and output of a hydrologic system. Rainfall input is a major component of recharge. Irrigation, fog drip, and runoff, which are subtracted from input, are measured from stream and stream gages. Evaporation of water from plants does not make it in as recharge. The soil stores water. Estimates need to be refined because pumping is occurring so close to the sustainable yield. The biggest unknown in the Iao Aquifer is the permeability and the storage property of the rocks. More testing is needed to analyze this. The output from the system is the natural groundwater discharge to the ocean in the absence of pumping. Most of the water goes directly to the ocean. Some groundwater is discharged in streams and springs or flows through adjacent systems. The location of wells and pumping will determine the pumpage of the system. The USGS, CWRM and the Dept. of Water Supply (DWS) are working together in collecting data. There has been a significant rainfall deficit since 1997 and 1998.

Mr. Gingerich pointed out some chloride concentration in a couple of wells. The chlorides in the Waihee Well has risen but not at a point of concern yet. In the Waiehu 1 during the past few years, the chloride levels have risen very dramatically. Mr. Gingerich also made note of rising chlorides in other wells.

TESTIMONY BY APPLICANT:

Ms. Dorothy Williams of Maui Meadows Homeowners Association (Association) stated that the main concern of the Association is that the Iao Aquifer is being over pumped. The Association has expressed their concern to the Department of Water Supply. They have recommended that a new independent source be developed to relieve the demands on the aquifer, but this has not occurred. The Association feels that better management of the resource should be implemented.

Mr. James Williamson stated that there is a serious problem with the entire aquifer. Pumping needs to be reduced and well distribution should begin. They disagree with the USGS data that the rise of the transition zone is slowing. Since 1998 the rise has been at a rate of 6.3 feet per year. The Association would agree to a deep monitor well. The saltwater transition zone has been rising at a significant rate. Mr. Williamson stated that the Commission should accept the responsibility as designation experts. He concluded that contrary to staff's view, the Association has not seen any improvements in management procedures for the Iao Aquifer over the last 4 years. He stated that it is time to take immediate steps to correct the overpumping of this aquifer system.

TESTIMONIES:

Ms. Sallie Raisbeck who lives in Wailuku and depends on the Iao Aquifer for water stated that despite reports from the DWS, some management of the aquifer is needed to prevent it from being overpumped. Ms. Raisbeck strongly urged the Commission to hold a public hearing on the petition so that the public could have the opportunity to voice their concerns about protecting the resource.

Mr. Jonathan Starr, Member of the Maui Board of Water Supply, gave his own personal comments on staff's submittal that may not represent how the board members feel. He feels that there are reasons of concern that the resources are suffering in that the water levels are decreasing and the salinity goes up. He feels that the Commission should move in the direction of numerical modeling than sustainable yield. He is concerned about the water utilization in Iao and Waihee Aquifers. Mr. Starr felt that the data the staff is collecting is not accurate. He felt that designation and management of the aquifers would obtain more accurate data from all sources.

Mr. Bill Meyer stated that he is for "management" of Iao. He also stated that members of the BWS feel the DWS is simply a utility entity and doesn't feel it can manage the resource properly. He feels that the aquifer is not being managed properly. He stated that he understood that the Commission has the authority to manage the aquifers if designation is approved.

Ms. Celeste King asked the Commission for their help in managing Maui's water system. She wants the Commission to take over management of the aquifers.

Ms. Christina Hemming stated that she strongly urged the Commission to make Maui a water management area. She encouraged the Commission to stop issuance of pump installation permits until an assessment of the water quantity has been made. Ms. Hemming works in a hotel and stated that there are no conservation measures being taken at this hotel.

Ms. Megan Powers, a 30-year resident of the island of Maui, stated that she urged and support the designation of a water management area for Maui.

Mr. Glenn Shepherd asked the Commission to take a look at the Iao Aquifer petition in a conservative manner. He stated that this is a very important resource. He also stated that in certain parts of the mainland where mismanagement of reservoirs occurred, the recovery process was not successful. He felt that the aquifer could be managed by the Department of Water Supply. He concluded that he would like to see the Iao Aquifer be managed.

Ms. JoAnne Johnson, Council Representative for West Maui, stated that the resources need to be managed and leadership needs to be implemented.

