February 25, 2011 DWS Amended Draft

LANA'I ISLAND WATER USE & DEVELOPMENT PLAN

Submitted by the Department of Water Supply

Exhibit 12

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Acronyms and Abbreviations

The following acronyms and abbreviations are used throught this document in various text and tables, and are provided here for the convenience of the reader.

AG	Agriculture, Agricultural Uses of Water
CCR	Castle & Cooke Resorts, LLC.
CFR	Code of Federal Regulations
COMM	Commercial, Commercial Uses of Water
CWRM	State of Hawai‘i Commission on Water Resource Management
DBPR	Disinfection By-Products Rule
DEVEL	Development, Use of Water for Development
DOH	State of Hawai‘i Department of Health
DWS	County of Maui, Department of Water Supply
EPA	United States Environmental Protection Agency
GOV	Government, Use of Water for Government
GPD	Gallons Per Day
GPM	Gallons Per Minute
GWUDI	Ground Water Under the Direct Influence of Surface Water
HAR	Hawai‘i Administrative Rules
HOT	Hotel, Use of Water for Hotel(s)
HRS	Hawai‘i Revised Statutes
IGGP	Irrigation Grid in Palawai, Palawai Area
IND	Industry, Industrial Uses of Water (mainly combined into Comm for Lana‘i)
IRR-AG	Agricultural Irrigation
IRR-DEV	Outdoor Uses of Water for Development, Dust Control, Irrigation, Etc.
IRR-GEN	Irrigation Uses Other Than Those Specifically Listed

Acronyms and Abbreviations

IRR-GOLF	Irrigation for Golf
IRR-HOT	Irrigation for Hotel Grounds
IRR-MF	Irrigation of Grounds & Common Areas in Multi-Family Developments
IRR-SF	Irrigation Use By Single Family Homes
LHI	Lanaʻi Holdings, Inc.
LSG	Lanaʻians for Sensible Growth
LWAC	Lanaʻi Water Advisory Committee
LWCI	Lanaʻi Water Company, Inc.
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MGD	Million Gallons Per Day
MNPD	Manele Project District, Manele-Hulopoʻe Area
MRDL	Maximum Residual Disinfectant Level
NNP	Not Necessarily Potable
NP	Non-Potable
NPV	Net Present Value
NPDWS	National Primary Drinking Water Standards
P	Potable (used in some tables where there is insuffICent space to write POT)
PD	Project District
PER	Percussion Drilled
POT	Potable
PQP	Public Quasi-Public
PUC	Public Utilities Commission
RES-MF	Multi-Family Residential
RES-SF	Single-Family Residential
ROT	Rotary Drilled
SDWA	Safe Drinking Water Act
SHF	Shaft
TUN	Tunnel
UAFW	Unaccounted-for Water
WHPA	Wellhead Protection Area

Summary

Lana‘i faces some daunting challenges in preparing for its water future. The sustainable yield of the island is small. Recharge is highly dependent on its forested watershed. The watershed itself is mesic and rather low elevation for a cloud forest, making it susceptible to rising inversion layers, climatic change, and fires as well as invasive species. That watershed has been in decline for decades as this report is written. Development programs are ambitious, with total build-out of Project Districts plus other known projects likely to meet or exceed sustainable yields. Unaccounted-for water is high. Much of the pipe on the island, particularly in the Palawai Grid, is old, leaking and in need of replacement. While this represents a conservation opportunity, the rate and fee structure of the Lana‘i Water Company is not sufficient to enable the necessary replacements. Per-unit consumption rates are also high, both in Manele and Koele.

FIGURE 7-1. **Sustainable Yields of Hawaiian Islands**

Island	1990 WRPP Sustainable Yield MGD	2007 Draft WRPP Update Sustainable Yield MGD	June 2008 Final WRPP Sustainable Yield MGD
Hawaii	2,431	2,175	2,410
Kauai	388	306	310
Lana‘i	6	6	6
Maui	476	386	427
Molokai	81 / 38 Dev	71	79
Oahu	446	419	407

Lana‘i also faces several regulatory challenges. The Commission of Water Resource Management (CWRM) decided in January 1990 to authorize the Chairperson to reinstitute water management area proceedings if the static water level of any production well should fall below one half its original level above sea level. It granted the same authorization should any source of supply in the Company's plans fail to materialize but full land development continues. In March of 1991, another trigger was set, to reinstitute designation proceedings should total pumpage exceed 4.3 MGD. Even without these triggers, the State may initiate designation proceedings when the withdrawal from any aquifer reaches 90% of its sustainable yield, which in the case of Lana‘i's aquifer systems would be 2.7 MGD each in the Windward and Leeward systems of the island's Central Aquifer sector.

In response to such challenges, a resource development strategy is identified that includes sufficient conservation and new supply resources to meet expected water demand for the 2030 planning horizon. Conservation opportunities are identified to help bring per-unit consumption and unaccounted-for water rates down. Roughly 485,000 GPD in reasonably achievable conservation opportunity has been identified. New supply resources are identified that, in conjunction with the identified conservation measures can meet water demands resulting from build-out of projects with existing entitlements, staying within groundwater pumping sustainable yield limits.

If conservation and leak reduction targets are achieved, this strategy would result in pumpage between 3.3 MGD and 3.66 MGD in the year 2030 assuming expected levels of water demand and build-out of projects with existing entitlements. Without implementation of the identified conservation measures, pumpage could exceed the 4.3 MGD trigger for proceedings by the State Commission on Water Resource Management (CWRM) to designate Lana‘iLana‘i as a groundwater management area. Measures for watershed protection and source protection are identified, as well as recommendations for changes to monitoring and data management.

Planning Process

Regulatory Framework

The Water Use & Development Plan (WUDP) for Lana'i is undertaken to meet the requirements of HRS §174(C)-31, HAR §13-7-170 and Maui County Code §2.88 A. Water Use & Development Plans under these provisions are required to:

- Be consistent with the State Water Resources Protection Plan; State Water Quality Plan, State Water Projects Plan, State Agricultural Projects Plan, State District Land Use Classifications and County General & Community Plans
- Provide an inventory existing water sources and uses
- Discuss existing and future land uses and related water needs
- Set forth a program by which water needs will be met
- Allocate water to land uses
- Discuss resource impacts of proposed capital and other plans
- Incorporate public involvement
- Consider multiple forecasts
- Consider a twenty year time frame for planning analysis
- Include specific suggestions for implementation

Chapter 2 of the Supporting Documentation provides a detailed discussion of the regulatory framework applicable to the WUDP and water resources more generally.

History

In 1990 each county in the State of Hawaii prepared and adopted its initial WUDP. These WUDP's were incorporated by CWRM into the Hawaii State Water Plan. Each county prepared a 1992 draft update to the 1990 WUDP's but none were approved by the CWRM. The most recent adopted WUDP for the Island of Lana'i is part of the Maui County WUDP adopted in 1990.

Resolving a petition filed in 1989, the CWRM in 1990 decided not to designate any of Lana'i's aquifers as groundwater management areas. In lieu of designation the CWRM required ongoing monitoring, preparation of a water shortage plan and annual information status hearings. The CWRM also set conditions that would trigger reconsideration of groundwater management area designation.

In 1993 the Maui County Council established a nine-member Lanaʻi Water Sub-committee. The Council re-established the sub-committee with amended membership in 1995.

In 1996 the CWRM established a Lanaʻi Water Working Group as a successor to the County subcommittee. The Working Group met regularly and drafted the *Final Report of the Lanaʻi Water Working Group* which it adopted in 1997. This document is included as Appendix A.

The Lanaʻi Water Working Group continued to meet under the unofficial auspices of the Maui Board of Water Supply (BWS) until it was formally reconstituted by resolution by the BWS as the Lanaʻi Water Advisory Committee (LWAC). The purpose of the LWAC is to "provide public input and involvement during the development of the Lanaʻi WUDP and to monitor the Lanaʻi WUDP implementation."

The CWRM adopted a "Statewide Framework for Updating the Hawaii Water Plan" in February 2000. This document serves as a guideline to the state and county agencies to prepare each of the components of the Hawaii Water Plan. Since preparation of Lanaʻi's WUDP update was already underway when the CWRM Framework was adopted, it was agreed by the County and CWRM that the specific requirements of the new Framework would not necessarily apply to the Lanaʻi WUDP.

After extensive involvement and review by the LWAC, a draft Lanaʻi WUDP, dated June 28, 2010 was submitted by the Maui Department of Water Supply (DWS) to the BWS for public hearings and recommendations. The BWS held public hearings on the Island of Lanaʻi and, after deliberations, approved its recommendations transmitted to the Maui DWS on December 23, 2010. The BWS "accepted" the draft Lanaʻi WUDP but with several recommendations.

In February 2011, the DWS amended the June 28, 2010 draft Lanaʻi WUPD in response to the recommendations by the BWS. Both the June 28,2010 draft and the amended February 25, 2011 draft (this draft) are being transmitted to the Maui County Council for review.

Detailed documentation of the Lanaʻi water planning process is provided in Appendix C.

Existing Resources and Systems

Lana‘i’s existing water resources and systems are identified and discussed in detail in the Supporting Documentation Chapter 3.

The sustainable yield of Lana‘i is estimated at 6 MGD. Virtually all of this is located in the Central aquifer sector which is divided into two aquifer systems with 3 MGD each. Total withdrawals in 2008 were about 2.2 MGD, with 1.9 MGD from the Leeward Aquifer System, and 0.33 MGD from the Windward Aquifer System. Withdrawals came primarily from six wells, with the exception of about 2,000 GPD.

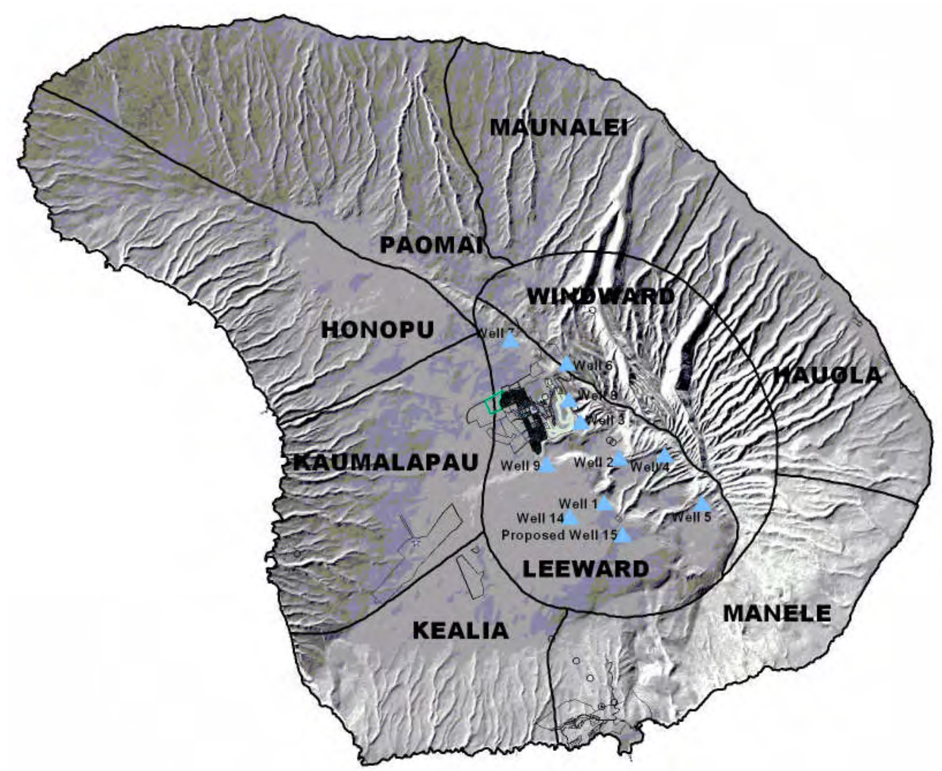

FIGURE 1-2. Lana‘i Aquifers and Wells

The island has no major surface water sources. Taro lo`i are found in Maunalei gulch.  Lana'i has 13 ahupua`a in which 110 kuleana claims were made, and 56 awarded.

Fog drip from Lana'ihale is unusually important on Lana'i. The State Commission on Water Resource Management has estimated that the loss of fog drip from the watershed could cause water levels in the key recharge area to drop by half. Groundwater recharge in the primary aquifer is also closely tied to survival of the watershed forest, and would be diminished by its loss. Precipitation on Lana'ihale summit averages 35"-40" per year, unusually low for a Hawaiian Cloud Forest. This is because Lana'i lies in the rain-shadow of Maui and Molokai.

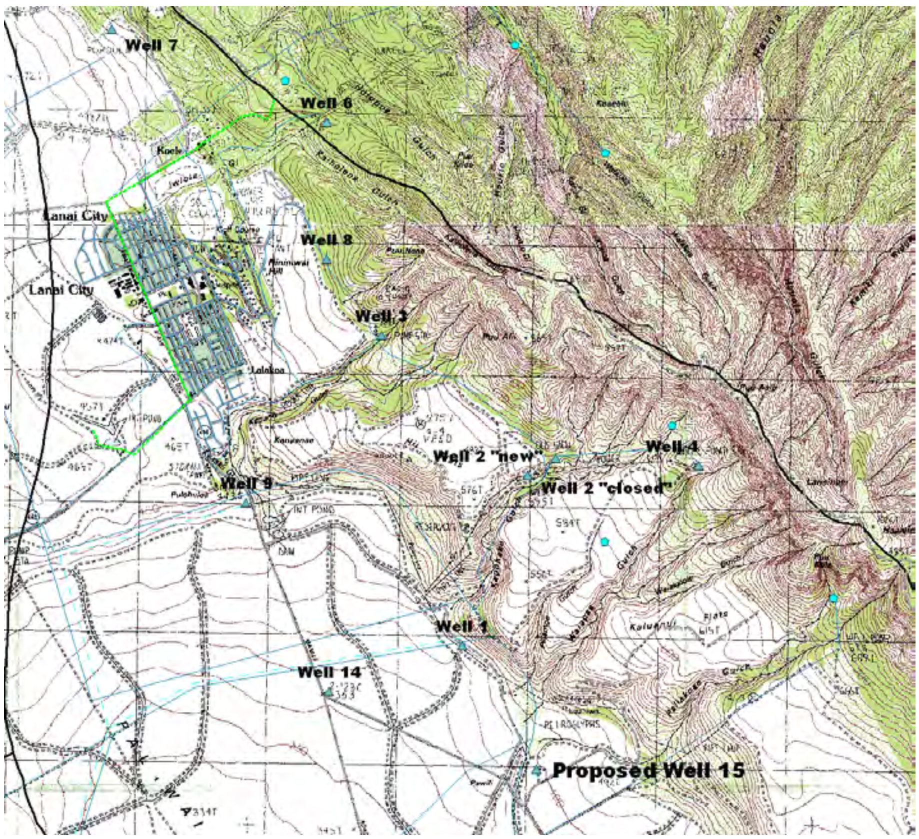

FIGURE 1-3. Lana'i Wells

Lana'i has five water supply systems, including two public drinking water systems, two reclaimed water systems, and a brackish water system. All are owned and operated by wholly owned subsidiaries of Castle & Cooke Resorts, LLC (CCR).

Lana‘i’s water systems include roughly 79 miles of active pipeline, 35 MG of storage (of which about 4.8 is potable water storage in eight tanks), and about 6.394 MGD in installed well capacity (of which 5.04 MGD is potable). About 23 well holes exist, but only 7 are in use, with one of those in use at a tiny rate of only about 2,000 GPD in 2008. The systems serve about 1,573 customers.

Reclamation facilities in Lana‘i have a total design capacity of about 1.9 MGD.

Existing potable water rates (effective in June 2010) are $1.10 for the first 25,000 gallons, and $1.62 thereafter. Existing rates and fees are not sufficient for the utility to be self-supporting. The cost of well operation is estimated at $2.17/Kgal for the Lana‘i City and Koele areas; $1.77 for the Manele and Palawai Grid areas., and $1.71 for brackish service to Manele.

Key system facilities issues include the age and condition of the system, substantial leaks and high pressures in certain areas - especially the irrigation grid, and inadequate revenue streams to support the necessary improvements.

Demand Analysis

Terminology

Water "demand" refers generally to the amount of underlying "need" for water associated with existing and projected end uses. Water demand can be met by supplying sufficient water to users or by conservation measures.

Water "consumption" refers to the amount of water (usually metered) that is delivered at the point of use.

Water "production" refers to the amount of water put in to the water system.

"Pumpage" refers to water production from wells.

"Unaccounted-for water" is the difference between production and metered consumption and consists of system leaks and unmetered consumption (including water used for fire protection, line flushing, unmetered services, illegal use).

On Lanaʻi, water is divided into several independent water distribution systems for potable water, brackish water and recycled wastewater.

Historical and Existing Water Demand

Historical pumpage on Lanaʻi peaked at around 3.5 million gallons per day (MGD) in 1989. With the end of the pineapple economy in 1992, pumpage dropped to just under 2 MGD, gradually rising to 2.24 MGD in 2008 (2,241,222 GPD).

Metered demand on Lanaʻi in 2008 was roughly 1.66 MGD. Of that amount, roughly 0.76 MD was from Wells 1, 9 & 14, serving brackish water for irrigation to the Manele Project District area. Roughly 0.52 MGD was for the areas of Lanaʻi City, Koele and Kaumalapau, and roughly 0.38 was fresh water for Manele Project District and the Palawai Irrigation Grid.

By region, metered demand for the Manele Project District was the highest, with consumption in 2008 of 1.08 MGD of combined fresh and brackish water, followed by Lanaʻi City with 0.36 MGD of metered demand, Koele Project District with 0.15 MGD of metered demand, the Palawai Irrigation Grid with 0.05 MGD of metered demand, and finally Kaumalapau with 0.015 MGD of metered demand.

FIGURE 1-4. **Metered Consumption by Service District Area**

Service District Area	Abbreviation	2008 GPD	Wells Serving Area
Koele Project District	KOPD	149,128	6 & 8 (potable)
Lana‘i City	LCTY	358,008	6 & 8 (potable)
Kaumalapau	KPAU	15,604	6 & 8 (potable)
Manele Project District	MNPD	1,082,999	2 & 4 (potable) 1, 9 & 14 (brackish)
Palawai Irrigation Grid	IGGP	52,505	2 & 4 (potable)

By type of use, irrigation was the largest, at about 0.9 MGD, followed by hotel use at 0.27 MGD, single-family residential at 0.26 MGD, commercial at 0.08 MGD, multi-family residential at 0.08 MGD, agricultural use at 0.04 MGD, government at 0.016 MGD and public-quasi-public at 0.008 MGD.

FIGURE 1-5. **Metered Consumption by Type of Use**

	By Meters	Adjusted
AG	44,401	44,401
OTHER IRR	897,462	1,087,111
COMM	82,007	66,772
DEVEL	411	411
GOV	15,944	15,944
HOT	272,102	123,200
PQP	8,218	8,218
RES-MF	79,865	79,865
RES-SF	257,835	232,323
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	1,658,244	1,658,244

Unaccounted-for Water

Unaccounted-for water includes water lost due to leaks in water system storage and pipeline components as well as several types of unmetered consumption, including water used for fire protection, line flushing, unmetered services and possible theft.

Fresh and brackish water service on Lana‘i is broken down into three well service areas. Wells 6 and 8 serve Lana‘i City, Koele and Kaumalapau. Wells 1, 9 & 14 serve brackish water to Manele for irrigation. Wells 2 & 4 provide fresh water to Manele and the Palawai Irrigation Grid. An unaccounted-for water analysis was performed for each of these well service areas. About 13.52% of pumped water in Lana‘i City, Koele and Kaumalapau was unaccounted-for. About 18.76% of pumped water on the brackish system was unaccounted-for. About 44. 61% of the fresh water pumped from Wells 2 and 4 to serve the Manele Project District area and the Palawai Irrigation Grid was unaccounted-for. This unaccounted-for water analysis revealed some opportunities for supply side savings, which were included in the proposed capital plan.

FIGURE 1-6. Pumped, Metered & Unaccounted-for Water by Well Service Area

Wells	Areas Served	Pumped Water 2008 MGD	Metered Demand 2008 MGD	Unccounted -For Water 2008%
6 & 8	Koele, Lana‘i City, Kaumalapau	0.605	0.523	13.52%
2 & 4	Manele-Hulopo‘e, Palawai Irrigation Grid	0.683	0.375	44.61%
1, 9 & 14	Manele-Hulopo‘e Irrigation	0.944	0.760	18.76%
		2.232	**1.658**	
Note: Percents are accurate, but are average of twelve individual monthly amounts, so may not match precisely here.				

Lana‘i’s unaccounted water for 2008 was 28% of production. This is depicted in the chart below. This is substantially higher than industry standards and is primarily due to leaks in water storage facilities and deteriorated pipelines.

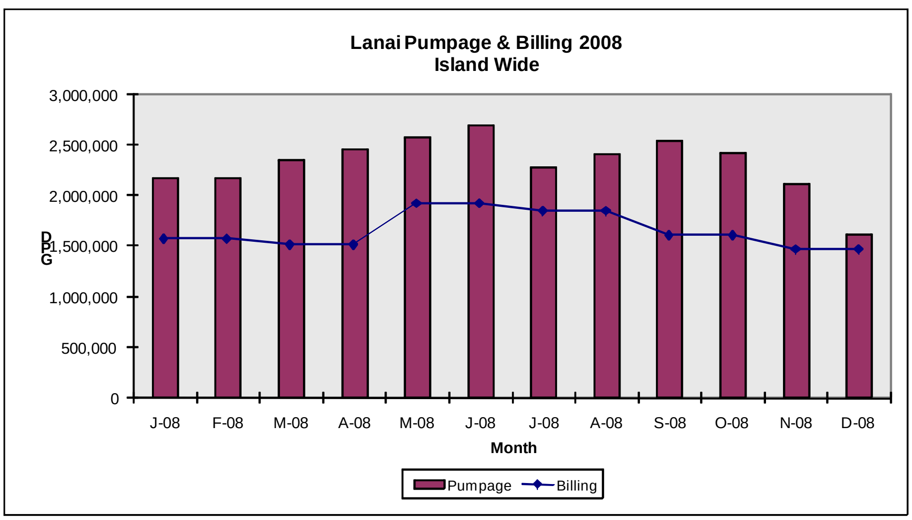

FIGURE 1-7. Lana‘i pumpage and billing - Island-wide unaccounted-for water

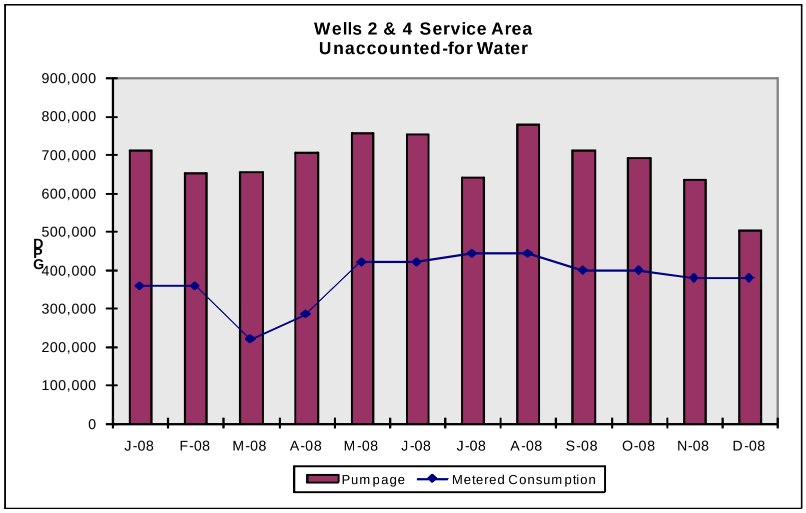

FIGURE 1-8. Pumpage and billing - Palawai grid unaccounted-for water

Unaccounted-for water losses on the Palawai grid are particularly high on a percentage basis, totalling 45% for the 2008 period depicted in the chart above. This means that only slightly more than half of the water pumped into the Palawai grid is actually delivered to metered water users.

Chapter 4 of the Supporting Documentation provides detailed information regarding the unaccounted-for water and improvement potential for Lana'i's water systems.

Projected Water Demand

The State's *Framework for Updating the Hawaii Water Plan* recommends that a range of forecasts be considered, and a range of supply options to meet multiple forecasts developed. This guideline was followed for Lana'i. Demand was forecasted to the year 2030 using three methods: simple time trend regressions; projections using forecast coefficients derived based upon the SMS forecast prepared for the ongoing Community Plan update process; and analysis of build-out of CCR project development proposals.

Trending Projections

Time trend analysis yielded projections of water consumption ranging from 2.4 to 3.2 MGD in 2030.

Simplified Econometric Projections

Forecast coefficients were derived for a low case, base case and high case forecast, each of which was run with three assumptions: 1) assuming each new consumer would use about the same amount of water as existing consumers, 2) assuming each new consumer would use one and a half times as much water as existing consumers, and 3) assuming each new consumer would use twice as much as existing consumers. Assuming new consumers would use the same amount per meter as existing consumers, projections of water production to the year 2030 ranged from 2.6 MGD to 3.1 MGD. Assuming new consumers would use one and a half times as much water as existing consumers, projections ranged from 3 MGD to 4 MGD. Assuming new consumers would use twice as much as existing consumers, projections ranged from 3.4 to 5 MGD.

Build-out Demand Analysis

Estimates of demand by analysis of project build-outs was somewhat higher, ranging from about 3.6 MGD for build-out of Phase II approvals, to over 7 MGD, for full build-out of proposals submitted by CCR, plus Project District elements approved by ordinance but not included in the proposals, plus other known projects.

Demand projections were made for both potable and non-potable water uses. The delineation between these types of water use is uncertain because it is affected by future supply resource choices, as well as by demand trends. Projected demands for potable uses ranged from 1.4 to 2.7 MGD. The projection of combined brackish and reclaimed uses ranged from 1.6 to 2.8 MGD. The low end of these projections assumes the low-case forecast, and that each new meter will use about the same amount of water as existing meters. The high end assumes both the high case forecast, and that each new meter will use twice as much pumped water as existing meters.

Two build-out projections were proposed by CCR:

- A 2006 CCR proposal included projects with a total demand of 6,079,523 GPD, of which roughly 4.163 MGD was to be met by pumping potable and brackish water, (3.411 potable and 0.752 brackish), 0.616 MGD was to be met by reclaimed water, and 1.3 MGD was to be met by one or more unidentified “alternative” sources.

A 2009 CCR proposal included projects with a total demand of 6,969,848 GPD, of which roughly 4.208 MGD was to be met through pumping potable and brackish water, (3.374 MGD potable and 0.834 MGD brackish), 1.209 MGD was to be met by reclaimed water, and 1.553 MGD was to be met by one or more unidentified “alternative sources”. Several adjusted versions of the CCR build-out projections were prepared recognizing that the water demand for the CCR build-out projections could be greater than shown, due to project district elements that are not included, known projects for which estimates are not included, and actual unaccounted-for water rates which are higher than what is characterized. Projections that include other known projects and portions of the project districts which are not included in the CCR projections indicate total demands as high as 7.13 MGD.

Combined Econometric and Build-out Projections

For planning purposes, a resource development strategy was developed that incorporates a projection of water demand that (1) includes an estimate of the rate of increase in water demand predicted by economic and demographic considerations through 2030 and (2) identifies the amount of water necessary for build-out of known projects and projects with Phase II approval. The Phase II build-out projection indicates water demand of over 5 MGD. With the conservation measures identified as part of the base plan resource development strategy described below, total pumpage would be 3.7 MGD.

FIGURE 1-9. Island-wide Projections for 2030 - Various Methods - MGD

Method	Low	High	Base Range
Time Trend of Production	2.43	3.23	2.43 - 3.23
Econometric Forecast - 2008 Base Year Production	2.98	5.84	3.03 - 4.10
Econometric Forecast - Metered Consumption Plus 12% UAFW LCTY, 15% MNPD	2.56	5.03	2.61 -3.53
Build-out - CCR 2006 Estimate * includes 12% UAFW			6.08
Build-out - CCR 2009 Estimate *includes 12% UAFW			6.97
Build-out - Re-Analysis of 2006 CCR proposal using system standards or forecast coefficients, adjusting existing uses to billed records, adding other known projects etc.*			6.29
Build-out - Re-Analysis of 2006 CCR proposal as above, adding Existing Phase I Project District Elements not included in proposal, updated scopes for affordable housing and HHL.			7.13
Build-out of Known Projects Plus Projects with Phase II Entitlements			5.07
Note: 2030 build-out numbers shown in this table do NOT include resource reserves, but DO include water demands which may be met by means other than pumpage, such as use of reclaimed water, unidentified sources, desalinization or conservation and efficiency measures.			

As shown in the table above, build-out of the projects with Phase I approval, including the CCR proposals would require more water demand than is available from groundwater sources. For comparison, the sustainable yield of the Windward and Leeward aquifers is 3 MGD each. 90% of the total sustainable yield is 5.4 MGD.

Resource Options

Supply Resource Options

Detailed information regarding a list of potential supply resource options is provided in Chapter 5 of the Supporting Documentation.

New supply resource options that were examined include:

- High level potable well near Well 5 in the Leeward Aquifer
- Well 2-B at the site of Shaft 3 in the Leeward Aquifer
- Recommissioning Well 7 in the Leeward Aquifer
- New wells in the Windward Aquifer at Mala‘au
- Recommissioning the Maunalei Shaft and Tunnels in the Windward Aquifer
- New wells in the Windward Aquifer at or near the Maunalei Shaft and Tunnel sites
  - Two (2) new wells using existing transmission
  - Three (3) new wells using existing transmission
  - Three (3) new wells using new transmission
- New wells in the Windward Aquifer at Kauiki
  - Assuming that these wells can tie into Maunalei Wells transmission
  - Assuming new transmission had to be constructed
- New wells in the Windward Aquifer at Kehewai Ridge
  - At 2,250’ elevation
  - At 2,750’ elevation
- New Brackish Well 15 in the Leeward Aquifer
  - Used without additional desalinization
  - Used with desalinization
- “General” Desalinization Options
  - Brackish to potable
  - Seawater to potable
  - Seawater to brackish for irrigation

Supply Side Efficiency Options include:

- Loss Reduction - Repair of Palawai Grid Pipes
- Loss Reduction - Cover for the 15 MG Brackish Reservoir
  - Floating cover

- Aluminum cover
- Hypalon balls

- Expanded use of Lanaʻi City Reclaimed Water
  - Lanaʻi City to Miki Basin
  - Lanaʻi City to Manele
  - Lanaʻi City to Manele via Miki Basin

Description and discussion of each of these potential resources is provided in the Chapter 5 of the Supporting Documentation. In order to develop a meaningful comparison of the value of each option, total costs of each option were derived and expressed as levelized to costs per 1,000 gallons of water produced. A summary is presented in the tables below.

Option Name	Plant Capacity			Capital Cost		Fixed Operating		Variable Operating Cost	Plant Life Economic	Economic Life Total Discounted Cost				
	Installed	Effective	Average Output	Cost	Unit Cost	Cost	Unit Cost			Total Unit NPV	**Total Levelized**	Capital Levelized	Fixed Op. Levelized	Var. Op. Levelized
	MGD	MGD	MGD	$M	$M/MGD	$/Year	$/Year/MGD	$/kgal	Years	NPV $2007 $M /MGD	**Levelized $ / kgal**	Levelized $ / kgal	Levelized $ / kgal	Levelized $ / kgal
Proposed New Well #2B @ Shaft 3 Site	0.864	0.300	0.300	$1.883	$6.276	$15,415	$51,383	$0.92	30	$14.901	**$2.97**	$1.25	$0.20	$1.51
Proposed New Brackish Well #15	0.864	0.300	0.300	$2.657	$8.856	$19,519	$65,063	$1.30	30	$20.894	**$4.16**	$1.76	$0.26	$2.14
Well - High Level Potable (1) 1mgd near Hi`i Tank	0.864	0.300	0.300	$2.867	$9.556	$20,599	$68,663	$1.41	30	$22.554	**$4.49**	$1.90	$0.27	$2.31
Well - High Level Potable (1) 1MGD near Well #5	0.864	0.300	0.300	$2.957	$9.856	$22,759	$75,863	$1.61	30	$24.650	**$4.91**	$1.96	$0.30	$2.64
Recommission Well#7	0.720	0.300	0.300	$2.678	$8.927	$26,719	$89,062	$2.37	30	$30.266	**$6.02**	$1.78	$0.35	$3.89
Wells - Windward (3)1MGD at Maunalei w/Existing Transmission	3.000	0.750	0.750	$8.001	$10.668	$118,144	$157,525	$2.43	30	$33.860	**$6.74**	$2.12	$0.62	$3.99
Wells - Windward (2) 1 MGD Maunalei w/Existing Transmission	2.000	0.500	0.500	$6.766	$13.531	$78,763	$157,525	$2.43	30	$36.723	**$7.31**	$2.69	$0.62	$3.99
Windward Well at Malau	0.864	0.300	0.300	$6.377	$21.256	$23,839	$79,463	$1.71	30	$36.948	**$7.35**	$4.23	$0.31	$2.81
Windward Well at Kauiki (Incremental)	0.864	0.300	0.300	$4.865	$16.216	$40,334	$134,445	$2.73	30	$41.431	**$8.25**	$3.23	$0.53	$4.49
Recommission Maunalei Shaft/Tunnels	1.000	0.500	0.500	$10.110	$20.220	$48,513	$97,025	$2.43	30	$42.213	**$8.40**	$4.02	$0.38	$3.99
Wells - Windward (3)1MGD at Maunalei w/New Transmission	3.000	0.750	0.750	$14.607	$19.476	$118,144	$157,525	$2.43	30	$42.668	**$8.49**	$3.87	$0.62	$3.99
Windward Well at Kehewai Ridge 2250ft.	0.864	0.300	0.300	$9.275	$30.916	$28,159	$93,863	$2.11	30	$50.200	**$9.99**	$6.15	$0.37	$3.47
Windward Well at Kehewai Ridge 2750ft.	0.864	0.300	0.300	$9.659	$32.196	$32,479	$108,263	$2.51	30	$55.073	**$10.96**	$6.40	$0.43	$4.12
Windward Well at Kauiki	0.864	0.300	0.300	$10.925	$36.416	$40,334	$134,445	$2.73	30	$61.631	**$12.27**	$7.24	$0.53	$4.49
Desalination - Seawater to 400 ppm Chlorides	0.250	0.250	0.250	$3.335	$13.338	$100,348	$401,390	$6.37	30	$73.969	**$14.72**	$2.65	$1.58	$10.48
Desalination - 50% Seawater to 225 ppm Chlorides	0.250	0.250	0.250	$3.272	$13.086	$111,598	$446,390	$9.97	30	$104.372	**$20.77**	$2.60	$1.76	$16.40
Desalination - Seawater to 225 ppm Chlorides	0.250	0.250	0.250	$3.382	$13.527	$121,598	$486,390	$13.17	30	$132.062	**$26.29**	$2.69	$1.92	$21.66

Levelized costs are calculated based on 3.0% inflation, 6.0% cost of capital and 6.0% discount rate. Operating costs are estimates of Haiku Design & Analysis.
Electricity costs included in Variable Operating Costs are $0.40 per KWH (= $125/bbl crude oil price) escalated at 4.0% for levelization.
All engineering assumptions, estimated costs and impacts are planning projections that will need to be verified by specific studies prior to implementation.
NPV = net present value MGD = millions of gallons per day kgal = one thousand gallons $2007 = constant (real) dollars

Resource Options

Option Name	Plant Capacity Installed	Plant Capacity Effective	Plant Capacity Average Output	Capital Cost Cost	Capital Cost Unit Cost	Fixed Operating Cost	Fixed Operating Unit Cost	Variable Operating Cost	Plant Life Economic	Economic Life Total Discounted Cost: Total Unit NPV	Total Levelized	Capital Levelized	Fixed Op. Levelized	Var. Op. Levelized
	MGD	MGD	MGD	$M	$M/MGD	$/Year	$/Year/MGD	$/kgal	Years	NPV $2007 $M /MGD	**Levelized $ / kgal**	Levelized $ / kgal	Levelized $ / kgal	Levelized $ / kgal
Pipe Replacement / Loss Reduction IGGP	0.202	0.202	0.202	$3.840	$19.010	-$3,737	-$18,500	-$1.49	20	$9.782	**$2.34**	$4.54	-$0.07	-$2.14
Recycled Water Line to Miki Basin Industrial Prk	0.060	0.060	0.060	$1.536	$25.600	$248	$4,140	$0.40	30	$28.974	**$5.77**	$5.09	$0.02	$0.65
Recycled Water Line to Manele (2030)	0.500	0.500	0.500	$16.896	$33.792	$2,070	$4,140	$0.40	30	$37.166	**$7.40**	$6.72	$0.02	$0.65
Phase II Recycled Water Line Miki Basin to Manele	0.440	0.440	0.440	$15.456	$35.127	$1,822	$4,140	$0.40	30	$38.501	**$7.66**	$6.99	$0.02	$0.65
Phase I Recycled Water Line to Miki Basin Industrial Park	0.060	0.060	0.060	$2.304	$38.400	$248	$4,140	$0.40	30	$41.774	**$8.31**	$7.64	$0.02	$0.65
Floating Cover on 15 MG Reservoir	0.017	0.013	0.013	$0.366	$27.692	$0	$0	$0.00	10	$27.692	**$10.31**	$10.30	$0.00	$0.00
Hypalon Balls on 15 MG Reservoir	0.017	0.014	0.014	$0.495	$35.294	$0	$0	$0.00	10	$35.294	**$13.14**	$13.13	$0.00	$0.00
Aluminum cover on 15 MG Reservoir	0.017	0.013	0.013	$4.024	$304.821	$0	$0	$0.00	30	$304.821	**$60.67**	$60.63	$0.00	$0.00

Notes: Levelized costs are calculated based on 3.0% inflation, 6.0% cost of capital and 6.0% discount rate. Operating costs are HDA estimates.
Electricity costs included in Variable Operating Costs are $0.40 per KWH (= $125/bbl crude oil price) escalated at 4.0% for levelization.
All engineering assumptions, estimated costs and impacts are planning projections that will need to be verified by specific studies prior to implementatic

Abbreviations: NPV = net present value MGD = millions of gallons per day kgal = one thousand gallons $2007 = constant (real) dollars

Conservation “Demand-Side” Resource Options

A list of “demand-side” management (DSM) conservation measures was analyzed. DSM refers to measures that are implemented on the customer “side” of the water meter. DWM programs are implemented by the utility or other agency to encourage, finance or directly install conservation measures on the premises of water users.

Discussion and detailed information regarding the characterization and analysis of conservation measures is provided in Chapter 5 of the Supporting Documentation. A table showing economic analysis of some of the DSM measures is provided below. In order to provide meaningful comparison of the costs of various measures with one another and with supply resource options, costs are expressed as levelized life-cycle costs per thousand gallons of reduced water consumption.

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Resource Options

Candidate DSM Program Characterization

Program Name	Delivery Mechanism	Measure Cost Equip Cost	Measure Cost Instal Cost	Measure Cost Total per unit	Utility Cost Rebate per unit	Utility Cost Admin per unit	Utility Cost Total per unit	Program Cost Participant per unit	Program Cost Utility per unit	Program Cost TRC per unit	Savings Efficacy gpdpf	Measure Life Years	Levelized Unit Cost Participant $ / kgal	Levelized Unit Cost Utility $ / kgal	Levelized Unit Cost TRC $ / kgal
Toilet Flapper Install	Per SPU CPA	$8	$0	$8	$8	$12	$20	$0	$20	$20	9.25	10	$0.000	$0.804	**$0.804**
Toilet Targeted Retro	Direct installation of fixtures in targeted buildings with existing 5-7 gpf fixtures	$80	$100	$180	$180	$75	$255	$0	$255	$255	50.00	15	$0.000	$1.438	**$1.438**
Urinal Retro Rebate	Rebate Application similar to Honolulu toile rebate program	$250	$100	$350	$150	$50	$200	$200	$200	$400	55.55	15	$1.015	$1.015	**$2.031**
Toilet Retro Rebate	Bounty for old fixtures brought to depo (dumpster) and destroyed	$80	$100	$180	$100	$50	$150	$80	$150	$230	30.00	15	$0.752	$1.410	**$2.162**
Toilet Retro Rebate	Rebate Application based on Honolulu program	$80	$100	$180	$100	$50	$150	$80	$150	$230	30.00	15	$0.752	$1.410	**$2.162**
Shwrhd Direct Install	Showerheads installed by trained technicians				$0	$30	$30	$0	$30	$30	7.29	10	$0.000	$1.531	**$1.531**
Shwrhd Canvass	Showerheads distributed by door to doo canvase with choice of type				$0	$20	$20	$0	$20	$20	4.86	10	$0.000	$1.531	**$1.531**
Showerhead Giveaway	Showerheads distributed at public events or by request				$0	$10	$10	$0	$10	$10	1.62	10	$0.000	$2.296	**$2.296**
Shwrhd Mass Mail	Showerheads mailed to all customers				$0	$15	$15	$0	$15	$15	1.62	10	$0.000	$3.444	**$3.444**
Water Eff Clothes Wash	Rebate Application with purchase documentation	$350	$0	$350	$150	$70	$220	$200	$220	$420	16.91	10	$4.400	$4.840	**$9.240**
Water Eff Dish Washer	Rebate Application with purchase documentation	$50	$0	$50	$50	$70	$120	$0	$120	$120	1.00	10	$0.000	$44.640	**$44.640**
Improve Irr. Scheduling	Per SPU CPA - Improve irrigation efficiency by better scheduling	$25	$0	$25	$25	$9	$34	$0	$34	$34	23.77	10	$0.000	$0.534	**$0.534**
Low Water Use Plantings	Per SPU CPA - Replace 300sq.ft. lawn with low water req. plants	$25	$0	$25	$25	$9	$34	$0	$34	$34	10.31	10	$0.000	$1.231	**$1.231**
Xeriscaping	HDA per SPU CPA - Replace irrigated landscaping with zeriscape	$500	$1,000	$1,500	$500	$300	$800	$1,000	$800	$1,800	500.00	10	$0.744	$0.595	**$1.339**
Soil Moisture Sensor	Per SPU CPA - Install soil moisture sensors on automatic irrigation systems	$150	$0	$150	$150	$9	$159	$0	$159	$159	34.11	10	$0.000	$1.735	**$1.735**
Improve Perf. of Irr. Sys.	Per SPU CPA - repair, replacement, adjustmen of in-ground irr. system	$188	$0	$188	$188	$9	$197	$0	$197	$197	38.03	10	$0.000	$1.923	**$1.923**
Auto Rain Shut Off	Per SPU CPA - Install automatic rain shut-off on automatic irrigation systems	$50	$0	$50	$50	$9	$59	$0	$59	$59	10.66	10	$0.000	$2.063	**$2.063**
Rain Barrel Catchment	Per SPU CPA - Install 50 gallon barrels to gutte downspouts for irrigation	$50	$0	$50	$50	$9	$59	$0	$59	$59	1.99	10	$0.000	$11.050	**$11.050**
Greywater for Irrigation	Per SPU CPA - Install grey water collect/dist. system -new and remod. with sand filtratior	$2,000	$0	$2,000	$2,000	$9	$2,009	$0	$2,009	$2,009	16.11	15	$0.000	$35.169	**$35.169**

Notes:
Shaded cells are data entry cells; other numerical cells are calculated
SPU CPA = Seattle Public Utilities Conservation Potential Assessment Final Project Report, May 1998. Delivery mechanisms were not explicitly identified for several programs
Documentation, calculations of estimates and sources are identified on a more detailed source spreadsheet
Levelized costs are calculated according to the identified measure life assuming a 3.0% inflation rate, 6.0% cost of capital, 6.0% discount rate.
All estimates and calculated costs and savings impacts should be considered rough approximations for purposes of intial measure and program assessment.

Abbreviations: gpd = gallons per day; gpdpf = gallons per day per fixture; kgal = thousand gallons; TRC = Total Resource Cost Test HDA = Haiku Design & Analysis (Carl Freedman)

Resource Development Strategy

A base case "resource development strategy" was developed to investigate and identify a viable approach to meet anticipated planning period water needs most economically within resource availability constraints. The strategy identifies new supply resources and conservation measures sufficient to provide for existing water needs as well as anticipated water needs for known new projects and projects with Phase II project district entitlements.

The resource development strategy serves as a planning and analysis tool to determine what new resources and conservation measures will be necessary and will most economically and effectively meet water demands that could develop during the planning period. In the context of Lana'i's limited water resources, the resource development strategy also serves to show what economic challenges can be expected in conjunction with build-out of entitled land developments.

Resource Strategy Demand Projections

The resource development strategy incorporates a projection of water demand through the year 2030 based on econometric analysis of the Socio-Economic forecast used in the current County general plan update. Projections beyond 2030 include estimate of water needs for build-out of known projects and projects with Phase II project district entitlements.

The table below shows the projected water production broken down by water system and service area for five year increments to the year 2030. The rightmost column shows production requirements to meet the needs of build-out of known projects and projects with Phase II entitlements. The projections identify and include the impacts of the conservation and leak reduction measures identified below.