Paul Achitoff, Esq. of Earthjustice stated that there is no attempt in the staff submittal to address the legal standard for designation, but instead a vague opinion is stated that if circumstances that exist change for the better sometime in the future. The submittal gives no suggestion of what the applicable law might be. Mr. Achitoff stated that according to the law, the Commission must designate the aquifer when it can reasonably be determined that the water resources may be threatened by existing or proposed withdrawals or diversions of water.

Mr. Daniel Grantham, Co-chair of the Maui group, Sierra Club, has for a long time supported management of the water resources on Maui. They have also expressed concerns about the usage and allocations of water. He stated that he would personally like to see the entire island designated. He felt that the island would benefit if management were imposed.

Ms. Lucienne de Naie of Maui Tomorrow urged the Commission for more management of the resources and to take the long-range view of the aquifers. The Iao and other aquifers are the public's resource and they deserve the highest level of responsible planning.

Mr. Danny Agsalad asked the Commission if designation will bring revenues to the Island of Maui and also if there was a process to undo the designation.

Mr. David Craddick, Manager of the Department of Water Supply (DWS), stated that they would continue to work with the Commission on doing what is needed for the better for everyone. He believes that the DWS is doing a good job at protecting the water resources.

Chair Coloma-Agaran asked for a motion to enter into executive session to confer with counsel on this item.

MOTION: (NOBRIGA/RICHARDS)

At 12:46 pm the Commission went into Executive Session to confer with counsel on Item 3 of this agenda.

The meeting was resumed at 1:32 am.

With regard to well developments in the 2 aquifers, Mr. Craddick stated that DWS will over the next 2 years inspect and install a pump in the Waikapu Well and North Waihee (Kupaa); drill another well north of the current where drilling is occurring; and continue the process in East Maui, drilling one well at a time. The Waiehu Heights Well will be used only for a backup situation and not for normal demand. At the Mokuhaul Well pump No. 2 was taken out about 4 years ago so there are no chlorides coming from that well. DWS is expecting to make the Wailuku Shaft a permanent well facility either drilling into that well or installing a well nearby. This will require additional funding by bringing it online, and this well will produce sufficient amounts of water. For about 3 to 4 months, the Mokuhaul Well will be shut down to see what the water level rises to in that area. He anticipates that the water level will rise to 17 feet.

Commissioner Anderson stated that the facts are clear as it relates to the degradation of the resources. There are chloride increases in some of the wells. There is also reduction in the head of those wells. He stated that this situation should stabilize at some point. He said that drought may have something to do with some of the issues. Commissioner Anderson is also concerned the users of the water supply who the DWS has no control over. One cannot manage property if he doesn't have the authority over. Commissioner Anderson feels that more information is needed on this issue before a final decision can be made. Given the circumstances, it is prudent to gather information so that a firm decision can be made on designation.

Commissioner Anderson made a motion to support Chair Coloma-Agaran's recommendation to continue the proceedings with the understanding that we will be able to gather more information on the lao and Waihee Aquifers before a final decision is made.

To clarify, Chair Coloma-Agaran stated that there will be a public hearing and a report from staff. Then, the Commission will make a decision.

MOTION: (ANDERSON/RICHARDS)

To approve the submittal as amended.

UNANIMOUSLY APPROVED AS AMENDED.

APPENDIX D Written Testimony from 1/9/02 Public Hearing

APPENDIX E Maui County Comments to 9/17/02 draft Findings of Fact

APPENDIX F Maui Department of Water Supply Iao Water Management Rule



**Maui County Administrative Rule
Title 16, Chapter 9
IAO WATER MANAGEMENT RULE**

- 16-9-1 Purpose.
- 16-9-2 Definitions.
- 16-9-3 Caution low groundwater condition.
- 16-9-4 Alert low groundwater condition.
- 16-9-5 Critical low groundwater condition.
- 16-9-6 Mandatory restrictions related to Alert low groundwater condition.
- 16-9-7 Mandatory restrictions related to Critical low groundwater condition.
- 16-9-8 Surcharge Penalties for Alert and Critical low groundwater conditions.
- 16-9-9 Penalties.
- 16-9-10 Procedures for control of water use during Alert or Critical low groundwater level conditions.
- 16-9-11 Termination of Caution, Alert or Critical low groundwater level conditions.
- 16-9-12 Exemption of private wells within designated groundwater control areas.
- 16-9-13 Effective date.

16-9-1 Purpose. The purpose of the rule is to prevent overdraft of Iao aquifer.

[Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-2 Definitions. The definitions as set forth herein, and in Board of Water Supply Rules and Regulations Rule Sections 1-2, 16-8-2,

and 16-7-3 shall apply in these rules unless another meaning is plainly evident from the context. If there is any conflict between definitions it is intended that the broader or more inclusive definition apply. If a word or phrase is not defined the commonly accepted definition of that word or phrase shall apply.

"Base period water use" or "base period" means the monthly average water use based on water usage for the immediately preceding full twenty-four (24) month billing cycle at the time of the caution low groundwater declaration. Partial billing cycles are not to be included in the determination of the monthly average.

"Sustainable yield" means the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the Commission on Water Resources Management.

[Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-3 Caution low groundwater condition.

- (a) A caution low groundwater condition exists:
 - (1) At any time the 12 month moving average pumpage of gallons of water withdrawn from the lao Aquifer exceeds 95% of the sustainable yield of the lao Aquifer; or
 - (2) Whenever chloride content reaches the absolute limit in ppm chloride shown in Column A in Schedule 1 in more than one area based on a 3 month moving average.
- (b) The board shall at any time during the period in which a caution low groundwater condition exists inform the public that a caution low groundwater condition exists. Thereafter the director shall:
 - (1) Conduct an intensive public appeal for water conservation through the mass media;
 - (2) Institute voluntary irrigation and other water use schedules to reduce water consumption;
 - (3) Send letters to large consumers and other private well

- operators asking them to cut back their usage; and
- (4) Notify the Mayor, Maui County Council, and the state Commission on Water Resources Management.
- (c) The goal for draft reduction is 5% of lao Aquifer sustainable yield as determined by the Commission on Water Resources Management.
- (d) Consumers shall be given a target of a 10% reduction of their base period water use as the goal for reduction of water use in the caution low ground water condition.
- (e) No new applications for water meters or payment of the water system development fee shall be accepted by the Department at any time when the combination of actual pumpage from the lao Aquifer plus the amount of water estimated to be used, based on paid for meter reservations for meters which have not been physically installed, equals or exceeds 98%.
- (f) The following procedure shall be followed to issue meters after the caution low ground water condition is lifted:
- (1) The director shall establish a system to put all such requests on a master list in the order in which they are received;
 - (2) When applications for meters may be accepted the director shall contact the persons on the master list in the order which the request was received and inform them that they may file an application. The application and payment of the fee must be submitted within 90 days of notification;
 - (3) If the person does not apply for a meter and pay the fee within this period the person is removed from the list and must reapply in the normal course of business; and
 - (4) No new applications for meters shall be accepted until all of the persons on the list have first been offered a meter and have either applied for a meter and paid the fee or have not applied within the period specified in

subsection (3), above.

- (g) The director shall, at each board meeting while a caution low groundwater condition exists, report to the board:
- (1) The status of the chloride levels of the department's facilities listed in Schedule 1;
 - (2) The weekly average of daily pumpage; the effectiveness of the voluntary conservation measures being advocated; increase or decrease in public appeals to conserve water; and
 - (3) Such other information which the board may require from time to time to evaluate the status of the low condition and make modification to the voluntary conservation measures being advocated.

(Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-4 Alert Low Groundwater Condition.

- (a) An alert low groundwater condition exists:
- (1) At any time the 12 month moving average pumpage of gallons of water withdrawn from the Iao Aquifer reaches 98% of the sustainable yield of the Iao Aquifer; or
 - (2) Whenever chloride content reaches the absolute limit in ppm chloride shown in Column B in Schedule 1 in more than one area based on a 3 month moving average.
- (b) The board shall at any time during the period in which an alert low groundwater condition exists declare that an alert low groundwater condition exists. Thereafter the director shall:
- (1) Implement mandatory restrictions pursuant to Section 16-9-6 of these rules;
 - (2) Take appropriate action against those person(s) failing to comply with these provisions as permitted within these and the other Board Rules and Regulations;
 - (3) Take any action authorized to be taken pursuant to

Section 16-9-3 of these rules; and

(4) Notify the Mayor, Maui County Council, and the state Commission on Water Resources Management.

(c) Private wells.