A 10% percent aquifer pumping reserve (to keep pumping below 90% of sustainable yield) is included in the projections. Totals are shown both including and excluding this pumping reserve. Production requirements in the year 2030 and for Phase II build-out exceed the pumpage sustainable yield of the Leeward aquifer (3 MGD) and would therefore require some contribution from resources developed in the Windward aquifer.

A more detailed version of the table below, along with clarifying footnotes, is provided in Chapter 4 *Demand Analysis* in the Supporting Documentation starting at page 4-113.

Resource Development Strategy

RESOURCE DEVELOPMENT STRATEGY - SOURCE USE TO THE YEAR 2030

Land Use Category	Present Metered (2008)	Source Requirement with Target UAFW 12% in LCTY,KOPD,KPAU 15% in MNPD, IGGP	Pumped Water For Each Demand Stream Including UAFW 2010	2015	2020	2025	2030	Phase II Plus Other Known Projects
Koele PD - Fresh	149,128	169,464	185,149	157,403	185,909	206,816	229,426	335,507
Koele PD - Brackish	0	0	0	0	0	0	0	0
Koele PD - Reclaimed Water	234,093	234,093	258,235	261,552	278,477	297,204	316,798	316,798
Lana`i City & Related Areas - Residential - Fresh	268,127	304,690	333,374	287,071	348,037	379,530	421,030	367,508
Lana`i City & Related Areas - Other - Fresh	105,486	119,870	131,173	116,067	134,386	151,973	165,457	165,592
Lana`i City Housing Project				87,290	155,551	223,813	257,943	292,074
County Lana`i City Recreation Area				15,455	15,455	15,455	15,455	15,455
DHHL Project				11,591	112,386	115,114	129,091	143,068
Lana`i City Redevelopment Project				41,081	82,161	133,071	144,604	156,136
Kaumalapau Subdivision								30,682
Lana`i City & Kaumalapau - Conservation Target - Fresh			5,750	91,200	95,800	100,400	105,000	105,000
Potable Resource Reserve - 10% of Aquifer Sustainable Yield (300 KGal each)		600,000	600,000	600,000	600,000	600,000	600,000	600,000
Palawai IGGP - Agricultural - Fresh	28,044	32,993	35,590	19,616	22,707	28,074	28,524	28,067
Palawai IGGP - Agricultural - Reserve - Fresh			588,235	588,235	588,235	588,235	588,235	588,235
Palawai IGGP - Other - Fresh - incl. warehouse (total is offset by reclaimed)	24,461	28,778	30,755	17,109	16,712	21,544	29,267	23,523
Palawai IGGP - Miki Basin Industrial Park (120 Kgal total offset by reclaimed)							86,629	93,262
Palawai IGGP - Agricultural - Brackish	0	0	0	0	0	0	0	0
Palawai IGGP - Other - Brackish	0	0	0	0	0	0	0	0
Palawai IGGP - Reclaimed Water from Lana`i City							60,000	60,000
Manele PD - Potable	322,641	441,348	405,819	189,448	149,726	242,046	284,311	474,603
Manele PD - Brackish (2008 actual metered)	760,357	650,000	650,000	650,000	650,000	650,000	650,000	650,000
Manele PD - Brackish Water Over 650,000 (2008 pumpage was 943,776, w/19% UAFW & water levels declini		244,538	112,634	163,191	199,091	240,285	270,220	294,639
Manele PD - Reclaimed Water from Lana`i City								124,666
Seawater to Brackish Desalt or Other Approved Source								300,000
Manele PD & IGGP - Conservation Target - Fresh			15,400	250,800	266,200	291,600	297,000	297,000
Manele PD & IGGP - Conservation Target - Brackish			14,000	27,800	41,600	55,400	83,000	83,000
Manele PD - Reclaimed Water	72,940	72,940	80,462	81,496	86,769	92,605	98,711	119,507
TOTAL	1,965,277	2,898,713	3,446,576	3,656,405	4,029,203	4,433,164	4,860,700	5,664,322
including resource reserve								
TOTAL REMOVING RESOURCE RESERVE	1,965,277	2,298,713	2,846,576	3,056,405	3,429,203	3,833,164	4,260,700	5,064,322
(above i.e. POTENTIAL PUMPED Including System Losses WITHOUT Conservation, Reclaimed Water or Desalt)								
SUBTOTAL PUMPED FROM AQUIFER Incl System Losses WITH Conservation & Etc.	1,658,244 (metered)	1,991,680 a	2,472,728 b	2,343,557 c	2,660,357 d	2,995,955 e	3,300,191 f	3,658,351 g

Note: 500 Kgal Ag Reserve is assumed to be pumped in all but "present" years

Water Conservation Measures

The resource development strategy includes a mix of conservation measures and new supply resource development. The conservation measures identified and assumed in the resource development strategy are shown in the table below. The derivation of these estimates of conservation measure impacts is presented in Chapter 5 of the Supporting Documentation.

FIGURE 1-10. Supply and Demand Side Conservation Measures Included in Resource Development Plan

	Manele & Grid Fresh	Manele Brackish	Lanai City Koele & Kaumalapau	
Palawai Grid	200,000.0			200,000
Landscape	50,000.0	50,000.0	11,000.0	111,000
Fixture Replacement	20,000.0		80,000.0	100,000
Leak Detection & Repair	15,000.0	13,000.0	12,000.0	40,000
Hypalon Cover		14,000.0		14,000
Hotel & Landscape Incentives	12,000.0	6,000.0	2,000.0	20,000
Rate Structure				
	297,000.0	83,000.0	105,000.0	485,000

Supply Resource Measures

A supply resource strategy was developed based on the supply resource options investigated and characterized as presented in Chapter 5 of the Supporting Documentation at pages 5-10 through 5-61. A schedule of potential new supply resources was identified that indicates how much water demand could be met with cumulative implementation of the new supply resources. This schedule is shown in the table below. The schedule identifies more new resources than are necessary to meet the needs of the base case resource development strategy. The supply resource schedule is explained in Chapter 5 of the Supporting Documentation starting at page 5-76.

FIGURE 1-11. Cumulative Capacity of Additional Supply Resources

Options in Order of Levelized Cost w/Adjustments	Gal	Average Day Ability to Meet Demand	Cumulative Aquifer Withdrawals	Cumulative Leeward Aquifer	Cumulative Windward Aquifer	Conservation and Reclaimed
Existing System		1,685,224	2,241,222	1,913,310	327,912	307033
Well 2 Replacement (2-A)	300,000	1,985,224	2,541,222	2,213,310	327,912	
Shaft 3 Replacement (2-B) *, **	150,000	2,135,224	2,691,222	2,363,310	327,912	
Well 15 *, **	100,000	2,235,224	2,791,222	2,463,310	327,912	
Well 3 Replacement**	200,000	2,435,224	2,991,222	2,663,310	327,912	
Well Near Hi`i Tank (btwn Hi`i and Well 3) **						
High Level Well Near Well 5 / Well 5 Replacement						
Well 7 Recommission						
Palawai Grid Pipe Replacement	200,000	2,635,224	2,991,222	2,663,310	327,912	200,000
Toilet and Fixture Replacement Program	100,000	2,735,224	2,991,222	2,663,310	327,912	300,000
Landscape Conservation	111,000	2,846,224	2,991,222	2,663,310	327,912	411,000
Hypalon Cover on 15 MG Reservoir	14,000	2,860,224	2,991,222	2,663,310	327,912	425,000
Annual Water Audit and Leak Detection Program	40,000	2,900,224	2,991,222	2,663,310	327,912	465,000
Hotel Incentives Program	20,000	2,880,224	2,991,222	2,663,310	327,912	485,000
Tiered Rate Structure						
Reclaimed Water Lana`i City & Koele	82,710	2,962,934	2,991,222	2,663,310	327,912	567,710
Reclaimed Water Manele	25,771	2,988,705	2,991,222	2,663,310	327,912	593,481
Windward Well at Malau	300,000	3,288,705	3,291,222	2,663,310	627,912	
Windward Wells at Maunalei (3)	750,000	4,038,705	4,041,222	2,663,310	1,377,912	
Windward Wells at Kauiki	300,000	4,338,705	4,341,222	2,663,310	1,677,912	
Windward Wells at Kauiki - Incremental	300,000	4,638,705	4,641,222	2,663,310	1,977,912	
Windward Well at Kehewai Ridge - 2,250' /oth wndwrd	300,000	4,938,705	4,941,222	2,663,310	2,277,912	
Windward Well at Kehewai Ridge - 2,750' /oth wndwrd	300,000	5,238,705	5,241,222	2,663,310	2,577,912	
Reclaimed Water Lana`i City & Koele	184,661	5,423,366	5,241,222	2,663,310	2,577,912	778,142
Reclaimed Water Manele	20,796	5,444,162	5,241,222	2,663,310	2,577,912	798,938
Ocean to Brackish	250,000	5,694,162	5,241,222	2,663,310	2,577,912	

* Wells are assumed to be installed, though they do not yield as much as anticipated.

** Levelized cost fof Well 2-B at 150,000 instead of 300,000 goes from $2.97 to $4.35. Well 15 goes from $4.16 to $8.05, & Well 7 from $6.02 to $8.08.

*** Well between Hi`i Tank and Well 3 could serve either system & appears to be less expensive than Well 7. Levelized costs go from 4.49 at 300KGal to 6.60 at 150 Kgal.

**** It may be desirable to go straight to Malau Well rather than Hi`i Tank or Well 7

***** As conservation savings are achieved, leeward aquifer wells can raise closer to design pumpage. Some resource reserve is still recommended.

Resource Strategy Costs A list of resources and system improvements necessary to implement the resource development strategy needs was developed to determine the cost of implementing the strategy. These include: source development, pipe replacements, storage improvements, pump improvements, needs for monitoring and telemetry, etc. The assumptions and derivation of costs are provided on pages 5-65 through 5-79 of Chapter 5 of the Supporting Documentation.

In order to determine the rate impacts associated with the necessary capital improvements, schedules of bi-monthly charges, water rates and new meter fees were developed. Several potential rate designs were considered. To estimate rate impacts, capital needs were converted to approximate carrying costs, and added to annual revenues and revenue losses as reported to the PUC and to anticipated increased costs in labor and facilities identified by Brown & Caldwell in the *Lana'i Water System Acquisition Appraisal.* The rate impact and design analysis is described on pages 5-80 to 5-84 of Chapter 5 of the Supporting Documentation.

Source Water Protection

Source water protection measures discussed for Lana‘i include watershed protection, wellhead protection and operational management to avoid over-pumpage.

- Lana`i is unusually dependent upon its mauka watershed, because Lana‘i is dependent upon fog drip. Over 65% of the recharge in the primary high level aquifer for Lana‘i is believed to be attributable to fog drip. Loss of fog drip from Lana‘i Hale would lead to the loss of over 50% of the water levels in the Central aquifer, essentially the only viable water source for the island. Estimates from studies elsewhere indicate that fog drip interception by mountain forests increase precipitation by as much as 30%, and recharge by 10-15%.
    - The watershed on Lana‘i is a low elevation cloud forest, with a strong mix of mesic species. Maintaining native cover becomes especially important in light of its role in the water budget for Lana‘i and the rising inversion layer. Yet less than 30% of the native cover in the cloud forest remains.
    - Threats to the watershed include: habitat alteration by feral animals, human activity and invasive species; continuing intrusion of exotic plant and animal species which can trample, prey on or out-compete native species; loss of critical populations; loss of native pollinators and other keystone species; introduced pathogens and insects; erosion; drought, and; high vulnerability to fire due to mesic conditions combined with the spread of fire inducing weeds.
    - Key management measures include: fencing the most valuable watershed; eliminating feral animal ingress to fenced areas; removal of non-desirable weed and animal species; planting of desirable native species; erosion and fire prevention measures; and limiting human activities in key areas. More specifics are provided in Chapter 6.
    - During the course of the planning process, a statewide sky bridge meeting of forestry experts was held to determine the most critical measures for watershed protection. This meeting resulted in recommendations for a fence on the Lana‘ihale. This was followed by a joint effort between the LWAC, The Nature Conservancy, and the community group *Hui Malama* to present fence options to the public, and finally by the establishment of the Lana‘i Forest and Watershed Partnership. Because this was deemed a crucial aspect of the plan by LWAC members, Chapter 6-A of this document is dedicated to measures to protect the Lana‘ihale forest. It is

hoped that inclusion of these items in the Water Use and Development Plan will lend weight to funding efforts to protect Lanaʻihale.

- Where drinking water is concerned, prevention of pollution is less expensive and more efficient than cleaning it up. One of the first tasks in any effective prevention program is to identify and inventory wells to be protected, areas that feed them and activities or sources of pollutants that pose a potential risk or could degrade water quality.

  - Drinking water wells on Lanaʻi were mapped, and a computer model was used to evaluate the area surrounding each well which could contribute to its water withdrawals within a 2, 5, 10, 15, 20 and 25 year time periods.

  - Water that can reach a well within two years can contribute bacteria and viruses to the drinking water in that well. Although chemical contaminants may be persistent well beyond 10 years, this is the time frame broadly used in wellhead protection programs, as it is assumed that within that time frame protective measures may be taken in the event of a spill.

  - Among the potential contaminant sources identified were the following: Wells 1, 9 and 7 are located in or near former pineapple fields. Well 9 is also near some former underground storage, and Well 7 near some old above ground storage. Traces of atrazine have been found in Well 1 in the past. Well 8 is within 1,000 feet of the Koele golf course. A list of contaminants that may be generated by the types of activities found is provided.

  - Potential management strategies and measures are described. These include regulatory measures such as overlay zones and prohibitions, non-regulatory measures such as purchase of easements or incentivization of best management practices, guidelines, education and others.

  - The recommended wellhead protection strategy involves an overlay zoning ordinance which either prohibits or prescribes best management practices for various uses at different times of travel. Also included in the strategy are non-regulatory measures, such as guidelines for mixed use developments, protective land agreements, incentives and education for best management practices or protective measures, and measures to improve well siting. Implementation of this ordinance would require coordination between the DWS and other agencies, particularly the Planning Department.

  - A draft wellhead protection ordinance is included in this document as Appendix F. The purpose of the wellhead protection strategy and ordinance is to ensure the protection of public health and safety by minimizing the risk of contamination to aquifers and sources used for drinking water supply. The proposed ordinance establishes a zoning overlay district to be known as the Wellhead Protection Overlay District. The wellhead protection strategy sets forth measures for the protection of this district, both through public education and public cooperation, as well as by creating appropriate land use regulations that may be imposed.

- The Wellhead Protection Overlay District is superimposed on current zoning districts and, based on the proposed strategy and ordinance, applies to new construction, reconstruction, or expansion of existing buildings and new or expanded uses. Applicable activities/ uses allowed in a portion of one of the underlying zoning districts which fall within the Wellhead Protection Overlay District must also comply with the requirements of this district. Requirements are set based upon whether a proposed use is within 1,000', two year time of travel or ten year time of travel to a well.

- If water levels in pumping wells reach half their initial head level, this is now grounds for designation proceedings, based on a January 31, 1990 decision by the CWRM.

  - Operating guidelines for withdrawals from Lana'i's wells were designed by Tom Nance for CCR. These guidelines were reviewed by the State Commission on Water Resource Management, and are included in the Source Water Protection Chapter.
  - These voluntary guidelines set action levels at about 2/3 of initial head in addition to the lowest allowable levels, consistent with the CWRM level of half initial head.
  - Upon reaching an action level, a well is to receive scientific review and investigation, as well as some public scrutiny.
  - Upon reaching a designation trigger or lowest allowable level, pumpage in a well is expected to stop.
  - Action levels and lowest allowable levels from CCR's voluntary well operating and management guidelines, as well as designation triggers, are provided on page 6-101.

Lanaʻi Island Water Plan Provisions

Overview

Lanaʻi faces several substantial water resource use and development challenges.

- Lanaʻi has the smallest amount of total water resources of any major inhabited Hawaiian island.
  - Gross water demands for build-out of projects with existing land use entitlements (without conservation) could exceed 90% of the total sustainable yield of the Island.
  - With conservation and supply system leak reduction measures identified in this plan, water demand for build-out of projects with existing land use entitlements would be within total Island sustainable yield but would still exceed the sustainable yield of the currently developed Leeward aquifer.
- The Lanaʻihale watershed area, which provides rainfall capture essential to support Lanaʻi's groundwater aquifers, is critically threatened by feral deer and muflon and by invasive plants.
- The existing plantation-era water supply system infrastructure is in need of substantial repair and replacement.

To address these challenges the Lanaʻi WUDP identifies several strategies that, together, may ensure adequate water supply for Lanaʻi's existing communities as well as planned growth. These strategies include:

- Diligent measures to re-establish and maintain the integrity of Lanaʻi's essential watershed areas
- Conservation measures to ensure that water is produced, distributed and used efficiently
- Development of new supply sources to distribute groundwater withdrawals and provide for increased system capacity to meet growing demand
- Deferral of additional or incremental discretionary land use development entitlements pending careful consideration of the adequacy of long term water supply sources and infrastructure.

The provisions below are identified as elements of a plan for responsible use and development of Lanaʻi's water resources necessary to maintain the long term adequacy and quality of water supplies for existing and future Lanaʻi residents and businesses.

Watershed Protection Measures

The Lanaʻihale watershed area is an essential resource that supports the groundwater aquifers that provide all of Lanaʻi's water needs. It is crucial that sufficient programmatic measures are diligently implemented to reestablish and protect the indigenous flora in the Lanaʻihale watershed area. Herbivores and invasive plants must be removed and effectively excluded from the watershed area.

The following measures have been identified as essential program components to improve and maintain the integrity of the Lanaʻihale watershed area:

- Development of a new publicly reviewed and supported comprehensive watershed protection plan incorporating the watershed protection provisions identified in Chapter 6 of the Supporting Documentation.
- Installation and maintenance of fencing adequate to exclude deer, muflon and other ungulates.
    - Maintain fencing Increments I and II and complete Increment III
    - Resolve issues regarding watershed area access
    - Eliminate ungulates from fenced watershed areas
    - Manage populations of deer and muflon outside fenced areas
- Review, funding and implementation of adequate fire protection measures for the Lanaʻihale watershed area
- Eradication or control and ongoing exclusion of invasive plants from the watershed area.
- Investigation and implementation of reasonable erosion management and appropriate reforestation measures

Existing agreements to implement these measures should be honored and enforced and further agreements, partnerships and measures as necessary should be identified, funded and implemented to effectively restore and protect Lanaʻi's watershed areas.

Water Resource Protection Measures

Several measures are identified to monitor and protect the integrity of Lanaʻi's groundwater aquifers:

- Wellhead protection : The County should draft, review and, as appropriate, adopt a wellhead protection ordinance with input from the Lanaʻi community

- Aquifer monitoring and reporting: The existing required *Periodic Water Reports* should be broken down by the 3 well service areas or the 5 individual districts and, if feasible, should be reported monthly.
- Watershed monitoring: The County and CWRM should support appropriate research and monitoring to improve understanding of aquifer recharge and determine measures to maintain or improve effective groundwater sustainable yield
- The CWRM should monitor aquifer use, conditions and contested issues on an ongoing basis to determine whether any of Lana‘i’s aquifers should be designated as groundwater management areas.
- All participating parties should abide by and enforce existing water management and allocation agreements

Water Conservation Measures

Efficient use of water and reductions in supply system leakage are essential to reduce waste of Lana‘i’s limited water resources.

- Lana‘i’s water and wastewater utilities should implement water recycling and water conservation programs targeting landscape and indoor water uses to substantially reduce water consumption to the extent allowed by the Public Utilities Commission.
- The County and public utilities should implement education and supporting measures to encourage planting of low-water-use plants for new and existing landscaping
- Lana‘i’s public water utility should reduce unaccounted for water to reasonable levels including implementation of the following measures:
    - Replace and/or repair deteriorating or leaking supply pipes including replacement of deteriorated Palawai grid pipeline
    - Implement programmatic leak detection and repair programs
    - Install floating or Hypalon Ball cover on existing 15MG brackish water reservoir

New Supply Resource Development

Sufficient new water supply resources are necessary to meet anticipated growth in water demands, distribute pumpage in the Leeward aquifer and, ultimately, to distribute pumpage as necessary to the Windward aquifer.

- Based on the analysis performed in the preparation of this plan, implementation of the following specific new supply resources is recommended in conjunction with any other measures necessary to provide economical and reliable water service:

- Develop planned Well 15 to distribute brackish groundwater withdrawals
- Replace Well 2-A equipment as necessary to provide operable system reliability
- Replace Well 3 equipment or drill new well as necessary to provide system reliability and distribution of groundwater withdrawals
- Evaluate and implement future expansion of wastewater recycling facilities
- Plan and ultimately develop operable groundwater sources in the Windward aquifer to distribute groundwater pumping and provide resources, as necessary, to provide for system growth beyond the capacity of the Leeward aquifer.

Land Use Entitlements

Water demand for build-out of projects with existing land use entitlements would exceed the capacity of the existing water system infrastructure. With implementation of the conservation and supply system leak reduction measures identified in this plan, build-out of these projects would exceed the sustainable yield of the currently developed Leeward aquifer.

Prior to issuing new land use development entitlements or subdivision approvals, the determining County agencies and any other determining administrative and regulatory agencies should ensure that sufficient water resources and infrastructure are available to meet resulting additional water demands without unreasonable risk or harm to existing or previously entitled water users and without overtaxing Lana'i's water resources. In making determinations the following factors should be considered:

- No groundwater aquifer should be drafted exceeding the 90% existing trigger for groundwater management area designation of the aquifer sustainable yield as periodically amended by the CWRM
- 500,000 GPD should be reserved for development of an agricultural park on Lana'i
- Projections of future water resource development should be based on resources that are identified and funded, with firm commitments for implementation.

LANA'I ISLAND WATER USE & DEVELOPMENT PLAN

SUPPORTING DOCUMENTATION

Supporting Documentation

CHAPTER 1

Introduction to Supporting Documentation

The *Supporting Documentation* supplement is part of the *Lana'i Island Water Use and Development Plan* (WUDP). This section presents the detailed information and analysis that support the development of the Lana'i WUDP.

Chapters 2, 3, 5 and 6 of the Supplement are identical to the corresponding Chapters 2, 3, 5 and 6 of the Draft Lana'i WUDP dated June 28, 2010 that was transmitted to the Maui County Board of Water Supply (Board) for public hearings and Board recommendations.

Chapter 4 *Demand Analysis* of the *Supporting Documentation* is identical to the corresponding Chapter 4 of the June 28, 2010 draft with the exception of the addition of several Resource Development Strategy Water Use tables that are edited moved from Chapter 7of the June 28, 2010 draft.

Chapter 7 of the June 28, 2010 draft addressed Policy Issues and Recommendations. Chapter 7 of the Supporting Documentation has been amended by removing the recommendations as well as the table and text referring to implementing water allocations. The recommendations are now addressed in the *Lana'i Island Water Plan Provisions* section of the Lana'i WUDP. The water allocation table in the June 28, 2010 draft has been relabeled and is now included as part of the Resource Development Strategy Water Use Tables documented in Chapter 4.

Chapter 8 of the June 28, 2010 draft identified several implementing actions, including actions listed in an implementing matrix and several tables. Some of these implementing actions are now identified in the *Lana'i Island Water Plan Provisions* section of the Lana'i WUDP. Chapter 8 of the *Supporting Documentation* omits most of the text and tables from the previous draft but retains the Implementation Matrix with some deletions. The Implementation Matrix is re-characterization as a list of possible actions that could support the intent of the Lana'i WUDP.

Introduction to Supporting Documentation

CHAPTER 2

Regulatory Framework

In This Chapter

Key Points

- This chapter summarizes pertinent regulations that affect water and water-related issues on Lana‘i. Several regulations are briefly summarized including
    - Requirements for the Water Use and Development Plan
    - Other provisions of the State Water Code
    - The Safe Drinking Water Act
    - Other Federal Regulations that have bearing on water
    - Various State Requirements that have relevance to water
    - Hawai‘ian principles of water management
    - A Table of Regulations is provided with short summaries of over 50 regulations.

Regulations which must be considered in drafting a Water Use and Development Plan include those which pertain to the drafting and implementation of the plan itself, as well as those which may affect utility operations, strategies or cost of capital decisions, and in Hawai‘i, also those which pertain to traditional Hawai‘ian Uses. Prominent among those affecting utility operations are the requirements of the Safe Drinking Water Act, but other federal environmental requirements such as the Clean Water Act, the Endangered Species Act and Government Accounting Standards must also be considered. For instance, if CCR decides to utilizie the Kehewai wells discussed in Chapter 5 of this document, it will have to consider provisions of the Endangered Species Act. If it decides to develop desalinization plants, it will have to consider the fact that the ocean surrounding Lana‘i is considered Class AA marine waters, meant to remain in as close to their natural state as possible. If CCR decides to use wells in Maunalei, it will have to consider old kuleana parcels in the area. The text below summarizes some of the more notable requirements. The table in Figure 2-1 provides additional detail.

Requirements for the Water Use & Development Plan

Constitution: The duty to conserve and protect water resources is established in the State Constitution. Article XI, Section 1 states, in pertinent part, "The State and its political subdivisions [emphasis added], have the responsibility to......conserve and protect resources...(including) water". Section 7 provides for a Water Resources Agency, which is the Commission on Water Resource Management (CWRM). This agency has primacy in dealing with water resource issues. However, the reference to the State's political subdivisions makes it clear that the counties, which are the political subdivisions of the State, also have responsibility to protect and conserve water resources.

Hawai'i Revised Statutes & Hawai'i Administrative Rules: State requirements for the plan are delineated broadly in HRS §174(C)-31, the State Water Code, and in HAR §13-7-170. More detailed delineation of requirements is found in the Commission's guidelines, known as the *State-wide Framework For Updating the Hawai'i Water Plan*.

HRS Part III - Chapter 174C - 31 requires that there be a Water Use and Development Plan for each County; that these Water Use & Development Plans be consistent with County General and Community Plans, State Land Use Classifications and policies; that the costs to maintain the plan be borne by the Counties, and; that the County Water Use & Development Plans include as a minimum: the status of water and development, an inventory of uses and sources, future uses and related needs; regional plans for development, costs and relationship to water resource protection and quality. It also requires that each county and the Commission incorporate the current and foreseeable development and use needs of the Department of Hawai'ian Homelands.

Hawai'i Administrative Rules - Title 13 Department of Land & Natural Resources - Subtitle 7 - Water Resources - Chapter 170 - Hawai'i Water Plan sets out further guidelines for the Water Use & Development Plans. According to this Chapter, each Water Use & Development Plan shall be consistent with:

- The State Water Resources Protection Plan
- The State Water Quality Plan
- State land use classifications and policies
- County zoning and land use policies

In addition, the Water Use & Development Plans should:

- Be updated to remain consistent with the plans & policies listed above
- Consider a 20 year projection for analysis

- Utilize the hydrologic units designated statewide by the CWRM for presentation of data and analysis
- Utilize information from the master water resources inventory identified within the Water Resources Protection Plan.

The Water Use & Development Plans shall include as a minimum:

- The status of water and related land development, including an inventory of existing water uses for domestic, municipal and industrial users, agriculture, aquaculture, hydropower development, drainage, re-use, reclamation, recharge and resulting problems and constraints.
- Future land uses and water related needs
- Regional plans for water development, including recommended and alternative plans, costs, adequacy of plans and relationship to Water Resources Protection and Water Quality Plans.

The ***Statewide Framework for Updating the Hawai'i Water Plan*** requires that the County Water Use and Development Plans:

- Set forth allocations of water to land use, to be adopted by ordinance
- Provide for update of demand, supply, hydrology, infrastrure and capital needs on a five year cycle of update.
- Contain appropriate recognition of the current and future development needs of the Department of Hawai'ian Homelands
- Include preparation of regional plans for water development, including recommended and alternate plans, costs, adequacy of plans and resources to meet proposed or anticipated needs, and relationship of County plans to the State Water Resources Protection Plan and Water Quality Plan
- Comply with all applicable environmental, health & other regulations
- Be consistent with the State Water Resources Protection Plan and Water Quality Plan, and demonstrate integration of the State Water Projects Plan and State Agricultural Water Use & Development Plan
- Be drafted in coordination with the Commission on Water Resources Management, including submittal of the proposed WUDP process description to CWRM (process proposal presented to Board September 2003, to CWRM February, 2004 and to Council April 2004 - approved by all), coordination throughout the process with CWRM, milestone briefings to CWRM including review of demand methodologies, and final project descriptions, including recognition and discussion of how information from the State Water Projects Plan and State Agricultural Water Use & Development Plan are integrated.
- Be drafted with substantial and credible public involvement that shall include as a minimum: identification of essential stakeholders, gathering and analysis of information on community values and incorporation of these into the plan; work with advisory or other groups (technical, focus, workshops, etc.), stakeholder interviews, etc.; possible inclusion of workshops, questionnaires, public meetings, newsletters, fact sheets, web sites, slide shows, press coverage, bill inserts or other public

outreach; clearly described public participation process within the document, and: clearly demonstrated incorporation of the results of public participation and review.

- Include a clear description of the following: planning objectives which form the basis of the resource strategy selection; process by which objectives were identified or defined; resource and supply strategies identified; process of evaluation, assessment and selection; demonstrable public involvement in an objective setting, evaluation and selection of alternatives; well delineated evaluation criteria for alternative resource scenarios; consideration of multiple demand scenarios, including as a minimum low, medium and high forecasts; forecasts for 1, 2, 3, 4, 5, 10, 15 and 20 years, as well as forecasts beyond 20 years if anticipated demand exceeds or may be close to established sustainable limits; incorporation of least cost planning; land use plans and how the WUDP addresses them; resource protection needs and plans; underlying assumptions and data; models or computer programs used in the planning process; existing systems, conveyances, resources, conservation or re-use programs; etc.
- Include screening of resource and supply alternatives by a process to include as a minimum: initial listing of a broad group of possible options for supply, to include as a minimum options in the categories of new supply, transmission, storage, conservation and use of reclaimed water; initial screening of a broad list of options by real criteria which must be specifically explained such that a “poor” option means one that does an unacceptable job of meeting defined objectives; initial screening should leave a “finalist” group in the neighborhood of half a dozen strategies; finalist strategies to be evaluated against uncertainties, contingencies and other defined objectives; final screening selection to result in a flexible sequence of supply, infrastructure, storage, transmission, conservation, reclaimed water, resource protection and other actions to meet the county’s water objectives.
- Include a well described implementation plan, to include near term, medium term and long term as well as allowance for flexibility.

Discussions with Commission on Water Resource Management Staff - Specific to the Lana‘i Plan: Early on in the process of forming the Lana‘i Water Advisory Committee as advisory to the Department of Water Supply, CWRM staff met with DWS staff to delineate specific requirements or targets for inclusion in the Lana‘i Water Use & Development Plan. These included: demand analysis showing various methods and scenarios; discussion of the regulatory framework and context and considerations affecting the plan; description of existing resources and systems; discussion of capital and operational considerations to include supply-side and demand-side options and alternate source development options; discussion of resource issues; discussion of policy considerations including relation to land use policies, preparedness for contingencies, prevention of over-pumpage or other externalities; an implementation matrix and an executive summary of key points.

The Maui County Charter - §8-11.6 requires that the Department of Water Supply prepare up-to-date Water Use & Development Plans for review by the Board of Water Supply and enactment by the Maui County Council by ordinance.

Maui County Code Chapter 14.02 stipulates that updates to the Water Use & Development Plan shall be deemed part of County Code Chapter 14; that the plan shall serve as a guideline to the

Council, Department and all other agencies of the County for approving or recommending the commitment of water resources or funds to develop resources; that the Plan shall be updated and amended as necessary to remain consistent with the Community Plans; that amendments to the plan as proposed by the Council, Director or any agency be referred to the Board of Water Supply for review and recommendation; that the Board of Water Supply shall hold hearings and transmit revisions and recommendations; and that upon receipt of the proposed amendment, the council shall act within forty-five days or the amendment is deemed disapproved. This chapter also stipulates that whenever the Planning Director recommends revisions to the general plan pursuant to §8-8.3(3) of the revised charter of the County of Maui (1983) as amended, the task force shall recommend to the Board amendments to the plan so as to be consistent with any community plan amendment. (Ord 3404 §5 (part), 2006)

Other Provisions of the State Water Code

Aside from requirements for the State Water Plan described above, the State Water Code, HRS 174-C, contains and enables the State Commission on Water Resource Management to establish requirements for: registration of wells, well construction permits, pump installation permits, well construction and installation standards; sealing and filling abandoned wells; and reporting of both pumped water and surface water use. It requires the State Commission on Water Resource Management to establish and maintain an instream use protection program, including setting instream flow standards; issuing permits for construction, alteration or abandonment of stream diversion works. It contains provisions for protection of native Hawai‘ian water rights. The code also sets forth criteria for designation of ground water management areas or surface water management areas, and procedures for designated areas.

The criteria for designation of a groundwater management area under the State Water Code are:

- 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 ground water management area
- Whether there is an actual or threatened water quality degradation, as determined by the Department of Health
- Whether regulation is necessary to preserve the diminishing ground-water supply for future needs, as evidenced by excessively declining ground-water levels
- Whether the 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 up-coning or encroachment of salt water
- Whether the chloride contents of existing wells are increasing to levels which materially reduce the value of their existing uses
- Whether excessive preventable waste of water is occurring
- Whether serious disputes respecting the use of ground-water resources are occurring
- Whether water development projects that have received any federal state or county approval may result in the opinion of the Commission in one of the above conditions

The Hawai'i Administrative Rules - Title 12 - Subtitle 7 are the administrative rules for the State Water Code. HAR §12-7-168 contains rules for well drilling and pump installation permits, well completion reports, registration of existing wells, well inspection, abandoned wells, stream diversion permits, stream diversion completion reports, stream diversion works inspection, and abandoning stream diversions. HAR §12-7-169 sets forth rules for determining instream flow standards, procedures for public notification and adoption, stream channel alteration permits, and provisions for emergency work. HAR § 12-7-171 covers designation and regulation of water management areas.

Safe Drinking Water Act

Laws enacted by Congress are compiled in the United States Code. The Office of the Law Revision Counsel of the U.S. House of Representatives prepares and publishes the United States Code pursuant to section 285b of Title 2 of the Code. The Code is a consolidation and codification by subject matter of the general and permanent laws of the United States. The Code does not include regulations issued by executive branch agencies, decisions of the Federal courts, treaties, or laws enacted by State or local governments. Regulations issued by executive branch agencies are found in the Code of Federal Regulations. Proposed and recently adopted regulations are published in the Federal Register. In the United States Code, the Safe Drinking Water Act is 42 U.S.C. §300 et. seq. or Title 42, Chapter 6A, Subchapter XII. In the Code of Federal Regulations it is 40 CFR Parts 140-149.

The Safe Drinking Water Act was passed by Congress in 1974 and amended in 1986 and 1996. Its purpose is to protect public health by regulating the nation's public drinking water supply. The law requires the United States Environmental Protection Agency (US EPA, EPA) to set national health-based standards for drinking water to protect against both naturally occurring and man-made contaminants, which are the National Primary Drinking Water Regulations.

History The Interstate Quarantine Act of 1893 authorized the Surgeon General of the U.S. Public Health Service to "make and enforce such regulations as in his judgement are necessary to prevent the introduction, transmission or spread of communicable disease from foreign countries into the states or possessions, or from one state or possession into any other state or possession". Interstate Quarantine Regulations were published in 1894. In 1912 the use of a common drinking cup on interstate carriers was prohibited. In 1914 the US Public Health Service issued the first bacteriological drinking water standard. It applied to any system that provided water to an interstate common carrier. The Public Health Service Standards were updated and revised in 1925, 1942, 1946 and 1962. The 1962 Public Health Service Standards were the precursor to the Safe Drinking Water Act, and regulated 25 health and aesthetic parameters in Drinking Water. When the 1974 Safe Drinking Water Act was passed, it enacted interim regulations which referenced the 1962 public health standards, and required the EPA to set national health-based standards for drinking water to protect against both naturally occurring and man-made contaminants. It required the EPA to establish National Primary Drinking Water Regulations within 180 days, and so the National Primary Drinking Water Regulations were first passed in 1975. From that time to 1986, approximately 26 contaminant regulations were completed and issued. The 1986 Amendments to the Safe Drinking Water Act required the EPA to accelerate the pace of regulation. The 1986 Amendments required the EPA to regulate 83 contaminants by 1992, and to regulate 25 more chemicals every three years after 1992. The 1986 Amendments also initiated monitoring of unregulated contaminants, mandatory filtration of surface water systems, mandatory disinfection of all water systems, public notification of violations and established a requirement for States to develop wellhead protection. The 1996 amendments overturned the required schedule, enabling the EPA to establish a process for selecting contaminants based on scientific data. The 1996 amendments also took the source water protection and public information initiatives of the 1986 amendments a few steps further, by requiring States to develop programs for preparing source water assessments for all public water supply systems (not merely those served by wells), and adding requirements for operator training, and consumer confidence reports. The 1996 amendments established the State Revolving Loan Fund, to provide funding for critical water system improvements.

Applicability The Safe Drinking Water Act, and National Primary Drinking Water Regulations under the Safe Drinking Water Act apply to Public Water Systems (PWSs). PWSs are defined as those which either have 15 service connections or more, or serve 25 or more people for more than sixty days of the year.

Lana'i has two public water systems under the definitions of the National Primary Drinking Water Regulations. The first covers the areas of Lana'i City to Kaumalapau (PWS 237) and the second includes Manele, Hulopo'e and the Palawai Irrigation Grid (PWS 238). Public Water Systems under the Safe Drinking Water Act are further broken down into Community Water Systems, Non-Community Water Systems, Non-Transient Non-Community Water Systems and Transient Non-Community Water Systems, with different applicability of regulations for each. Lana'i's drinking water systems are considered Community Water Systems, in that they each serve 15 or more service connections or 25 or more residents year-round.

There are many rules or sub-parts of the National Primary Drinking Water Regulations under the Safe Drinking Water Act, each with its own applicability provisions based on size or type of water system or type of source or treatment used. Because there are two separate regulated drinking water systems on Lana'i, the size of each is smaller than the total population. In some cases this can result in a mild time lag in reaching certain regulatory thresholds, such as sampling requirements or compliance deadlines for different sized systems.

Requirements

The National Primary Drinking Water Regulations, first passed in 1975, are legally enforceable standards that apply to public water systems. Primary standards protect the public health by limiting the levels of contaminants in drinking water. Maximum contaminant levels are set for microorganisms, disinfectants, disinfection by-products, inorganic chemicals, organic chemicals, and radionuclides, as well as sampling, analytical and reporting methods. EPA has regulated more than 90 contaminants. MCLs for these contaminants are known as the National Primary Drinking Water Standards.

The EPA prioritizes contaminants for protection using a risk-based analysis that considers both the toxicity or potential harmfulness of the contaminant, and the extent of exposure within the population. EPA sets both a Maximum Contaminant Level Goal (MCLG) and a Maximum Contaminant Level (MCL). The difference is that the Maximum Contaminant Level Goal (MCLG) is based purely on health effects without regard to treatment feasibility or cost. For known or probable carcinogens, the Maximum Contaminant Level Goal is set at zero. For non-carcinogens the Maximum Contaminant Level Goal is set at the "No Observed Adverse Effect Level", or the "Lowest Observed Adverse Effect Level" that has been identified from scientific study of humans and animals. For chemicals that are deemed "potential" carcinogens, either the reference dose with a safety factor is used, or the 1 in 10-5 or 1 in 10-6 risk range is used, where levels are estimated to result in no more than x cancers per 100,000 or million population.

The Maximum Contaminant Level (MCL), on the other hand, is based both on health concerns and other factors such as the available methods for measuring contaminant levels, whether targeted contaminants can even be detected at the MCLGs, available techniques for treating contaminants, and costs and logistics of such treatments. These MCLs and MCLGs are known collectively as the National Primary Drinking Water Standards.

The Public Notification Rule, published in 2000, requires that any exceedances to National Primary Drinking Water Standards (NPDWS) must be reported to the State Department of Health and to the public. Exceedances are classed into three tiers. Tier 1 notifications are those for which immediate notice or notice within 24 hours is required. These include fecal coliform violations, nitrates, nitrites or total nitrate and nitrite Maximum Contaminant Level (MCL) violations, chlorine dioxide Maximum Residual Disinfectant Level (MDRL) violations, exceedance of maximum allowable turbidity levels, waterborne disease outbreak or emergencies, as well as monitoring violations. Tier 1 notifications must be issued within 24 hours of the utility becoming aware of the violation. Notice must be provided via radio, TV, hand delivery, posting or other method (specified by DOH). Consultation with DOH must also be initiated within 24 hours. Tier 2 notifications include any other MCL or MRDL violation other than those designated as tier one, various monitoring violations and failure to comply with variance and exemption conditions. Notice of these must be published as soon as practical, or within thirty days. Notice should be repeated every three months until the violation is resolved. Community Water Systems must also send notice via mail or direct delivery. Tier 3 notifications are for monitoring or procedure violations, except for those which the States have elevated to Tier 1 or 2, operation under variance or exemption (need not be violation) or other special public notices such as secondary maximum contaminant level exceedance, availability of unregulated contaminant monitoring results, etc. These notices go out within 12 months and annually, by mail or direct delivery, and can be combined into one annual mailing.

The National Secondary Drinking Water Regulations are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor or color) in drinking water. EPA recommends secondary standards to water systems, but does not require water systems to comply. However, states may choose to adopt them as enforceable standards. Secondary standards have been set for aluminum, chloride, color, copper, corrosivity, fluoride, foaming agents, iron, manganese, pH, silver, sulfate, total dissolved solids and zinc. The secondary standard for chloride is 250mg/L.

The Drinking Water Contaminant Candidates List consists of both microbiological and chemical contaminants which are not currently regulated, but which are known to cause potential health impacts, anticipated to occur in public water systems, and may require future regulation. The first Contaminant Candidate List was published in 1998. It included 10 microbiological and 50 chemical contaminants. Final regulatory determination for the first Contaminant Candidate List was published on June 3, 2002. It concluded that sufficient data was available to make regulatory determinations for 9 of the contaminants, and that no primary drinking water regulation was necessary for any of these nine, but issued guidance on Acanthamoeba and health advisories for magnesium, sodium and sulfate. The second Contaminant Candidate List was finalized in 2005, and included 51 contaminants. In July 2008, EPA issued final regulatory determination that no regulatory action was appropriate for eleven of the fifty-one contaminants on that list, and that data gaps prevented EPA from making a regulatory determination for the other forty contaminants at this time. One State agency suggested that 2,4-Dinitrotoluene and 2,6-Dinitrotoluene should have been regulated, but EPA replied that these contaminants appeared to be a local and not a national problem. The third Draft Contaminant Candidate List was published in February, 2008. It includes 11 microbial and 93 chemical contaminants, and may be found at http://www.epa.gov/safewater/ccl/ccl3.html.

The Total Coliform Rule, passed in 1989, applies to all public water systems. It establishes a maximum contaminant level (MCL) based on the presence or absence of total coliform. Coliform are a group of ubiquitous, mostly harmless bacteria, used as a surrogate or indicator for a large group of more harmful microorganisms. Presence of these organisms in a drinking water system is taken as a potential indication of problems in the treatment or distribution, environmental contamination, or possible human or animal waste contamination, requiring disinfection of the water. The rule requires a sample siting plan, subject to review by DOH, to insure that samples are collected at sites which are representative of water quality throughout the distribution system. Systems serving 2,501-3,300 people are required to take 3 samples per month. Systems serving 3,301-4,100 people are required to take 4 samples per month. If any routine sample is coliform positive, at least three repeat samples must be taken within 24 hours of learning of the result: at the original sampling site, within five connections upstream, and within five connections downstream. Repeat samples must be analyzed for fecal coliforms or *E coli* as well as total coliform. Systems collecting fewer than 5 routine samples per month and having one or more total coliform positive samples in one month must collect at least 5 samples during the following month unless the State has determined the reason for the positive finding and that the problem has been corrected. The rule requires sanitary surveys every five years for systems collecting fewer than five total coliform samples per month. Systems serving Ground Water Under the Direct Influence of Surface Water (GWUDI) but meeting the criteria for avoidance of filtration must collect and have analyzed one coliform sample each day that the turbidity of the water exceeds 1 NTU. This sample must be collected from a tap near the first service connection.