(1) During an alert low groundwater condition period the Board shall ask owners of private wells that adversely affect the Iao Aquifer sustainable yield to comply with maximum monthly water allotments established for each private well or battery of private wells. Such allotments shall be stated as a percentage of the highest average daily draft for each month of the year over the last five years prior to the effective date of the alert low groundwater condition as declared by the board.

Example:

John Doe Well - Average Daily Pumpage Each Month

	1993	1992	1991	1990	1989
Jan	2.3 mgd	1.7 mgd	*2.4 mgd	2.0 mgd	1.9 mgd
Feb	1.8 mgd	1.9 mgd	1.8 mgd	*2.0 mgd	1.8 mgd
Mar	*1.9 mgd	1.8 mgd	1.8 mgd	1.7 mgd	1.8 mgd
Apr	2.2 mgd	2.0 mgd	*2.6 mgd	2.3 mgd	2.3 mgd
etc.	etc.	etc.	etc.	etc.	etc.

* Highest Average Daily Pumpage for Each Month of the Year Over the Last 5 years for John Doe Well.

Jan - 2.4 mgd

Feb - 2.0 mgd

Mar - 1.9 mgd

Apr - 2.6 mgd

etc - etc

- (2) In no case shall the allotment be less than 90% of the highest average daily draft for each month of the year over the last five years;
- (3) Any Owner of two or more separate wells may regulate the draft of their wells so that aggregate monthly draft will not exceed the combined monthly allotment for all of their wells;
- (d) The goal for draft reduction is 10% of lao Aquifer sustainable yield as determined by the Commission on Water Resources Management.
- (e) Consumers shall be given a target of a 15% reduction of their base period water use as the goal for reduction of water use in the alert low ground water condition.
- (f) The director shall, at each board meeting while an alert low groundwater condition exists, report to the board:
 - (1) The status of the chloride levels of the department's facilities listed in Schedule 1;
 - (2) The weekly average of daily pumpage; the restrictions and allotments in force; plans to increase or decrease public appeals to conserve water; and
 - (3) Such other information which the board may desire or require from time to time to evaluate the status of the low groundwater condition and make modification to the mandatory conservation measures being advocated.

[Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-5 Critical Low Groundwater Condition.

- (a) A critical low groundwater condition exists:
 - (1) At any time the 12 month moving average pumpage of gallons of water withdrawn from the lao Aquifer reaches 100% of the sustainable yield of the lao Aquifer;
 - (2) Whenever chloride content reaches the absolute limit in ppm chloride shown in column C in Schedule 1 in more

than one area based on a 3 month moving average.

(b) The board shall at any time during the period in which a critical low groundwater condition exists declare that a critical low groundwater condition exists. Thereafter, the director shall;

- (1) Implement mandatory restrictions within the scope of these rules and regulations;
- (2) Take appropriate action against those person(s) failing to comply with these provisions as permitted within these and the other Board Rules and Regulations;
- (3) Take any action authorized to be taken pursuant to Section 16-9-3 and 16-9-4 of these rules; and
- (4) Notify the Mayor, Maui County Council, and the state Commission on Water Resources Management.

(c) Private wells.

- (1) During a critical low groundwater condition period, the board shall ask owners of private wells that adversely affect the Iao Aquifer sustainable yield to comply with maximum monthly water allotments established for each private well or battery of private wells. Such allotments shall be stated as a percentage of the highest average daily draft for each month of the year over the last five years prior to the effective date of the critical low groundwater condition as declared by the board. The board may, from time to time, increase or decrease the initial percentage limit set for each well or battery of wells provided that in no case shall the percentage be less than 70% of the highest average daily draft for each month of the year over the last five years.
- (2) Any Owner of two or more separate wells may regulate the draft on their wells so that the aggregate monthly draft will not exceed the combined monthly allotment for

all of their wells.

- (d) The goal for draft reduction is 15% of lao aquifer sustainable yield as determined by the Commission on Water Resources Management.
- (e) Consumers shall be given a target of a 20% reduction of their base period water use as the goal for reduction of water use during a critical low ground water condition.
- (f) The director shall, at each meeting while a declared critical low groundwater condition as provided herein is in effect, report to the board:
 - (1) The status of the chloride levels of the department's facilities listed in Schedule 1;
 - (2) The weekly average of daily pumpage; the restrictions and allotments in force; plans to increase or reduce restrictions and allotments; and
 - (3) Such other information which the Board may require from time to time to evaluate the status of the low groundwater condition and make modifications to the restrictions and allotments imposed.

[Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-6 Mandatory restrictions related to alert low groundwater condition.

- (a) Board of water supply consumers. During an alert low ground-water condition period, the director may set lawn and ground cover water irrigation restrictions on any of the department's consumers. Such restrictions shall relate to the time when such irrigation may take place and the quantity of water used and may be different for the various classes of the department's consumers as the director shall determine. In addition, the director shall establish water allotments for consumers which shall not be less than 90% of the base period water use, but not less than 400 gallons/day for

single family and duplex residences.

(b) During an alert low groundwater condition no meter applications shall be accepted and no meters shall be installed.

(c) Department personnel may issue warnings and citations for violations of mandatory restrictions.

[Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-7 Mandatory restrictions related to critical low groundwater condition.

(a) Board of water supply consumers. The director shall declare that one or more of the following restrictions apply to any or all classes of the department's consumers. Such restrictions may relate to the time when the uses listed in this paragraph may occur and the quantity of water used and may be different for the various classes of the department's consumers as the director may determine.

(b) The restrictions include the following:

(1) Limits on lawn and ground cover water irrigation;

(2) Limits on plant and garden irrigation;

(3) Limits on the washing of cars, boats, trailers, and other vehicles;

(4) Limits on the filling of swimming pools and other types of pools and ponds;

(5) Limits on the washing of sidewalks, walkways, driveways, patios, parking lots, tennis courts, and other hard-surfaced areas; and

(6) Limits on the operations of fountains.

(c) Department personnel may issue warnings and citations for violations of mandatory restrictions set by the director.

[Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-8 Surcharge penalties for Alert and Critical Groundwater Conditions.

- (a) During alert and critical low groundwater condition periods, a surcharge schedule for excess water use shall be established according to the following procedure. The director shall set water allotments per billing period for each class of the department's consumers. Such allotments shall be stated as a percentage (which may be greater than 100% but not less than 70%) of the base period water use. In addition, the allotment shall not be less than 400 gallons per day for single family and duplex residences.
- (b) The base period water use as defined in section 16-9-2, above, shall be used to determine surcharge penalties. This amount is not a moving average but is intended to be used for the duration of any Alert or Critical Groundwater condition.
- (c) Surcharge penalties shall be charged as follows during Alert and Critical Groundwater conditions:
1. Usage between the allotment as set forth in Section 16-9-8(a), above, and the base period water usage shall be subject to a surcharge of three (3) times the current highest block rate;
 2. Usage above the base period water usage shall be charged at twenty (20) times the current highest block rate; and
 3. Consumers who use more than the base period water usage are also subject to the installation of a flow restriction device and/or the discontinuation of water service, including removal of the meter.
- (d) Surcharges shall be assessed each consumer after receipt of the first water bill following the establishment of allotments by the board. Upon termination of allotments by the board, surcharges shall cease.

[Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-9 Penalties. Any violation by any person of the restrictions

declared by the board under Sections 16-9-6 and 16-9-7 of this chapter or who consumes water in excess of the amount designated for their class shall be subject to the installation of a flow restriction device by the department and punishable according to these rules and regulations and section 3-26 of the rules and regulations of the department of water supply. An offender shall pay the actual cost for the installation and removal of a flow restriction device by the department, which cost shall be billed at the prevailing wage rate(s) plus costs for equipment and materials. Water service may be discontinued for an offense committed after the installation of a flow restrictor in accordance with section 3-12 of the rules and regulations of the department of water supply. [Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-10 Procedures for control of water use during Alert or Critical low groundwater conditions.

(a) Declaration of low groundwater level condition. The Director shall inform the public and the department's consumers of the declaration of an alert or critical low groundwater condition by publishing such declaration in a newspaper of general circulation on the island of Maui at least once a day for three consecutive days. The alert or critical low groundwater condition shall begin at midnight on the third day of the publication declaring such condition. The following notices shall be issued during an alert or critical low groundwater condition:

(l) Notice of restrictions. The Director shall inform the public and the department's consumers of the restrictions being imposed because of an alert or critical low groundwater condition by publishing such restrictions in a newspaper of general circulation on the island of Maui at least once a day for three consecutive days. The restrictions shall begin at midnight on the third day of

publication declaring such condition and shall terminate at midnight on the first day of a publication terminating such condition;

(2) Notice of water allotment to consumers. Each consumer shall be notified of their water allotment per billing period by printing such amount on their water bill or by direct mail to the consumer. In cases where a water bill is not sent directly to the person using the water, the consumer shall be responsible for informing the user of the water allotment per billing period applicable to them; and

(3) Notice of maximum monthly water allotment to private well operators. Private well operators shall be notified by mail of their monthly water allotment.