The Unregulated Contaminant Monitoring Rule (UCMR) The 1986 amendments to the Safe Drinking Water Act required public water systems to monitor for specific unregulated contaminants on a five year cycle and to report the monitoring results to the States. Data was compiled in a federal Unregulated

Contaminant Monitoring Information System. Data on unregulated was collected for 62 contaminants in 40 states from1987 - 1992 (UCM 87), and for 48 contaminants in 35 states from 1993-1997 (UCM 93). The 1993 Amendments to the Safe Drinking Water Act added contaminants to the unregulated contaminant list for required monitoring, and the 1996 Amendments to the Safe Drinking Water Act directed EPA to develop a revised program for Unregulated Contaminant Monitoring, and to limit monitoring requirements to 30 contaminants per five year cycle. This program was published in 1999 as the Unregulated Contaminant Monitoring Rule and updated in 2000, 2001 and 2007. UCMR 1, passed in 1999 established three lists of contaminants for monitoring. List one contaminants had established, available testing methods. Monitoring of these was required by large and selected small systems. List two contaminants had testing methods only recently developed. Monitoring of these was to be required by selected large and small systems. Contaminants on list three had known health effects, and were identified for development of analytical methods, so that they could be included in future UCM. The UCMR 2, was signed in December 2006, and printed in the January 2007 CFR. UCMR 2 established the second cycle of monitoring with an updated list of 25 contaminants, to be monitored during 2008-2010. As before it required list one contaminants to be monitored by large and selected small systems, and list two contaminants to be monitored by selected large and small systems. An added requirement was set that laboratories used in sample analysis have EPA approval to analyze samples for the UCMR 2. The new list of contaminants included (among other contaminants) various flame retardants, explosives, parent acetanilides, acetanilide degradates, and nitrosamines.

The Groundwater Rule, finalized in 2006, provides for additional, multi-level protection against microbial pathogens in Public Water Systems that use groundwater. These protections are source monitoring, compliance monitoring, more frequent sanitary surveys, and corrective action.

Ground water systems have to monitor their sources (wells) if there is a total coliform positive sample in the distribution system. Sources deemed susceptible to contamination may have to monitor the source even if there is no coliform positive in the distribution system. If disinfectants (such as chlorine) are added to the systems, routine monitoring is required. Systems serving less than 3,300 people have to have a daily grab sample. Systems serving more than 3,300 people have to have a continuous analyzer. The Lana'i City system is currently regulated based on an estimated population of 3,000. This may change with the 2010 population census. States have the authority to require additional source monitoring in aquifers deemed high risk or susceptible to contamination. Examples of criteria that could lead to an aquifer being considered high risk include high population density combined with on-site wastewater treatment; alluvial or coastal plain sand aquifers in which viruses may travel further and faster than bacteria; shallow unconfined aquifers, aquifers with thin or absent soil cover; wells previously identified as having been fecally contaminated, areas in which aquifers of limited geographic extent underlie communities without centralized sewage treatment, etc.

For groundwater systems that already treat drinking water to achieve 4-log (99.99%) removal of viruses, regular compliance monitoring is required to insure that 4-log (99.99%) removal of viruses is maintained. Groundwater systems that do not provide at least 4-log treatment of viruses must conduct triggered source water monitoring upon being notified that a TCR sample is total coliform positive. Within 24 hours of receiving notice of a coliform positive sample, the system must collect at least one ground water sample from each ground water source unless there is a specifically approved triggered source water monitoring plan. Source water samples must be tested for E. coli, enterococci, or coliphage. If the source sample is fecal indicator-positive, the system must notify the State and the public. Unless notified by the State to take immediate corrective action, the system must collect and test five additional source water samples for the presence of the same state-specified indicators within 24 hours. The State also has the option to require assessment source water monitoring, which would require 12 monthly samples.

Regular sanitary surveys are also required. Lana'i's water systems are required to have a sanitary survey every three years. A sanitary survey is an on-site review of the water source(s), facilities, equipment, operation and maintenance of a Public Water System, performed by the State primacy agency (Department of Health), for the purpose of evaluating the adequacy of such sources, facilities, equipment, operation and maintenance for producing and distributing safe drinking water. State Department of Health staff write descriptions of the system, point out shortcomings, and discuss how to fix them. Elements reviewed generally include sources, treatment processes, supply pumps and pumping facilities, storage facilities, distribution systems, monitoring, reporting and data verification, system management and operations, and operator compliance with state requirements.

Corrective action is required where deficiencies are discovered. Deficiencies are classed in one of three categories: 1) significant or major; 2) moderate, or 3) minor. If deficiencies are identified, the PWS will be notified within 30 days and has 120 days after initial State notification to complete the required corrective actions. Treatment technique requirements are that a system correct all the deficiencies, provide alternate sources of water, eliminate the sources of contamination, or provide treatment that can reliably achieve 4-log (99.99%) removal of viruses. Further, the public must be notified of any uncorrected significant deficiencies and /or fecal contamination. Failure to comply with required corrective actions result in violations.

The Surface Water Treatment Rule, Interim Enhanced Surface Water Treatment Rule, and Long Term Enhanced Surface Water Treatment Rules I & II passed in 1989, 1998, 2002 and 2006 respectively, contain provisions that primarily apply to surface water systems, systems serving mixed ground and surface water, or systems serving Groundwater Under the Direct Influence of Surface Water (GWUDI). They do not currently apply to Lana'i, with one possible exception worthy of note. The 1998 sanitary survey indicated that the Maunalei Tunnel systems, once a major source for the city, could be possible GWUDI, or ground water under the direct influence of surface water, due to run-off entering the tunnel. If these sources were in fact deemed to be GWUDI, this could trigger Surface Water Treatment Rule requirements, which are not applicable at present. Ground Water Under the Direct Influence of Surface Water is defined as "any water beneath the surface of the ground with significant occurrence of insects or other macroorganisms, algae, or large diameter pathogens such as Giardia lamblia or Cryptosporidium, or significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions" (40CFR 141)

The Disinfection Byproducts Rule applies to all sizes of community water systems that either add a primary residual disinfectant other than ultraviolet light to drinking water, or deliver water that has been treated with primary residual disinfectant other than ultraviolet light. The Stage I Disinfectant and Disinfection Byproduct Rule updated and superseded the 1979 regulations for total trihalomethanes, established Maximum Contaminant Levels and Maximum Contaminant Level Goals (MCLGs) for total trihalomethanes (TTHM), haloacetic acids, bromate (where ozonation is used) and chlorite (where chlorine dioxide is used). It also sets Maximum Residual Disinfectant Levels (MRDLs) for chlorine, chloramine and chlorine dioxide, and requirements for public notification if maximum contaminant levels or maximum residual disinfectant levels are exceeded. Water in Lana‘i is chlorinated, and so Lana‘i Water Company is subject to this rule, and must monitor for trihalomethanes; chloroform, bromodichloromethane, dibromochloromethane, and bromoform; and for five haloacetic acids (HAA5): monochloracetic acid, dichloracetic acid, trichloracetic acid, bromoacetic acid and dibromoacetic acid. Under the Stage II Disinfection ByProducts Rule, all systems will conduct an Initial Distribution System Evaluation (IDSE) to identify locations with high disinfection byproduct concentrations. These locations will then be used as sampling sites for compliance monitoring. Systems will have to perform one year of increased monitoring for TTHM and HAA5. Systems with populations between 500 and 3,300 and systems with populations between 3,301 and 9,999 must monitor twice per quarter. Lana‘i will have to complete its IDSE by March 31, 2010, and submit the report by July 1, 2010. Upgraded compliance monitoring will take effect October 1, 2013. By this date, all systems must have completed their State II DBPR Compliance Monitoring Plan and begin compliance monitoring. Stage II also changes from an average of system results to locational running annual average (LRAA), meaning that systems must now comply at each sampling point, rather than merely by system-wide average.

The Consumer Confidence Report Rule, finalized in 1998, requires Public Water Systems to send to each consumer annual reports which contain fundamental information about their drinking water. The reports should include information on:

- the aquifer river or other source of drinking water;
- a summary of the susceptibility to contamination of the local drinking water source, based on state water assessments;
- information on how to obtain a copy of the system’s complete source water assessment;
- the level or range of levels of any contaminant found in the drinking water, as well as EPA’s Maximum Contaminant Level for comparison;
- the likely source of that contaminant in the local drinking water supply;
- the water system’s compliance with other drinking water-related rules;
- an educational statement for vulnerable populations about avoiding Cryptosporidium;
- educational information on nitrate, arsenic or lead in areas where these commandants may be a concern; and
- phone number of additional sources of information, including the water system and EPA’s Safe Drinking Water Hotline (800-426-4791)

If the island is designated, the company will have to apply for existing use permits for use as of the date of designation, as well as for future use permits for any additional water needed subsequent to that date. Even without designation, the State Water Code requires that water pumpage and surface water use be reported regularly, and that permits be issued for well drilling and pump installation.

The Lead and Copper Rule, passed in 1991 establishes action levels and a treatment technique for lead and copper. It requires public water systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb (parts per billion) or copper concentrations exceed an action level of 1.3 ppm (parts per million) in more than 10% of customer taps, systems must inform consumers about steps they can take to protect their health and must undertake actions to control erosion. The first three years of lead & copper sampling on Lanaʻi were1993-1995. The 10th percentile lead level did not exceed the action level. As a result, Lanaʻi has been on a reduced sampling schedule since 1995, and so its only requirements with regard to the Lead and Copper rule involve monitoring every three years. Corrosion control is not required at this time. Monitoring continues once each three years for a smaller sample size. Based on system size, a minimum 20 samples were required initially. Resident population as of 2005 was expected to exceed 3,301, but official disaggregated census data counts are still not available on which to estimate this anticipated increase. If the island were served by a single system, or if resident population served by PWS 237 were to exceed 3,300, the number of samples required would double. Therefore it is not clear whether additional samples will be required in the near future, even under reduced monitoring.

Operator Certification Rule The 1996 Safe Drinking Water Act amendments directed EPA to initiate a partnership with states, water systems and the public to develop information on recommended operator certification requirements, issue guidelines specifying minimum standards for certification and re-certification of operators, and reimburse training and certification for systems serving 3,300 persons or fewer through grants to the states. Baseline standards were published by EPA in February of 1999. Systems serving 3,300 or fewer persons can be reimbursed the costs of training and certification, including per diem for unsalaried operators. Both systems on Lanaʻi fall within this eligibility criteria according to DOH estimated population served. Operator certification is being implemented by the States. System operators are required to be certified by the Hawaiʻi State Department of Health. As of 2008, Lanaʻi Water Company is required to have one grade 2 certified operator on duty at all times, with two certified operators on staff.

Other Federal Regulations

The Public Health Security and Bioterrorism Preparedness and Response Act of 2002 is divided into five titles with regulations to protect national food, drug and water supplies as well as other provisions. Requirements for drinking water security and safety are found in title IV of the Act. Among the provisions of the act, all community water systems serving over 3,300 people are required to prepare a vulnerability assessment and emergency response plan. Completion of vulnerability assessments was required by June 30, 2004 and emergency response plans by December 31, 2004. Vulnerability assessments are treated as privileged information for security purposes. As of the writing of this Water Use & Development Plan, the State Department of Health lists the population served by the Lanaʻi City Water System as 3,000, so Lanaʻi may not have been technically required to produce a Vulnerability Assessment.

The Occupational Safety and Health Act of 1970 was enacted to assure worker and workplace safety. It established the National Institute for Occupational Safety and Health, as well as a new division of the U.S. Department of Labor called the Occupational Safety and Health Administration. Under OSHA standards are set to limit and protect against exposure to toxic chemicals and fumes, noise levels, mechanical dangers, heat or cold stress and unsanitary conditions. Employers have a legal obligation to inform employees of safety and health standards that apply to their workplace. Provisions for site safety for operations such as pipe replacement and repair, road work, confined space entry in manholes, handling chlorine, and other provisions are among those that would apply to Lanaʻi Water Company.

The Emergency Planning and Right to Know Act 42 U.S.C. §11011 et. seq. applies to both workers and the public. It requires annual submission of chemical inventories and risk management plans where specified substances over a given quantity are stored - such as chlorine in excess of 2,500 pounds. It also requires that MSDS sheets be available for any substance stored in quantities over the Threshold Planning Quantity - 100 pounds for chlorine. This rule also requires reporting of spills or leaks over "Reportable Quantities" - 10 pounds for chlorine gas release.

Well drilling slurries, lubricating fluids and well purge wastewaters are subject to provisions under the Clean Water Act - National Pollutant Discharge Elimination System 40CFR Parts 100-140, 400-470 (NPEDES part 122) and HAR 11-55.

Pumps and generators can require air pollution and noise pollution permits or controls pursuant to the Clean Air Act 42 U.S.C. 7401-7671q.; 40 CFR 50-95 , HRS 342 B; and the Noise Pollution Control Act 42 USC 4901-4918; 40 CFR Parts 204, 211; HRS 342 F.

The Endangered Species Act, enacted by congress in 1973, provides a legal mechanism for the conservation of endangered and threatened species and the ecosystem on which they depend. The act requires the Secretary of the Interior to list threatened and endangered species based on established criteria; and to determine and designate critical habitats for listed species. The Secretary of the Interior is further required to develop recovery plans for listed species and report to congress on efforts to implement these plans, and to publish agency guidelines for the implementation of the act. The Secretary of the Interior, together with the Secretary of Agriculture for the National Forest System, must establish and implement a program to conserve fish, wildlife and plants, including those listed. The act authorizes acquisition of land for that purpose. It also authorizes cooperative management with the States and financial assistance for the purpose of conserving listed species. Trade in listed species is prohibited. All Federal agencies are required to consult with the Fish and Wildlife Service whenever they wish to fund, authorize, or carry out an action that could affect an endangered or threatened species or adversely modify the species' critical habitat. This includes both direct actions, such as work in a given area, and indirect actions, such as registration of pesticides that may be used in a given area. The act is limited to projects which involve federal funds, licenses or permits.

The US Fish and Wildlife Service is the agency within the Department of Interior that has been establishing critical habitat areas. In Hawaiʻi, the US Fish & Wildlife Service initially found that critical habitat designation for three of the thirty-seven species was prudent, but deemed it not prudent for the other thirty-four plants because it would not benefit the plant or would increase the degree of threat to the species. This determination was challenged in *Conservation Council for Hawai'i vs. Babbitt* 2F, Supp 2d 1280 (D. Haw 1998). In 1998, the US District Court for Hawai'i ordered the US Fish & Wildlife Service to review the prudency findings for 245 Hawai'ian species, including the 37 species on Lana'i, and to publish critical habitat determinations for at least 100 of the species by 2000, and the rest by 2002. At that time thirty seven species on Lana'i were listed as endangered or threatened under the Endangered Species Act. (An updated list of these species is found in Appendix D). In response to these rulings the US Fish and Wildlife Service proposed eight critical habitat units, initially covering about 19,405 acres on the island of Lana'i. However, the majority of these were not included in the final ruling, as illustrated on the image below from the January 9, 2003 Federal Register, (Vol 68, No. 6, also found in Appendix D). This decision was based in part on ongoing management efforts and establishment of the Lana'i Forest and Watershed Partnership. Despite establishing less critical habitat than initially proposed, the final determination as published in the Federal Register was instructive. It indicates critical actions for preservation of the watershed in Lana'i;

"In general, taking all of the above recommended management actions into account, the following management actions are ranked in order of importance:

- Feral ungulate control;
- Wildfire management;
- Non-native plant control;
- Rodent control;
- Invertebrate pest control;
- Maintenance of genetic material of the endangered and threatened plant species;
- Propagation, reintroduction, and augmentation of existing populations into areas deemed essential for the recovery of the species;
- Ongoing management of the wild, outplanted, and augmented populations;
- Maintenance of natural pollinators and pollinating systems, when known;
- Habitat management and restoration in areas deemed essential for the recovery of the species;
- Monitoring of the wild, outplanted, and augmented populations;
- Rare plant surveys; and
- Control of human activities/access

(Service 1995,1996a, 1996b, 1997, 1998a, 1998b, 1999, 2001). On a case-by-case basis, some of these actions may rise to a higher level of importance for a particular species or area, depending on the biological and physical requirements of the species and the location(s) of the individual plants. "

FIGURE 2-1. Endangered Species Act - Critical Habitat Designation - Summary of Changes from Proposed Rule to Final Rule

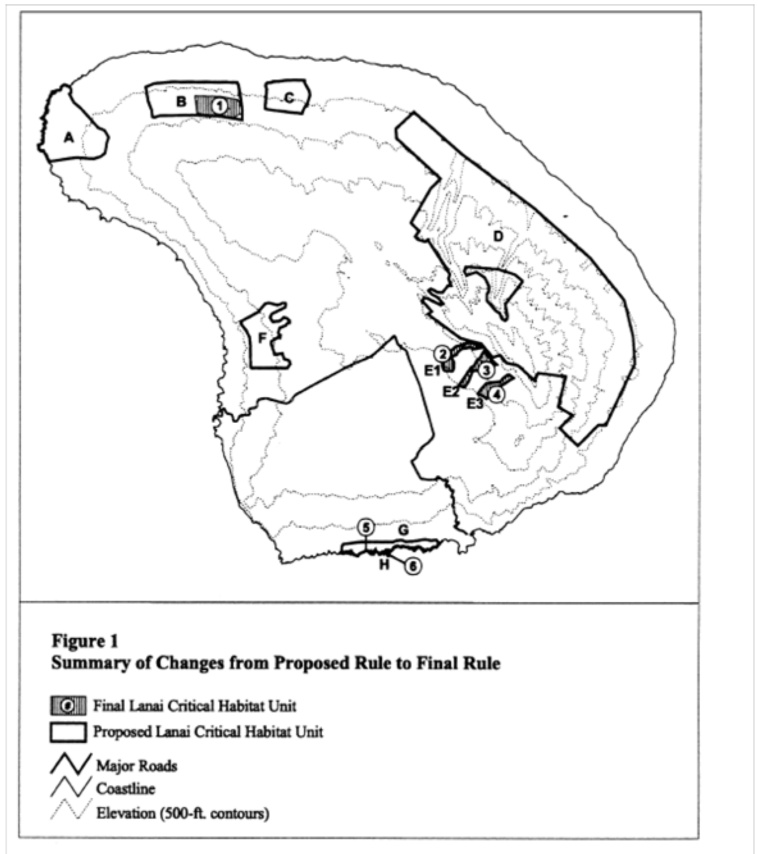


Figure 1
Summary of Changes from Proposed Rule to Final Rule

General Accounting Standards Lana‘i Water Company is also subject to various federal and state accounting and financial reporting requirements. The General Accounting Standards Board (GASB) issues accounting requirements for government agencies and publicly held utilities. Requirements known as GASB 34 passed in June of 1999 and became effective July 1, 2003. GASB 34 was intended to require sound fiscal practices and to create a fiscal connection to infrastructure planning and development. It requires that utilities report the value of their assets on consolidated annual financial reports. Two methods are acceptable: 1) depreciation, and 2) “modified” method. Either method requires that systems maintain an inventory of infrastructure assets. The depreciation method requires that utilities know the initial purchase cost of each asset, ancillary costs, and useful life. Assets can be expensed over their useful life. The modified method involves an asset management program, and allows for reporting based on utility knowledge of the condition of assets and other information. This is especially recommended for old systems, in which many assets typically outlive their “useful life” expectation. In such systems the depreciation is low, but the assets may need replacement and the costs for that will not be low. The modified method would involves inspection, maintenance and a refurbishment plan, to maintain assets above “minimum acceptable” condition. Development of improved system data and mapping will help the Company to maintain compliance with this program. The last rate making for potable water on Lana‘i was in 1994. At that time, depreciation expense was very low, indicating either that assets are fully depreciated, or that the depreciation could not be charged as they were not constructed by the Water Company. While it may not be realistic for the small rate base to cover 100% of the currently required system replacement, having an inventory of age and condition could enable the Lana‘i Water Company to establish rates that would help to recover at least a greater portion of replacement expense.

State Requirements

Enforcement is not limited to the federal level. States may apply to the EPA for a determination that the State has primary enforcement responsibility, called “primacy”. The Safe Drinking Water Act gives primary enforcement responsibility to the States, provided that they meet certain requirements, delineated in 40CFR142 Subpart B. These are:

- The State must have regulations for contaminants regulated by the National Primary Drinking Water Regulations
- The State must have adopted and be implementing procedures for the enforcement of State regulations
- The State must maintain an inventory of public water systems within the State
- The State must have a program to conduct sanitary surveys of the systems in the State

- The State must have a program to certify laboratories that will analyze water samples required by the regulations
- The State must have a laboratory that will serve as the State's principal lab, which must be certified by the EPA
- The State must have a program to ensure that new or modified systems will be capable of complying with the State Primary Drinking Water Regulations
- The State must have adequate enforcement authority to compel water systems to comply with National Primary Drinking Water Regulations, including:

  •authority to sue in court

  •right to enter and inspect water system facilities

  •authority to require systems to keep records and release them to the State

  •authority to require systems to notify the public of any system violation of the State requirements, and

  •authority to assess civil or criminal penalties for violations of the State Primary Drinking Water Regulations and Public Notification Requirements
- The State must have adequate recrudescing and reporting requirements
- The State must have adequate variance and exemption requirements, as stringent as EPA's, if the State chooses to allow variances or exemptions
- The State must have an adequate plan to provide for safe drinking water in emergencies like a natural disaster
- The State must have adopted authority to assess administrative penalties for violations of their approved primacy program.

In order to maintain primacy, State regulations must be at least as stringent and protective as those of the EPA. Though they may not be less protective, they may be more protective, particularly in circumstances where exposure levels within a given State are likely to be higher than those within the Country in general. For instance, the Hawai‘i State MCL for DBCP is more stringent than the federal standard, in part because DBCP was used in pineapple fields and Hawai‘i had a higher acreage in pineapple than most states. The MCL for DBCP in Hawai‘i is 40 parts per trillion, or 0.04 parts per billion, versus the federal standard of 0.02 parts per billion.

The Hawai‘i Revised Statutes Chapter 340 E - Safe Drinking Water (HRS §340-E), and Hawai‘i Administrative Rules Title 11 - Department of Health - Chapter 20 - Rules Relating to Potable Water Systems (HRS §11-20) are the State level equivalents of the Safe Drinking Water Act and National Primary Drinking Water Regulations. §HRS 340-E directs the Director of the State Department of Health (DOH) to promulgate and enforce State Primary Drinking Water Regulations and enables the DOH Director to promulgate and enforce State Secondary Drinking Water Regulations. HAR §11-20 sets these standards. Also covered are monitoring, analytical requirements, inspections, exemptions, emergency provisions, notification requirements, and the state revolving loan fund.

Similarly, Hawai‘i Revised Statutes Chapter 340-F Hawai‘i Law for Mandatory Certification of Public Water System Operators, and Hawai‘i Administrative Rules Chapter 11-25 - Rules Relating to Certification of Public Water System Operators, are the State corollaries to the Federal Operator Certification Rule.

Hawai‘i Administrative Rules Chapter 11-21 address cross connection and backflow. All projects which propose the use of dual water systems or the use of a non-potable water system in proximity to existing potable systems must be carefully designed and operated to prevent cross-connection of these systems and possible backflow of water from the non-potable system into the potable system. Approved backflow devices must be installed and tested periodically. Labelling requirements are set to prevent inadvertent consumption of non-potable water.

The use of reclaimed water over a potable aquifer creates potential regulatory challenge. The use of wastewater effluent for irrigation falls under §11-62-25(b) of Hawai‘i Administrative Rules, and under the Guidelines for the Treatment and Use of Recycled Water. If the irrigation rate with reclaimed water were to exceed 1.2 times the agronomic (consumptive) rate, then it would be considered groundwater recharge by means of effluent reclamation. If irrigation were 3 times the natural evapotranspiration rate, then the irrigation on the Koele golf course would be considered “underground injection”. This would require additional permitting. In addition, the golf course is within the two year zone of contribution for drinking water well number 6. Under the Groundwater Rule that becomes effective December 1, 2009, if reclaimed water use affected water quality, the system could then be deemed sensitive to fecal contamination - which would require more frequent sanitary surveys. If deemed sensitive, monthly monitoring for fecal contamination would be required.

The State Drinking Water Branch has also established Guidelines Applicable to Golf Courses in Hawai‘i to address groundwater protection and environmental concerns relating to Golf Courses.

If the Lana‘i Water Company elects to use desalinization for drinking or irrigation water, additional requirements will result. HAR §11-23 refers to brine disposal injection wells. Brine disposal would have to be below the UIC line. HAR §11-54 and §11-55 would apply in the event that ocean outfalls were utilized. Additional safe drinking water requirements would depend upon source water and other factors such as selected treatment, which would be reviewed with new source approvals under §11-20-29.

As a private water utility, Lana‘i Water Company is regulated by the Public Utilities Commission. Hawai‘i Revised Statutes Chapter 269 delineates the powers of the Public Utilities Commission. §269-7.5 requires utilities to have a certificate of convenience and necessity to operate. To issue such a certificate, the PUC must find that a utility is fit, willing and able to properly perform the proposed service. Certificates may be revoked. The PUC also has the authority to determine the reasonableness of proposed rates, charges, tariffs or other policies affecting the consumer. §269-8 empowers the PUC to inspect books, records, maps or other documents including a complete inventory of a utility’s property in such form as the Commission may direct. §269-15 establishes procedures for hearings, investigations, proceedings and complaints. §269-15 states that if the PUC is of the opinion that a utility is neglecting to comply with provisions of Chapter 269 or otherwise failing to perform its obligations, it shall inform the utility and institute proceedings as necessary to require the utility to correct the deficiencies, including citations and civil penalties. §269-16 states that all rate fee and charge structures, or rules shall be reviewed by the PUC. §269-26 authorizes the PUC to investigate charges for water supplied to consumers for domestic purposes, where the water is supplied by virtue of a lease from the state. §269-27 states that if the charges are found to be unreasonable, the PUC shall inform the attorney general, who shall take action to cancel the lease. §269-51 provides for a consumer advocate. §269-54 sets forth the authority and powers of the consumer advocate.

Other State programs have little impact on the Utility, but must still be kept in mind. One such example is the Hawai‘i Coastal Zone Management Program (Chapter 205A HRS, 1977), the State's counterpart to the Federal Coastal Zone Management Act of 1972. These programs were enacted to protect coastal resources, including ecosystems and aquatic resources, but also recreational, historic and scenic resources. Special management areas extend not less than 100 yards inland from the shoreline, but in some places they can extend much further, wherever development activities are deemed to have direct effects on coastal resources. The Counties can amend their special management boundaries to protect coastlines and meet CZM objectives. The Coastal Zone Management program has little impact on day-to-day utility operations, but it may affect utility infrastructure planning.

Hawai‘ian Principles of Water

Traditional Hawai‘ian water law was based upon water rights, rather than land use and possession. *Kanawai*, the word for law in Hawai‘i, means belonging to the waters, and describes a system that ensures that all users receive their fair share. Farmers would take what was required and then close their inlets, so that the next farmers could have their share. Hawai‘ian land divisions also reflected this principle. Hawai‘ian Islands were *moku puni*, and were divided into large land divisions called *moku-o-loko*. Within each *moku-o-loko*, there were smaller land divisions called *ahupua‘a*, which generally, but not always, ran from the mountains to the first reef. Each *ahupua'a* had sufficient natural resources to sustain the people living within it. (Luana L. Kawa‘a, not yet published article entitled "Regional Geography of Na Poko, Na Wai Eha", 2006)

Ahupua‘a boundaries were established in various ways. Munro in *The Story of Lana‘i*, notes that some *ahupua‘a*, including Paoma‘i on Lana‘i, were initially delineated based on the amount of land that a man could run around in a given time. "Pao rather overdid himself when he encircled 17 miles of country on Lana‘i and then had to get back to Lahaina to earn some land there. After all this effort, he was *ma‘i* (ill) - hence the name Paoma‘i". (Munro, pg 18) Smaller land divisions were also delineated, such as *‘ili aina*, which were part of ahupua‘a and *‘ili ku pono*, which were independent of ahupua‘a and paid tribute directly to the king. There were also *mo‘o ‘aina* or *pauku* - sections set aside for specific types of cultivation.

The *ahupua‘a* supplied food and materials to the *maka‘ainana* (commoner residents/tenants) who tended the land, as well as to the *konohiki* (overseers), who administered the *ahupua‘a*, and the *ali‘i* *nui* (chief), who was responsible for several *ahupuaʻa*. This responsibility to provide for himself and the *aliʻi* on a long-term basis generally compelled the *konohiki* toward sustainable management of both human and natural resources. (Garovoy, Jocellyn B. "Ua Koe Ke Kuleana O Na Kanaka" (Reserving the Rights of Tenants: Integrating Kuleana Rights and Land Trust Priorities in Hawaiʻi, Harvard Law Review Volume 29, 2005) There was no concept of land ownership in the way it is used today.

Prior to the "Great Mahele", King Kamehameha III came under pressure from foreigners wanting lands to provide for fee simple ownership. In response to this, a declaration of rights was issued in 1839 declaring that the chiefs and the people were entitled to the same protection under the same law, that all persons should be secured protection in their lands, building lots and all property; and that nothing should be taken from any individual except by express provision of law . . .

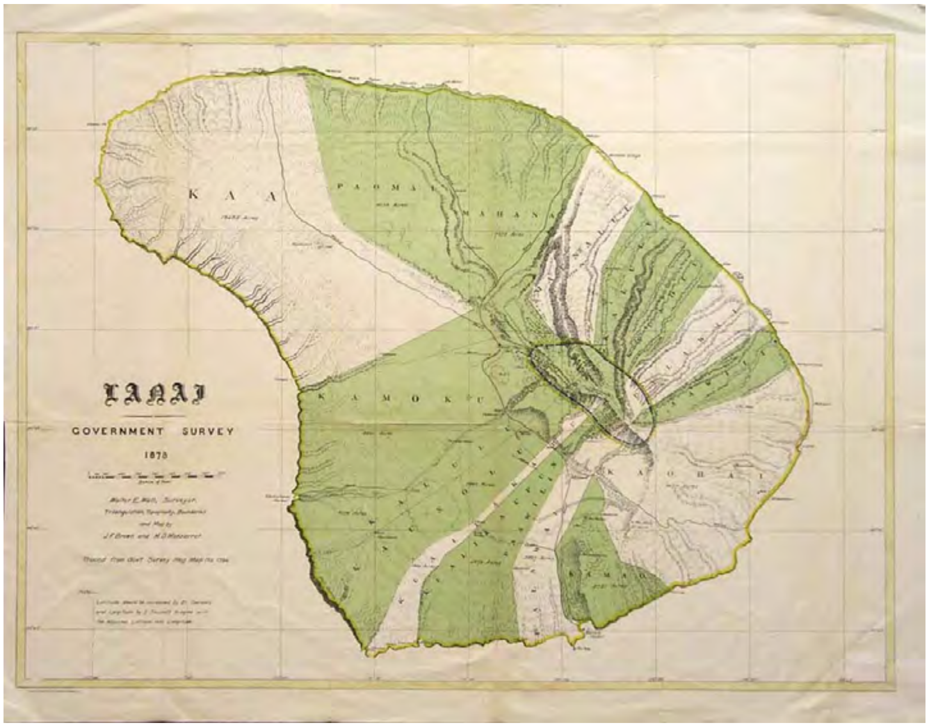
> [In the constitution] is the declaration that to Kamehameha I, the founder, had belonged all the land, but not as his own private property; that the land belonged in common to the chiefs and people, of whom the king was the head, and that it was subject to his management ["The land was not his own property. It belonged to the chiefs and people in common, of whom Kamehameha I was the head and had management of the landed property. This appears to have been the first formal acknowledgement by the government that the common people had some form of ownership interest in the land as distinguished from rights of use.] (source: Miike, Lawrence H.; *Water and the Law in Hawaiʻi*, University of Hawaiʻi Press, Honolulu, c 2004, pgs. 40-57)

In 1845 the Board of Commissioners to Quiet Land Titles (The Land Use Commission) was formed. In 1846 the Board published "Principles Adopted by the Board of Commissioners to Quiet Land Titles in Their Adjudication of Claims Presented to Them", in which they concluded that foreigners could not acquire title to land under existing law, and that there were only three classes of persons having vested rights in the land, the government, the landlord and the tenant. Since their interest was undivided, there was no mechanism for private property acquisition.

Mahele means division, but it also means share. The reason for the *"Great Mahele"* was established to enable individuals to gain clear title to land, while protecting the rights of the existing users. In 1848 the king and 245 konohiki reached agreement on the division of their lands. The Konohiki were then to make their claims to the Land Commission, and if confirmed the award was made by the Land Commission and title to the land was obtained through issuance of a royal patent with payment. The King also divided the remainder of the lands and established the classes of "Crown Lands" (for the occupant of the throne) and "Government Lands" (for the support of government operations). It is said that the King saw that the foreign system of private ownership was inevitable, and so established the Great Mahele, "that the people of the land sould not be left destitute."

The thirteen *Ahupuaʻa* that make up the island of Lanaʻi have been described in detail, with comments on place name meanings and traditional uses in *The Island of Lanaʻi: A Survey of Native Culture*, (Kenneth P. Emory, 1924) and in *"E ʻIke Hou Ia Lanaʻi: To Know Lanaʻi Once Again: A Historical Reference and Guide to the Island of Lanaʻi"*, (Lanaʻi Culture & Heritage Center, 2008). These are listed below. Descriptions are included in Chapter 3, "Existing Sources and Systems".

FIGURE 2-2. **Lana‘i Survey Map - 1878**



- Ka‘a 19,468 acres (The Rocky Area)
- Kalulu: 6,078 acres (The Shelter)
- Kama‘o 2,751 acres (The Ma‘o - *Gossypium tomentosum* plant)
- Kamoku: 8,291 acres (The District)
- Ka‘ohai 9,677 acres (The ‘Ohai - *Sesbania tomentosa* plant)
- Kaunolu: 7,860 acres (meaning uncertain)
- Kealia Aupuni 4,679 acres (The Salt Beds of the People/Nation)
- Kealia Kapu 1,829 acres (The Restricted Salt Beds)
- Mahana 7,973 acres (The warmth)
- Maunalei 3,342.38 acres (Mountain Garland)
- Palawai 5,897 acres (Fresh Water Moss)
- Paoma‘i 9,078 acres (Sick Pao)
- Pawili 1,930 acres (Strike and Twist, as of the wind)

Total 88,853.38 acres

The *Kuleana* Act of 1850 authorized the Land Commission to award fee simple titles to all native tenants who lived and worked on parcels of Crown, Government, or *Konohiki* Lands. To receive their *kuleana* award, the Land Commission required native tenants to prove that they had occupied, improved, or cultivated the claimed lands. The Commission also required claimed lands to be surveyed before they would issue an award for the land. (Gavaroy, Jocellyn B. "Ua Koe Ke Kuleana O Na Kanaka" ; Reserving the Rights of Tenants: Integrating Kuleana Rights and Land Trust Priorities in Hawai‘i, Harvard Law Review Volume 29, 2005 - quoting MacKenzie, Melody *Native Hawai‘ian Rights Handbook*) The *kuleana* award could include land actually cultivated and a house lot of not more than a quarter acre. (Garavoy, Jocelyn). While the Mahele was underway, it was realized that a weakness in the program existed, and parcels of Government land were made available to applicants for lots ranging in size from 1 to 50 acres, with a price ranging from 25 cents to $1.00 per acre. (Kepa Maly, 2008) According to Miike, tenants of government, king or konohiki lands need not pay because payment had in effect already been made by the king and konohiki. Government lands were to be set aside in 1 to 50 acre lots for sale to natives who did not have sufficient land. (Miike, Lawrence)

The most detailed summary of the *Mahele ‘Aina* on Lana‘i is found in a working paper entitled, "*Mahele Claims and Awards on Lana‘i"*, compiled by Kumu Pono Associates LLC, 2008. It identifies 105 claims for land on Lana‘i recorded in the Native Register, 88 claims recorded in Native Testimony, 2 claims recorded in the Foreign Register, 21 claims recorded in Foreign Testimony, 64 claims recorded in the Mahele Award Survey Books, and 51 claims recorded in the Royal Patent books. "Of the total number of claims recorded in 331 documents [some overlapping in records of the native and foreign books] identified as being from Lana‘i; 56 claims were awarded. Of these, five claims were chiefly awardees, who received entire *ahupua‘a*. Fifty-one awards made to native tenants and individuals of lower chiefly lineage, totaled a little over 600 acres of the approximately 89,000 acres of land on Lana‘i." (pg. 10) Cultivated crops claimed by land claimants included gourds, taro, ti leaves, sugar cane, *kou* trees, bananas, coconut trees, native tree ferns, sweet potatoes, and paper mulberry and cotton, as well as pasture lands.

Of awarded claims, the document lists:

- 12 in Maunalei
- 7 in Palawai
- 6 in Mahana
- 4 in Kaa
- 2 in Kamao
- 1 in Kealia
- 1 in Pawili
- 1 in Kamoku
- 13 in Kaunolu
- 2 in Ka‘ohai
- 7 in Kalulu

According to Kepa Maly of Lanaʻi's Cultural Heritage Center, records of Maunalei alone include claims for at least 71 loʻi kalo and one *ʻauwai*. Other claims included references to *loʻi kalo* and taro lands, but specific numbers of features were not recorded, and are thus difficult to make an accurate count of. In addition, every cove between Kaʻena point at the north, through Kauonolu and down to Hulopoʻe and Manele, and every part of the reef-lined coastline from Kamaiki Point to Polihua, had significant traditional places of residence including house sites, shelters and ceremonial shrines, indicating that water was available and in use at or near these locations. Claims for fisheries were also made at several locations on Lanaʻi, notably at Kaunolu and Kalulu, and fish ponds also occur at Palawai and Kaʻohai. (personal communication with K. Maly, 2008).

In 1850 and 1854 laws were passed that enabled foreigners to acquire title. (source: Miike, Lawrence H.; <u>*Water and the Law in Hawaiʻi*</u>, University of Hawaiʻi Press, Honolulu, c 2004) The first and only patent granted to a non-Hawaiʻian was a 128 acre parcel granted by royal patent of Kamehameha V to William Beder in Kaunolu. (Index of All Grants Issued by the Hawaiʻian Government Previous to march 31, 1886). Following the overthrow of the Hawaiʻian Monarchy, Land Patent Grants were issued to four primary foreigners on Lana'i. These land grants removed all land on Lanaʻi from the Crown and Government (Ceded) Land Inventories by 1907.

Munro summarized land tenure on Lanaʻi, observing that the first lands owned outright by commoners on Lanaʻi were Land Commission Awards of small lots granted in 1852 and 1853. Between 1864 and 1907 nearly all government and crown lands on Lanaʻi were transferred to private parties, either through lease or sale. By 1921, only 208.25 acres remained in title to Hawaiʻians, and of this only 54.74 still remained in good title, while the other 154.51 were "lost" *kuleana*. Further history of the disposition of these lands, or the statutory or legal history of water rights is beyond the scope of this chapter. However, it is instructive to note that it is conceivable that some *kuleana* rights and protections remain under provisions which exist today. Kepa Maly of the Lanaʻi Cultural Heritage Center is presently conducting a review of all public land records for the island of Lanaʻi, and notes that at the time of this writing, at least four families and several extant *kuleana*, particularly along the windward coast, and at least one active *kuleana* in Palawai basin, exist.

A summary of *kuleana* rights is offered by Garovoy (Gavoroy, Jocellyn B. "Ua Koe Ke Kuleana O Na Kanaka" (Reserving the Rights of Tenants: Integrating Kuleana Rights and Land Trust Priorities in Hawaiʻi, Harvard Law Review Volume 29, 2005).

> Contemporary sources of law, including the Hawaiʻi Revised Statutes, the Hawaiʻi State Constitution, and case law interpreting these laws protect six distinct rights attached to the *kuleana* and/or native Hawaiʻians with ancestral connections to the *kuleana*. These rights are:
>
> (1) reasonable access to the land-locked *kuleana* from major thoroughfares;
>
> (2) agricultural uses, such as taro cultivation;
>
> (3) traditional gathering rights in and around the *ahupuaʻa*;
>
> (4) a house lot not larger than 1/4 acre;

(5) sufficient water for drinking and irrigation from nearby streams, including traditionally established waterways such as *‘auwai*; and

(6) fishing rights in the *kuanalu* (the coastal region extending from beach to reef).

Kuleana rights are often associated with a native Hawai‘ian ancestral connection to specific lands, but in fact these rights can run with the *kuleana* land itself, where the courts and legislature have not explicitly stated otherwise. Land trusts deciding how to plan for properties that contain *kuleanas* within their boundaries should consider developing policies of their own regarding how to approach *kuleana* lands held by Hawai‘ians with ancestral connections to the land, versus *kuleana* owned by non-native Hawai‘ians.

There are five sources of *Kuleana* rights:

(1) Article XII, section 7 of the Hawai‘i Constitution;

(2) Hawai‘i Revised Statutes section 1-1;

(3) Hawai‘i Revised Statutes section 7-1;

(4) Precedent-setting case law that has applied these primary sources to actual scenarios that have tested and refined specific elements of these laws; and

(5) The *Kuleana* Act.

<u>State Constitution Article XII § 7</u> "The State reaffirms and shall protect all rights, customarily and traditionally exercised for subsistence, cultural and religious purposes, and possessed by ahupua‘a tenants who are descendants of native Hawai‘ians who inhabited the Hawai‘ian Islands prior to 1778, subject to the right of the State to regulate such rights".

<u>HRS §1-1</u> The common law of England, as ascertained by English and American decisions, is declared to be the common law of the State of Hawai‘i, in all cases, *except as . . . established by Hawai‘ian usage*; provided that no person shall be subject to criminal proceedings except as provided by the written laws of the United States or the State.

<u>HRS §7-1</u> Where the landlords have obtained, or may hereafter obtain, allodial titles to their lands, the people on each of their lands shall not be deprived of the right to take firewood, house-timber, *aho* cord, thatch, or *ki* leaf, from the land on which they live, for their own private use, but they shall not have a right to take such articles to sell for profit. The people shall also have a right to drinking water, and running water, and the right of way. The springs of water, running water, and roads shall be free to all, on all lands granted in fee simple; provided that this shall not be applicable to wells and watercourses, which individuals have made for their own use.

The Kuleana Act of 1850 has been briefly described above. Again, it authorized the Land Commission to award fee simple titles to all native tenants who lived and worked on parcels of Crown, Government, or *Konohiki* Lands. To receive their *kuleana* award, the Land Commission required native tenants to prove that they had occupied, improved, or cultivated the claimed lands. Most maka‘ainana never claimed their kuleana. Of 29,221 adult males in Hawai'i eligible to make land claims in 1850, only 8,205 actually received kuleana awards, and these totaled less than 1% of all Crown and Kingdom lands. Several reasons have been posited. Hawai'ians at that time were accustomed to communal property rights and management, and claims to land may have gone against the grain to some. Claims could only be made for actively cultivated land, and the Hawai'ians had a tradition of resting the lands. Some tenants in remote areas may not have received adequate notice to fully understand the implications of the registration process in time. Some tenants may have feared that their ali'i would be displeased by assertions to personal claims, given the traditional shared use of the lands. (Garavoy, 2005)

An exhaustive summary of case law is beyond the scope of this document. What follows is brief and incomplete. Different authors sometimes disagree on the implications of pivotal cases. This document makes no attempt to resolve such questions.

Three major types of water rights are found in Hawai'i common law. These are appurtenant, riparian and correlative rights. Appurtenant water rights refer to those uses associated with a land parcel at the Mahele, the time the land passed into private ownership. Riparian rights are associated with lands with or adjacent to flowing streams. Correlative rights refer to the right to use groundwater under a parcel of land, so long as similar use by adjacent lands over the same aquifer are not adversely effected. Other concepts encountered in case law, though less prominently are prescriptive, appropriative and usufructuary rights. Prescriptive rights refer to the right acquired by adverse use over an extended period of time. Appropriative rights may be simply appropriative or based on prior appropriation. Prior appropriation is used more in the western mainland states than Hawai'i, and refers generally to senior rights based on the principle of first-in-time, first-in-right. Appropriative rights can also refer to water rights issued by permit, as occurs upon designation of a groundwater management area. Usufructuary rights are rights of use and enjoyment of water without ownership, so far as possible without causing damage to other users.

Kuleana parcels have both appurtenant and riparian rights.

Until the 1973 *McBryde V. Robinson* (504 P2d 1330, 1229 Haw 1973) decision, case law on water rights seemed to strengthen prescriptive rights and privatization of water. (Miike *Water Law in Hawai'i*, 2004 pg. 82)

In *McBryde*, the court found that title for water could not be transferred, ownership of water remained the State's, riparian rights are statutory based upon HRS §7-1, appurtenant rights apply only to the parcel of land to which the rights are appurtenant, riparian rights pertain only to lands adjoining a natural water course, there can be no title to State-owned property based upon adverse use, and there can be no "normal daily surplus water" because riparian rights entitle flows and shape of water course as given by nature, and freshet water is the property of the state.

In *Reppun vs. Board of Water Supply* (656 P2d at 57). the court held that "where surface water and groundwater can be demonstrated to be physically interrelated as parts of a single system, established surface water rights may be protected against diversions injure these rights, whether the diversion involves surface water or groundwater."