(b) Exceptions. Consideration of written applications for exceptions regarding the allotment system or regulations and restrictions on water use shall be set forth in this chapter. Written applications for exceptions shall be accepted, and may be granted, by the director. The director shall report to the Board at each Board meeting a list of all exemptions requested and exceptions granted by consumer class since the previous meeting. Grounds for granting such exceptions are:

(1) Failure to do so would cause an unnecessary and undue hardship to the applicant, including but not limited to adverse economic impacts such as loss of production or jobs;

(2) Failure to do so would cause an emergency condition affecting the health, sanitation, fire protection, or safety of the applicant or the public;

(3) For single family residences with more than four persons permanently residing in the home, if a written application for exception is granted as provided herein, the applicable allotment shall be increased by 40

gallons per person per day for each person permanently residing in the home in excess of four persons;

(4) For multiple residential units with more than two dwelling units where the allotment is less than 280 gallons per day per dwelling unit, if a written application for an exception is granted as provided herein, the applicable allotment shall be 280 gallons for each unit; and

(5) Denial of an application for exception may be appealed in writing to the board, which shall consider the appeal as a contested case pursuant to Board of Water Supply Rules of Practice and Procedure, Title 16, chapter 2.

(c) The director shall inform the public and the department's consumers of the termination by the Board of an alert or critical low groundwater condition by publishing such termination in a newspaper of general circulation on the island of Maui at least once a day for three consecutive days. The alert or critical low groundwater condition and all restrictions and allotments associated therewith shall terminate at midnight on the first day of a publication terminating such condition.

[Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-11 Termination of Caution, Alert, or Critical low groundwater conditions. The board may terminate a declared Caution, Alert, or Critical Low Groundwater condition whenever chloride content and moving annual average pumpage over three consecutive months at sources that caused the declared low groundwater level conditions to exist are appropriately reduced below their respective amounts.

[Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-12 Exemption of private wells within designated groundwater

control areas. New and existing private wells within designated groundwater control areas only shall be exempt from the provision of these rules and regulations. However, owners of private wells shall be asked to comply with any allotments set by the board for private wells. Control and regulation of such wells shall be subject to state statutes, rules, regulations, directives, and standards as currently exist and as may, from time to time hereafter, be amended.

[Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-13 Relationship between designation of the lao Aquifer for management and the lao Water Management Rule. Upon designation of the lao Aquifer by the appropriate state agency the Board shall meet and consider the reasons for designation and independently determine whether the criteria for declaring either a caution, alert, or critical low groundwater condition exists and, if so, to declare the appropriate low groundwater condition as existing. Nothing in this rule shall require the Board to declare that any such low groundwater condition exists, even though the lao Aquifer may be so designated by a state agency.

[Eff. 03/15/99] (Auth: HRS 54-33) (Imp: HRS 54-33)

16-9-14 Effective date. This rule shall become effective ten (10) days after it is filed with the county clerk of the county of Maui.

[Eff. 03/15/99] (Auth: HRS 91-4) (Imp: HRS 54-33)

Adopted on the 14th day of January, 1999, by the Board of Water Supply of the County of Maui.

**LOW GROUNDWATER
SCHEDULE 1**

COLUMN A ("Caution Low Ground- Water Condition)		COLUMN B ("Alert" Low Ground- Water Condition)		COLUMN C ("Critical" Low Ground- Water Condition)	
Central District		Central District		Central District	
Area	Absolute Chloride Level ppm	Area	Absolute Chloride Level ppm	Area	Absolute Chloride Level ppm
Wailuku Shaft	80	Wailuku Shaft	100	Wailuku Shaft	120
Mokuhau	160	Mokuhau	180	Mokuhau	200
Waiehu Heights	160	Waiehu Heights	180	Waiehu Heights	200
Waiehu	80	Waiehu	100	Waiehu	120
Kepaniwai	40	Kepaniwai	60	Kepaniwai	80

"By Water All Things Find Life"

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