In *Re:Waihole Ditch Combined Contested Case Hearing* (94 Haw 97, 9 P 3d 409; 2000) the court described the scope substance, powers, duties and burdens of proof of Hawai‘i's public trust doctrine and precautionary principle. "... where uncertainty exists, a trustee's duty to protect the resource mitigates in favor of choosing presumptions that also protect the resource." It directs the State to "...preserve the rights of present and future generations in the waters of the State." The decision notes that the counties will be required to articulate their land use priorities with greater specificity. For example, even at the present time, there is more land zoned for various uses than available water to supply those proposed uses. Thus, it is not sufficient to merely conclude that a particular parcel of land is properly zoned and that the use is "beneficial". That minimal conclusion may be inadequate to resolve situations in which competitive demands exceed supply" (p. 187) In response to Honolulu's objections the court stated "the city itself must, as a matter of sound planning policy, actively develop integrated water use plans addressing the contingencies arising from the limitations in supply, see e.g. HRS §174-C-31(d). Such a process, if properly undertaken will necessarily entail prioritizing among competing uses."

Kalipi V. Hawai‘ian Trust Co. 656 p2d, 745, 752 (Haw 1982) held that customary rights still practiced, may be protected even if not specifically listed in §HRS 7-1.

Other Kuleana rights include access, cultivation, gathering, residing etc. Access rights have been established in *Kalaukoa v. Keawe* (9 Haw 191, 192; 1993), *Henry V. Ahlo* (9 Haw 490; 1894), *Rogers v. Pedro* (440 P2d 95, 96 Haw. 1968) and others. Gathering rights have been established in *Pele Defense Fund v. Paty* (837 P2d 1247 Haw 1992) and *Public Access Shoreline Hawai‘i v. Hawai‘i County Planning Commission* (aka PASH) 903 P2d at 1246, 1250 (Haw 1995), and limited somewhat by *State v. Hanapi* (970 P2d 485, 494-95, Haw 1998) Rights to cultivation, grazing and fishing are also granted for kuleana parcels. In *Hatton v. Piopio* (6 Haw 334, 336; 1882) the court held that a tenant of an ahupua‘a has a right to fish in the sea appurtenant to the land as an incident of his tenancy.

The State Water Code, HRS §174-C also addresses traditional and customary rights:

HRS §174C-101 (a) Provisions of this chapter shall not be construed to amend or modify rights or entitlements to water as provided for by the Hawai‘ian Homes Commission Act, 1920, as amended, and by chapters 167 and 168 relating to the Molokai Irrigation system. Decisions of the Commission on Water Resource Management relating to the planning for, regulation management and conservation of water resources in the State shall, to the extent applicable and consistent with other legal requirements and authority, incorporate and protect adequate reserves of water for current and forseeable development and use of Hawai‘ian Home Lands as set forth in section 221 of the Hawai‘ian Homes Commission Act. (b) No provision of this chapter shall diminish or extinguish trusts revenues derived from existing water licenses unless compensation is made. (c) Traditional and customary rights of ahupua‘a tenants who are descendants of native Hawai‘ians who inhabited the Hawai‘ian Islands prior to 1778 shall not be abridged or denied by this chapter. Such traditional and customary rights shall include, but not be limited to, the cultivation or propagation of taro on one's own kuleana and the gathering of *hihiwai*, *opae*, *o'opu*, *limu*, thatch, ti leave, aho cord and medicinal plants for subsistence, cultural and religious purposes. (d) the appurtenant water rights of kuleana and taro lands, along with those traditional and customary rights assured in this section, shall not be diminished or extinguished by a failure to apply for or to receive a permit under this chapter. [L 1987, c 45, pt of §2; amL 1991, c 325, §8]

Act 212, A Bill for an Act Relating to Native Hawai'ians, was signed into law on June 27, 2007. The ultimate purpose of this act was to establish a council of indivuals, wise both in in the ways of Hawai'ian cultural practice and in the specifics of their own moku, so that if any project affected a moku, there could be a known contact, knowledgeable in the specifics of the area. Traditionally, each ahupua'a had, not only its own specific flora and fuana, but also its traditions and practices. By establishing a statewide network of "elders" with representation from each moku, there would always be an avenue for accurate cultural and spiritual information about any given area, as well as guidance in indigenous resource management practices. Central to the purpose of the act was the desire for a system whereby knowledge of the values and concerns of each moku could be accessed, so that decisions were not being made by those who knew nothing of the specifics of an area. The proximal purpose of the act was to set up an "'Aha Kiole" advisory committee to oversee the establishment of this 'aha moku council.

Regulatory Schedule Affecting Lana`i - Safe Drinking Water Act

Rule	EPA Status	State Adoption	Actions
Ground Water Rule 40CFR §141 Sub-part S FR65 No. 91 May 10, 2000	Promulgated 11/08/2006 Effective 1/8/2007		♦ Sanitary surveys required every 3 years for groundwater community water systems (CWSs) and every 5 years for non-CWSs ♦ Groundwater systems that do not provide 4-log virus inactivation must make a one time hydrogeologic sensitivity assessment. Monthly source water monitoring for fecal indicators required if deemed sensitive ♦ If groundwater system is notified of source water contamination, it must: 1) eliminate the contamination source, 2) provide alternative source water, or 3) install 4-log virus removal treatment within 90 days ♦ If deficiencies found, all must be corrected. Groundwater systems must inform customers of any uncorrected significant deficiencies or fecal indicator-positive samples. ♦ Groundwater systems that disinfect to 4-log removal in order to avoid source water monitoring must monitor their disinfection process.
Disinfectants & Disinfection By-Products Rule - Stage 1 Dec 16, 1998 63 FR 69389	Promulgated 12/16/1998 Revised 01/16/01 Effective 01/15/01 Revised Rule Effective 02/15/01		♦ All systems that disinfect must comply ♦ Lana'i would be considered a small system. Small systems must comply by 12/16/03 ♦ Maximum Residual Disinfectant Levels (MRDLs) and Maximum Contaminant Levels (MCLs) based on best available technology described in the rule ♦ Maximum Residual Disinfectant Level Goals (MRDLGs) for chlorine 4mg/L; for chloramine, 4 mg/L and for chlorine dioxide 0.8 mg/L ♦ Maximum contaminant level goals (MCLGS) for four trihalomethanes: chloroform 0; bromodichloromethane 0; dibromocholoromethane 0.06 mg/L; and bromoform 0. for two haloacetic acids (dichloro-acetic acid 0 mg/L and trichloroacetic acid 0.3 mg/L); for bromoate 0 and for chlorite 0.8 mg/L ♦Maximum Residual Disinfectant Levels (MRDLs) for three disinfectants (chlorine 4 mg/L; chloramines 4 mg/L; and chlorine dioxide 0.8 mg/L) ♦ Maximum contaminant levels (MCLs) for Total Trihalomethanes (TTHMs) - a sum of the four listed above, chloroform plus bromodichloromethane plus dibromochloromethane plus bromoform 0.08 mg/L; haloacetic acids (HAA5) 0/06mg/L (sum of dichloro-acetic acid, trichloroacetic acid, monochloroacetic acid and mono and dibromo acetic acids); MCL for two inorganic disinfection byproducts : chlorite 1 mg/L; and bromate 0.01 mg/L ♦ System operators must meet requirements to be listed in State register of qualified operators ♦ Monitoring, reporting & public notification requirements for compounds listed above. Monitoring of TTHMs and HAA5 for 4 consecutive quarters to determine need for disinfection profiling. A monitoring plan must be maintained and made available for DOH inspection and the general public no later than 30 days following the compliance date. Plan must include 1) locations for collecting samples, 2) how compliance with MCLs, MRDLs and treatment techniques are calculated and 3) must reflect the entire distribution system ♦ New analytical methods for TTHM monitoring

Disinfectants & Disinfection By-Products Rule - Stage 2	Promulgated 1/4/06 Effective 3/6/06		• Applies to CWS and NTNCWSs that produce and or deliver water that is treated with a primary or residual disinfectant other than ultra violet light • Requires an initial distribution system evaluation (IDSE) to identify locations with high disinfection byproduct conscentrations. These locations will then be used as sampling sites for compliance monitoring. • Compliance with MCLs for two groups of disinfection byproducts calculated for each location, referred to as the locational running annual average (LRAA). • Requires each system to determine if they have exceeded an operational evaluation level, based upon monitoring results. The operational evaluation level provides an early warning of possible future MCL violations, thereby enabling systems to proactively take steps to remain in compliance. A system that exceeds an operational evaluation level is required to review its operational practices and submit a report that delineates actions taken to mitigate or prevent future high disinfection by-product levels. • Total trihalomethanes (TTHM) and five haloacetic acids (HAA5) monitoring for one year on a regular schedule determined by source type and system size. Systems have the option of performing a site-specific study based on historical data, distribution system models or other means. Waivers available for systems that meet certain criteria. • MCL value same as in Stage 1. Annual average at each sampling location, rather than system-wide used to determine compliance with the MCLs. 0.08mg/L for TTHM; 0.06 mg/L for HAA5. Switching from the system-wide average to the LRAA will reduce exposure to high disinfection by-product concentrations by ensuring that each monitoring site is in compliance. • MCLGs added for cloroform, monocloracetic acid and trichloracetic acid. • Lana'i will have to complete its IDSE by March 31, 2010, and submit the report by July 1, 2010. Upgraded compliance monitoring will take effect October 1, 2013.
Interim Enhanced Surface Water Treatment Rule	Promulgated 12/16/98 Effective 1/16/99 Revised rule effective 1/16/01	12/30/00	• Does not affect Lana`i at this time. Main potential for the surface water treatment rules to impact Lana`i would be if sources were Ground Water Under the Direct Influence of Surface Water (GWUDI). • Ground Water Under the Direct Influence of surface water means "any water beneath the surface of the ground with significance occurrence of insects or other macroorganisms, algae, or large diameter pathogens such as *Giardia lamblia* or (for subpart H systems serving at least 10,000 people) *Cryptosporidium,* or significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions. Direct influence must be determined for individual sources in accordance with criteria established by the State. The State determination of direct influence may be based on site-specific measurements of water quality and/or documentation of well construction characteristics and geology with field evaluation. • Applies to surface water systems & to ground water under the direct influence of surface water (GWUDI) systems serving 10,000 people or more •2-log *Cryptosporidium* removal (99%) for systems that filter •Strengthened combined filter effluent turbidity performance standards • Individual filter turbidity monitoring provisions • Disinfection profiling required if a system exceeds 80% of MCLs for TTHM or HAA5. Disinfection benchmarking required when significant system change • Covers required on new finished water reservoirs for which construction begins 60 days after rule promulgation minor revisions: • Compliance coincides with calendar quarters • Clarifies some regulatory provisions found in the published rules

Longterm I Enhanced Surface Water Treatment Rule	Proumulgated 01/14/02 Effective 02/13/02	Nov-02	♦ Applies to surface or groundwater under the direct influence of surface water (GWUDI) systems serving <10,000 ♦ 2-log Cryptosporidium removal (99%) for systems that filter ♦ Disinfection profile required unless TTHM and HAA5 disinfection byproduct (DBP) levels levels <0.064 mg/L and 0.048 mg/L respectively can be demonstrated. Systems planning a significant change to disinfection practices must determine their current lowest level of microbial inactivation and consult with the state for approval prior to implementing that change. ♦ Filtered systems must comply with strenghtened combined filter effluent (CFE) turbidity performance. Conventional and direct filtration systems must continuously monitor the turbidity of individual filters and comply with follow-up activities based on this monitoring. ♦Combined, filtered turbidity levels <0.3NTU in at least 95% of measurements, and must at no time exceed 1 NTU ♦Continous turbidity monitoring of individual filters, with results recorded every 15 minutes ♦ Covers required on new finished water reservoirs for which construction begins after March 15, 2002 ♦ Microbial inactivation benchmarking: systems required to develop a profile of microbial inactivation levels unless they perform monitoring which demonstrates that their disinfection byproduct levels are less than 80% of the MCLs established under the Stage I DBPR. Systems making a significant change to their disinfection practice must determine their current lowest level of microbial inactivation and consult with the state for approval prior to implementing the change ♦ Unfiltered systems must comply with updated watershed control requirements that add *Cryptosporidium* as a pathogen of concern. (unfiltered systems not allowed in Hawai'i)
Longterm II Enhanced Surface Water Treatment Rule	Promulgated 2/06 Effective 3/06	May-02	♦ PWSs using surface water or GWUDI required to monitor source influent to determine average *cryptosporidium* level. PWSs serving 10,000-49,999 must begin source water monitoring no later than April 1, 2008. PWSs serving <10,000 people must begin *E coli* monitoring no later than October 1, 2008 and at least once every 2 weeks thereafter for 12 months. ♦ Large PWSs serving >10,000 people must monitor for Cryptosporidium, plus E coli and turbidity in filtered systems) for two years. Small filtered PWSs serving <10,000 people initially monitor for E coli only, for one year and must monitor for Cryptosporidium only if E coli levels exceed trigger values. Small filtered PWSs that exceed E coli triggers must monitor for Cryptosporidicum for one or two years. Specific criteria are set for sampling frequency, schedule, locations, data grandfathering, treatment instead of monitoring, sampling by PWSs that use surface water only part of the year, and monitoring new plants and sources. ♦ Date for PWSs to begin monitoring is staggered by PWS size. Largest systems start Januuary 2008. Requirements are set for monitoring results, analytical methods, use of approved laboratories. ♦ Additional risk-targeted treatment technique for Cryptosporidium ♦ PWSs with uncovered finished water storage facilities must either cover or treat facility discharge to achieve inactivation and or 4-log virus removal, 3 log Giardia lamblia removal and 2 log Cryptosporidium removal on State-approved schedule.

Consumer Confidence Reports Rule 40 CFR §141 Sub-part O 63 FR No. 160 44511	Promulgated 08/19/ 1998 Effective 09/19/1998	Aug-99	♠ Community Water Systems (CWSs) are required to mail annually to each customer a report on the contaminant level in the drinking water purveyed ♠ Reports are required to include but not limited to the following: 1) the water source, a definition of MCLG, MCL, variances & exemptions, 2) if any regulated contaminant is detected in the water purveyed, a statement of MCLG, MCL, level of contaminant in water system, statement regarding the health concerns that resulted in regulation of any regulated contaminant for which there has been an MCL violation during the year covered by the report; 3) information on compliance with the NPDWR (National Primary Drinking Water Regulations), and a notice if the system is operating under a variance or exemption, and the basis on which the variance or exemption was granted; 4) information on the levels of unregulated contaminants for which monitoring is required under section 1445(a)(2), including levels of cryptosporidium and radon where states determine that they may be found; 5) a statement that the presence of contaminants in drinking water does not necessarily indicate that the drinking water poses a health risk, and that more information about contaminants and potential health effects can be obtained by callng the SDW Hotline.
Public Notification Rule	Promulgated 05/18/ 2000 Effective 06/05/2000		♠Public Water Systems (PWSs) are required to notify customers for violations of the National Primary Drinking Water Regulations (NPDWRs), or if they have a variance or exemption from the regulations, have violated the terms of a variance or exemption, or are facing other situations posing a risk to public health. ♠Public notices are divided into three tiers, defined based on the seriousness of the violation or situation, and on potential health effects. The new rule adds to the violations about which PWSs must notfiy customers. ♠ Tier 1 notices are required within 24 hours. Additional notices for the same violation are not required. The system must provide notices to the state for initial and repeat notice cycles. Consultation with the state is required within 24 hours for tier 1 violations. Tier one violations include 5 NTU turbidity exceedence, or turbidity treatment technique resulting from single exceedence in addition to those in the current rule. ♠Tier 2 notices include violations under the disinfection by products rule and the interim enhanced surface water treatment rule (IESWTR) (Note: the IESWTR does not apply on Lana`i, unless tunnel is considered GWUDI) - also serious and persistent monitoring and testing procedure violation as determined by the primacy agency. Notice is required within 30 days. Consultation with the state is required within 24 hours of a maximum turbidity limit exceedence. Repeat notice required every 3 months where the violation persists. ♠Tier 3 notice required to announce availability of unregulated contaminant monitoring results for exceedances of flouride. Notice required within 1 year, and repeated annually. ♠ Notice required to new customers for any outstanding violation requiring notice ♠ Minimum delivery methods include media, hand delivery or posting for tier 1 notices ♠ Simplified standard language and new standard language required for monitoring violations.
Operator Certification Rule	Promulgated 02/ 1999 Effective 02/01	2/5/01	♠ Applies to all Community and Non-Transient Non-Community Water Systems ♠ EPA guidelines require certification of all distribution system workers and plant operators. All operators must maintain certification level equal to or greater than that of the facility that they operate. ♠ HAR 11-25 defines classes of certification, requirements, continuing education units, classification of treatment plants and distribution systems, procedures, remedies, etc.

Lead & Copper Rule	Promulgated 06/ 0791 Effective 12/07/ 1992 Revisions 01/12/00 Effective 04/11/00		♦ Lead action level 15 ppb, or 15ug/L = 0.015 mg/L; copper action level 1.3 ppm, or 1.3 mg/L ♦ Lana'i initially served between 501 & 3,300 people, so was required to sample at 20 sites - Tier I or as nearly Tier 1 sites as possible. With the increase in population, 40 sites would now be required. ♦ Lead free pipe, solder or flux is required after 1/19/86 for any connection to a PWS and well pump ♦ Corrosion control and source water treatment requirements ♦ Public education and supplemental monitoring for customers required if action level exceeded ♦ Monitoring requirements for tap water, source water, and water quality parameters in distribution system ♦ Reporting and record keeping requirements ♦ Systems must perform optimal corrosion control treatment (OCCT) and continue to maintain and operate any corrosion control that is already in place and meet any requirements that the State determines appropriate to ensure OCCT maintained ♦ Systems that are deemed to be optimized due to little or no corrosion in distribution systems, must - monitor for lead and copper at the tap once every three years if lead levels <0.005 mg/L and copper less than 0.65 mg/L - meet the copper action level ♦ Replace lead service lines and notify customers ♦ Report change of source or treatment

National Primary Drinking Water Standards	Various Promulgation dates		Over 90 maximum contaminant levels (MCLs) or treatment techniques (TTs) for various contaminants. Included are: ♦ *Cryptosporidium* ♦ *Giardia lamblia* ♦ Heterotrophic Plate Count ♦ *Legionella* ♦ Total coliforms (including fecal coliform and *E. coli*) ♦ Turbidity ♦ Viruses (enteric) ♦ Bromate ♦ Chlorite ♦ Haloacetic acids (HAA5) ♦ Total Trihalomethanes (TTHMs) ♦ Chloramines as (Cl_2) ♦ Chlorine (as Cl_2) ♦ Chlorine Dioxide ♦ Antimony ♦ Arsenic ♦ Asbestos (fibers >10µm) ♦ Barium ♦ Beryllium ♦ Cadmium ♦ Chromium (total) ♦ Copper ♦ Cyanide (as free cyanide) ♦ Cyanide ♦ Flouride ♦ Lead ♦ Mercury (inorganic) ♦ Nitrate (measured as Nitrogen) ♦ Nitrite (measured as Nitrogen) ♦ Selenium ♦ Thallium ♦ Acrylamide ♦ Alachlor ♦ Atrazine ♦ Benzene ♦ Benzo(a)pyrene (PAHs) ♦ Carbofuran ♦ Carbon tetrachloride ♦ Chlordane ♦ Chlorobenzene ♦ 2,4 D ♦ Dalapon ♦ 1,2-Dibromo-3-chlorpropane (DBCP) ♦ o-Dichlorobenzene ♦ p-Dichlorobenzene ♦ 1,2-Dichloroethane ♦ 1,1-Dichloroethylene ♦ cis-1,2-Dichloroethylene ♦ trans,1,2-Dichloroethylene ♦ Dichloromethane ♦ Dichloromethane ♦ 1,2-Dichloropropane ♦ Di(2-ethylhexyl)adipate ♦ Di(2-ethylhexyl)phthalate ♦ Dinoseb ♦ Dioxin (2,3,7,8-TCDD) ♦ Diquat ♦ Endothall ♦ Endrin ♦ Epichlorohydrin ♦ Ethylbenzene ♦ Ethylene dibromide ♦ Glyphosate ♦ Heptachlor ♦ Heptachlor epoxide ♦ Hexachlorobenzene ♦ Hexachlorocyclopentadiene ♦ Lindane ♦ Methoxychlor ♦ Oxamyl (Vydate) ♦ Polychlorinated biphenyls (PCBs) ♦ Pntachlorophenol ♦ Picloram ♦ Simazine ♦ Styrene ♦ Tetrachloroethylene ♦ Toluene ♦ Toxaphene ♦ 2,4,5-TP (Silvex) ♦ 1,2,4-Trichlorobenzene ♦ 1,1,1-Trichloroethane ♦ 1,1,2-Trichloroethane ♦ Trichloroethylene ♦ Vinyl chloride ♦ Xylenes (total) ♦ Alpha Particles ♦ Beta particles & photon emitters ♦ Radium 226 & Radium 228 (combined) ♦ Uranium
National Primary Drinking Water Standards - Arsenic	Promulgated 01/22/2001 Effective 03/23/2001		♦ Systems of all sizes must comply by 01/23/2006 ♦ Final rule changes arsenic MCL from 50ppb to 10ppb (µg/L) ♦ Establishes new analytical method and best available technologies for treatment

National Primary Drinking Water Standards - Radon	Proposed 11/02/1999 Final 1/12/2000 Effective 04/11/2000		♦ appplies to all community water systems using ground water and mixed ground & surface water ♦ MCLG (maximum contaiminant level goal) is zero; MCL is 300 pCi/L alternative MCL is 4000 pCi/L ♦ quarterly monitoring in the first year, and annual monitoring thereafter ♦ PWS qualifies for alternative MCL if it follows a state or local multi-media mitigation (MMM) program that reduces radon levels in indoor air caused by non-water sources. MMM program must satisfy four EPA requirements: public involvement in its development, quantitative goals for fixing existing homes, and building radon-resistant new homes, strategies for achieving these goals and a plan to track and report results. ♦ HI State DOH will not adopt an MMM program, since the average indoor radon level is 0.1 pCi/L. However PWSs can develop MMMs if needed.
National Primary Drinking Water Standards - Radionuclides	Promulgated 12/07/2000 Effective 12/08/03		♦applies to all community water systems ♦ final MCL for uranium set at 30µg/L and MCLG set at 0 ♦ new rule revises monitoring requirements for combined radium-226 and radium-228, gross alpha particle radioactivity, beta particle and photon radioactivity ♦ current MCL for combined radium 226-228 is 5 pCi/L, and for gross alpha particle radioactivity 15 pCi/L retained ♦ current MCL for beta particle and photon radioactivity of 4mrem/year is retained for this rule, but will be further reviewed in near future
National Primary Drinking Water Standards - Chloroform	Effective 05/30/2000		♦ EPA removed the 0 MCLG from the NPDWR in accordance with a recent order of the U.S. Court of Appeals for the District of Columbia Circuit ♦ No other provision of the D/DBP regulation was affected
Contaminant Candidate List	CC 1 03/98 CC 2 02/05 CC 3 02/08		♦ List of unregulated contaminants that may warrent regulation. ♦ The third Draft Contaminant Candidate List was published in February, 2008. It includes 11 microbial and 93 chemical contaminants, and may be found at http://www.epa.gov/safewater/ccl/ccl3.html.
Filter Backwash Recycling	Final 06/08/01 Effective 08/07/01	before 6/9/2003 to retain primacy	♦ Does not currently affect Lana`i ♦ Applies to all PWS that use surface water or GWUDI that utilize direct or conventional filtration processes; and recycle spent filter backwash water, sludge thickener supernatant or liquids from dewatering processes ♦Recycled filter backwash water, sludge thickener supernatant, and liquids from dewatering must pass through all processes of the system's representative treatment in order for conventional and direct filtration systems which recycle to maintain 2-log removal credit ♦ Systems must notify the State in writing that they practice recycle and provide detailed recycling treatment information. States may, after evaluating the information, require a system to modify their recycle location or recycle practices.
Secondary Drinking Water Standards	Various Dates		Sets recommended guideline MCLs for contaminants with cosmetic or aesthetic effects. Standards are set for aluminum, chlorides, color, copper, corrosivity, flouride, foaming agents, iron, manganese, pH, silver, sulfate, total dissolved solids and zinc. Secondary standard for chloride is 250 mg/L.

Unregulated Contaminant Monitoring Rule	Proposed 09/17/00 Final 01/11/01 Effective 05/31/02		♦ Does not currently affect Lana`i ♦ Monitoring of 48 contaminants to be continued until final rule in effect. Community water systems and non-transient, non-community water systems serving >10,000 people, and a nationally representative sample of small systems are required to monitor for not more than 30 contaminants. Monitoring suspended for systems serving <10,000 people on 01/08/1999 ♦ List 1 contaminants must be monitored by all. List 3 methods are being researched ♦ Large systems must monitor for a 12-month period within the years 2001-2003 for 2,4-dinitrotoluene, 2-6 dinitrotoluene, DCPA mono acide degradate, DCPA di acid degradate, 4,4'-DDE, EPTC, molinate, MTBE, nitrobenzene, terbacil, acetochlor, and perchlorate. Systems must also analyze for water quality parameters including, for chemical contaminants; pH; and for microbiological contaminants: pH, temperature, turbidity, free disinfectant residual and total disinfectant residual. Surface water systems must monitor during 4 consecutive quarters. Ground water systems must monitor twice, 5 to 7 months apart. One sampling must be between May 1 and July 31. Composite sampling not acceptable. ♦ Monitoring must be conducted at each entry point to the distribution system, or at other sampling locations previously specified by the State, for sampling points representative of each principal, non-emergency water source in use over the one year of monitoring. In-system points monitoring will be required for List 2 contaminants ♦ Large and small systems must monitor according to the quality control procedures described. Laboratories that are certified to use the indicated methods for the contaminants listed are automatically certified ♦ Test results must be reported electronically, or in an alternate format previously arranged, to EPA, within 30 days following the month they receive the results. EPA will report the results for selected representative small systems. A system can have a laboratory report for its results. Previously collected data can be reported if the data meets specified requirements and includes the applicable water quality parameters and data required to be reported ♦ States can enter into MOA with the EPA concerning the implementation of the monitoring program Additions in Final Rule: ♦ approves the analytical methods for 13 chemical contaminants on List 2 ♦ monitoring required for list 2 contaminants ♦ sets the schedule for monitoring microbiological contaminant, Aeromanas, contingent on promulgation of its analytical method ♦ Modifications affecting the sample collection, analysis and reporting of List 1 and List 2 contaminants, including clarifying source water monitoring, resampling conditions, additonal methods, and clarification of definitions of some data elements for reporting
Total Coliform Rule	Published 6/24/89 Effective 12/31/90		♦ Requires that sanitary surveys be conducted at least once every five years for systems that take fewer than five samples for month. EPA has encouraged the state to perform more frequent sanitary surveys; annually for surface water systems and triennially for ground water systems

HAR Title 11 Chapter 25 Rules Relating to Certification of Public Water System Operators	• Contents: purpose; definitions; public water system operation & management; classes of certification; education & work experience requirements for certification; continuing education units; application for certification; examination for certification; issuance and renewal of certification; revocation, suspension & refusal to renew certification; schedule of fees for certification; classification of water treatment plants; classification of distribution systems; procedures of the board; penalties & remedies; severablility clause • Class 1 distribution systems <or= 1,500 persons; Class 2 systems 1,501-15,000 persons; Class 3 systems 15,001 -50,000 persons; Class 4 systems >50,000 persons • Class 1 water treatment plant includes any chemical addition such as chlorination, flouridation; pH control or corrosion control; slow sand filtration, granular activated carbon filtration, or packed aeration towers or air stripping towers. Class 2 treatment plant includes membrane filtration, cartridge filtration, or desalinization (incl. distillation, electrodialysis, reverse osmosis. Class 3 treatment plant includes diatomaceous earth filtration, or package water treatment plants with processes similar to diatomaceous earth filtration; Class 4 water treatment plants use conventional treatment (coagulation with rapid mixing, flocculation, sedimentation and filtration); or direct filtration (conventional treatment without sedimentation); or package plants with features similar to those of conventional treatment or direct filtration. • Applies to all community and non-transient non-community water systems. • Each public water system covered by this chapter shall be under the responsible charge of an operator(s) holding valid certification equal to or greater than the classification of water treatment plant or distribution system. • All operating personnel making daily process control or system integrity decisions about water quality or quantity that affect public health shall be certified. • A designated certified operator shall be available for each operating shift
Drinking Water State Revolving Fund	Established to help public water systems finance important infrastructure improvements. EPA awards grants to states. States establish revolving loan funds to assist with projects needed either for regulatory compliance, source protection or to avert problems from old or failing facilitiies. Act requires 20% State match. All funded projects must comply with all state and federal requirements. Approvals are phased: first a project is put on the prioity list, then there are requirements for the planning process, the loan agreement, the construction, loan payment and close-out and operations.

Regulatory Schedule Affecting Lana`i - Other Than Safe Drinking Water Act

Rule	EPA Status	State Adoption	Actions
Clean Water Act - National Pollutant Discharge Elimination System	40 CFR Part 122 USC Title 33	HAR 11-55	Before discharging any pollutants into state waters, altering the quality or substantially increasing the quantity of any discharge, a general permit application must be filed for discharges, including: ♦Hydrotesting waters: water used to test the integrity of a tank or pipeline ♦ Construction activity dewatering effluent: dewatering process of construction activities of any size ♦ Treated effluent from well drilling activities; treated process wastewater includes all drilling slurries, lubricating fluids, wastewaters and well purge wastewaters An individual permit may be required where effluent limitation guidelines are promulgated for point sources covered by the general permit; a water quality management plan containing requirements applicable to the point sources is approved, circumstances have changed so that the permittee is no longer appropriately controlled under general permit or a reduction or elimination of the authorized discharge is necessary, or the discharge is a significant contributor of pollutants to state waters. NPDES applications shall be filed no less than 180 days before discharge of any pollutants, or in sufficient time prior to discharge to ensure compliance with national standards of performance for manufacturing type industry, or with any applicable zoning or site requirements under a waste treatment management plan, and any other applicable water quality or effluent standards and limitations. NPDES permits must comply with any applicable standards of performance for new sources, applicable water quality standards, effluent standards, effluent prohibitions and pretreatment standards, and effluent limitations as specified in issued permits Permits must comply with any more stringent limitations, including: 1) standards established by state laws or rules, 2) federal standards an regulations for toxic pollutant effluents, secondary treatment, point source discharges of conventional pollutants, and sludge handling, 3) any waste treatment management plan approved for the area. The permittee shall report planned changes, anticipated non-compliance, transfers, monitoring results at the intervals specified in the permit, compliance schedule and any non-compliance. Any new or increased discharges require a new application, or submission of a notice if the discharge does not violate effluent limitations specified in the permit. Permanent discontinuance of the treatment works or waste outlet must be reported within 30 days

Clean Water Act - Total Maximum Daily Load	Proposed 08/23/99 Final 07/13/2000 64 FR 46057 www.epa.gov/ owow/tmdl		♦Does not apply to Lana'i. ♦Objectives: 1) to progress towards meeting water quality standards, especially in non-attainment water areas, and 2) to assure that TMDLs are implemented ♦ States must develop lists of polluted water bodies every 4 years, and establish a schedule for clean-up within 10 years (or 15 years if needed). Higher prioirity given to polluted waters that are sources of drinking water. ♦ TMDL will identify water body name, location, pollutant, amount of pollutant allowable to meet standards, load reduction to meet standards, sources of the pollutant, wasteload allocation for point sources, load allocation for runoff and other sources,and implementation plan, conssideration fo seasonal variation, allowance for reasonably foreseeable increases in pollutant loads. Plans and actions may be phased in over time. Public to have opportunity to comment. ♦ Implementation plans should have list of actions needed to reduce pollutant loads, time-lines for implementation, reasonable assurances that implementation will occur, monitoring and modeling plans with milestones for measuring progress, plans for revising the TMDL if progress toward cleanup is not made, and anticipated date by wihich water quality standards will be met. ♦ Reasonable assurance is established either through NPDES permit for point sources, or through a four part test for non-point sources: 1) actions must apply to the pollutant; actions will be implemented expeditiosly; actions will be accomplished through effective programs, 4) actions will be supported by adequate water qualtity funding ♦EPA authority to review State TMDLs and will also back-stop State efforts to develop them. Authority to override State-issued, expired, or administratively-continued permits authorizing discharges into impaired water bodies In effect, ability to over-ride allows the EPA to control all legal discharges to ensure that permits are consistent with water quality standards, as well as with applicable wasteload allocations in a TMDL. ♦EPA can require selected dischargers to offset any increase in mass loadings of a pollutant(s) into already impaired waters, or should the increase cause nonattainment of the water body.

Occupational Safety & Health Act (OSHA)	29 CFR Parts 1910 and 1926	HAR 12-9	general safety and health requirements include elimination or reduction of existing or potential hazards, written safety and health program to identify, evaluate and control work place hazards, periodic inspections by trained individuals to identify new or missed hazards, and safety and health training. In addition, there are specific requirements for the following: ♠ safety, training & education ♠ medical and first aid ♠ fire protection ♠ personal protective equipment ♠ housekeeping ♠ illumination ♠ ventilation ♠ signals, signalling & barricading ♠ means of egress ♠ work areas & working surfaces ♠ materials handling, storage & use ♠hazardous materials process/safety mgmt ♠ management of highly hazardous chemicals handling & processes ♠ flammable & combustible liquids mgmt ♠ liquified petroleum gas mgmt ♠ logging operations ♠ welding, cutting and brazing ♠ use of hand & power tools ♠ machinery & machine guarding ♠ motor vehicles & mechanized equipment ♠ ladders, scaffolds, other special working conditions ♠ powered platforms ♠ cranes & derricks ♠ material hoists ♠ abrasive blasting ♠ storage batteries ♠ air receivers ♠ permit-required confined spaces ♠ hazardous waste operations & emergency response ♠ control of hazardous energy (lock-out,tag-out) ♠electrical ♠full-protection systems ♠ demolition ♠ excavation ♠ steel erection ♠ underground lines ♠ asbestos handling ♠ lead handling ♠ retention of DOT markings, placards & labels ♠ rollover protective structures & overhead protection ♠ occupational noise exposure ♠radiation hazards ♠toxic materials & harmful physical agents ♠hazardous chemicals in laboratories ♠hazard communication

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	40 CFR Part 171		♦ History: The first pesticide control law was enacted in 1910 to protect consumers from ineffective products and improper labeling. FIFRA was initially passed in 1947 was under the US Department of Agriculture. In 1972 it was amended to focus on protection of human health and the environement, with EPA as the lead agency. Mandates that EPA regulate the use and sale of pesticides for this purpose. ♦ Before pesticides can be registered, the burden of proof is on the would-be registrant to prove that the pesticide can be safely used on the product it is intended for. Each pesticide registration applies to one particular use of a chemical, specifying crops and sites on which it may be applied. In some cases conditional registration may be granted pending additional data. ♦ EPA must set a tolerance, or maximum amount that can be used on a raw product and consisered safe, or not cause residues above accepted tolerances. ♦ Data which must be reviewed in registering and setting tolerances include environmental fate, residue chemistry, dietary and non-dietary hazards to humans, animals and non-target organisms; and these data gathered by studies conducted with approved methods. To register a pesticide the composition must warrant the claims proposed for it, its labeling and other materials must comply with the provisions of FIFRA for same, it must perform its intended function without unreasonable adverse effects, when used in accordance with widespread practice. States may register additional uses of a federeally registered pesticide product to meet specific local needs. EPA may disapprove State registrations if the registered pesticide will not stay within acceptable tolerances or if the pesticide has been denied by EPA. ♦ Emergency exemptions may be granted when there is a problem situation that registered pesticides will not alleviate, and the proposed exemption will not cause unreasonable adverse effects. If States concur that necessary conditions have been met they send request to EPA to register for a given situation. ♦ Some pesticides are registered for "restricted use" only. These are pesticides that may only be applied by properly trained and certified applicators. States can certify applicators if their certification training plan meets with EPA approval. Gaseous Chlorine, used in drinking water utilities is a restricted pesticide,and requires a certified applicator . ♦ Pesticide registrations must be reviewed every 15 years. EPA makes re-registration determinations. Pesticdes may also be cancelled where EPA believes that conditions of the rule have not been met. Cancellation procedures are delineated in the rule, but EPA may issue an emergency order and cancellation where an imminent hazard would result if the pesticide continued to be used during cancellation proceedings. ♦ Labeling requirements include contents, registered uses, requirements of rmixing, storage and application, time periods after use before fields may be re-entered, or before crops may be harvested, container disposal requirements, and other information. ♦ Imported pesticides are subject to pesticide regulations. Exported pesticides are subject to recordkeeping and certain procedures for data and for labeling related to safe storage, disposal, handling and transportation. Companies may export pesticides not registered in the United States subject to a signed statement from the foreign purchaser acknowledging the unregistered status of the product before it can be shipped. ♦ Can affect drinking water utiliities in combination with other acts such as ESA or FQPA below: ♦ §7(a)(2) of the Endangered Species Act requires that agencies ensure that their actions are not likely to jeopardize listed species, nor their critical habitat. Pesticide registrations have been challenged on this basis. If species or habitat "may be" affected, an Endangered Species Act consultation is required.

FIFRA (continued)	40 CFR Part 171		♦ The Pesticides and Groundwater State Management Plan Regulation required states to create specific management plans (pesticide manqagement plans) to protect groundwaters from pesticides or lose the ability to register/ use those pesticies.
Food Quality Protection Act	August 13, 1996		♦ Amended both FIFRA and the Federal Food, Drug, and Cosmetic Act (FFDCA) to establish a new safety standard for pesticide residues in food and emphasizing protection of infants and children, and protection from aggregate exposures. ♦ Under FQPA, EPA must be able to conclude with "reasonable certainty that no harm will result from aggregate exposure" to each pesticide from dietary and other sources. In determining allowable levels of pesticide residues in food, the Agency must conduct a comprehensive assessment of each pesticide's risks, considering: • Aggregate exposure of the public to residues from all sources including food, drinking water, and residential uses; ² Cumulative effects of pesticides and other substances with common mechanisms of toxicity; ² Special sensitivity of infants and children to pesticide; and ² Estrogen or other endocrine effects. ♦ Within ten years of enactment of the new law, EPA must reassess all existing "tolerances" (maximum limits for pesticide residues in foods) and exemptions from the requirement of a tolerance, for both the active and inert ingredients in pesticide products. The Agency must consider the pesticides posing the greatest potential risks first, to ensure that they meet FQPA's new safety standard. ♦ FQPA requires EPA to review every registered pesticide on a suggested 15-year cycle.

Emergency Planning & Community Right-to-Know Act (EPCRA) Hawai'i Emergency Planning and Community Right-to-Know Act (HEPCRA)	40 CFR Part 68	HAR 128E-6, 128E-7, and 128E-9; HAR 11-451-7; The State Contingency Plan Title 11 Chapter 451	♦EPCRA applies to processes that have a regulated substance present in more than a threshold quantity as determined under Sec. 68.115 (2,500 lb for chlorine). ♦Requirements include: off- site consequence analysis for worst case and alternate case scenarios: five year history of releases, integrated prevention program; emergency response program; risk management plan, management program supervising implementation of the risk management plan, five year revision provisions. ♦The risk management plan must contain an executive summary, the registration for the facility, the certification statement, at least one worst case scenario to cover all progam 2 and 3 processes involving regulated toxic substances, at least one worst case scenario to cover all program 2 and 3 processes involving regulated flammables; the five year accident history fo reach process, and a summary of the emergency response program for the facility. There are numerous requirements to update and re-submit the RMP based upon whether and what changes occur at the facility. ♦ HEPCRA requires: ♦ reporting for all hazardous substances requireing MSDAS sheets under OSHA that are present at the facility in amounts not less than 10,000 lbs, and extremely hazardous substances present at the facility in amounts not less than 500 lbs., or the Threshold Planning Quantity, (TPQ) whichever is lower. The TPQ for chlorine is 100 lbs. ♦Annual submission of chemical inventories must include the Hawai'i Chemical Inventory Form (HCIF) in place of the Federal Tier II Form; facility maps indicating chemical storage locations; and a $100 filing fee per year per facility. ♦ Reporting of spills or releases that exceed the reportable quantity (RQ). RQ for chlorine gas release is 10 lb.
Endangered Species Act (ESA) Endangered & Threatened Wildlife and Plants: Determination of Prudency and Proposed Designation of Critical Habitat for Plant Species from the Island of Lana`i, Hawai'i; Proposed Rule	50 CFR Part 17 FR 66 No 67 04/06/ 2001 pg. 18223		♦Critical Habitat designation affects activities on State or private lands only if a federal permit, license or funding is involved. ♦Federal agency funding, performing or authorizing activity within CH must ensure that a listed species is not jeopardized and the CH not adversely affected. Federal action agency is responsible for determining whether CH will be affected. ♦On Lana`i, a total of 5,027acres in 10 areas were proposed for critical habitat designation; including 2,619 acres at Lana'ihale. Need to get final decision.

Regulatory Schedule Affecting Lana`i Water - State Legislation & Rules

Rule	Actions
State Water Code HRS 174 C	Part I - Administrative Structure - establishes CWRM, water plan, definitions, funding, proceedings,etc. Part II - Reports of Water Use - declarations of water use, certificates of water use Part III - Hawai'i Water Plan - Resource Protection Plan, Water Use & Development Plans, State Water Projects Plan, Water Quality Plan Part IV - Regulation of Water Use - permits, designation, criteria for designation, declaration of water shortage, procedings and rights, etc. SETS CRITERIA FOR DESIGNATION OF GROUNDWATER AND OF STREAMWATER ♦ Notwithstanding an imminent designation of a water management area conditioned on a rise in the rate of ground water withdrawal to a level of ninety percent of the area's sustainable yield, the commission, when such level reaches the eighty percent level of the sustainable yield, may invite the participation of water users in the affected area to an informational hearing for the purposes of assessing the groundwater situation and devising mitigative measures. Part V - Water Quality - refers to coordination with DOH and to HRS chapters 340 E and 342 Part VI - In Stream Uses of Water - protection, flow standards, etc. Part VII - Wells - registration, permits to construct, pump installation permits, standards, completion reports, abandonment, etc. Part VIII- Stream Diversion Works - registration, permits, completion reports, abandonment Part IX - Native Hawai'ian Water Rights - protects traditional & customary rights, appurtenant rights of kuleana and taro lands, refers to Hawai'ian Homes Commission Act of 1920 §221 and to HRS Chapters 167 and 168

Administrative Rules of the State Water Code - HAR Title 13 - Subtitle 7 Water Resources Chapters 167 through 171	13-7-167 - Rules of Practice and Procedure for the Commission on Water Resource Management 13-7-168 - Water Use, Wells and Stream Diversion Works ♦ Certificate of water use, report of water use, registration of existing wells, well construction and installation permits, well completion reports, well construction and pump installation standards, well inspection, abandoned wells, registration of existing stream diversion works, stream diversion permits, stream diversion completion reports, stream diversion works inspection, abandoned stream diversions ♦ No well shall be constructed altered, or repaired, and no pump or pumping equipment installed, replaced or repaired without an appropriate permit from the CWRM ♦ Well construction and pump installation standards refer to & incorporate by reference ANSI/AWWA E101-77 as may be amended 13-7-169 - Protection of In-Stream Uses of Water ♦ General provisions, in-stream use protection program, in-stream flow standards, interim instream flow standards, stream channel alteration ♦ Defines development of in-stream flow standards, procedures and public notification for adoption ♦ Delineates permit process for stream channel alteration, criteria for ruling on applications, fees, etc. ♦ Provides for emergency repair work 13-7-170 - Hawai'i Water Plan ♦ Elements of plan to include: Resource Protection Plan, Water Use & Development Plans, State Water Projects Plan, Water Quality Plan ♦ Guidelines for preparation, preparing agencies, funding, coordination and integration of plan elements described 13-7-171- Designation and Regulation of Water Management Areas ♦ Criteria for designation as defined in HRS 174-C ♦ 1) Whether an increase in water use, or authorized planned use may cause the maximmum rate of withdrawal from the ground water source to reach ninety percent of the sustainable yield of the proposed water management area ♦ 2) Whether the rates, times, spatial patterns or depths of existing withdrawals of groundwater are endangering the stability or optimum development of the groundwater body due to upconing or encroachment of salt water ♦ 3) Whether the chloride contents of existing wells are increasing to levels which materially reduce the value of their existing uses ♦ 4) Whether excessive or preventable waste of water is occurring ♦ 5) Whether there is an actual or threatened water quality degradation as determined by the Department of Health ♦ 6) Whether there exist serious disputes respecting the use of groundwater resources are occurring ♦ 7) Whether regulation is necessary to preserve the diminishing groundwater supply for future needs, as evidenced by excessively declining groundwater levels ♦ 8) Whether water development projects that have received any federal state or county approval may result in the opinion of the commission in one of the above conditions ♦ Sets procedures and notification for designation, modification of designation and rescinding of designation ♦ Sets permitting procedures for use of water in designated areas, review, duration, modification, revocation, transfer ♦ Sets procedures & criteria for water shortage declaration, including notice, duration, end of water shortage, etc. ♦ Sets procedures & criteria for declaration of water emergency, notification, challenges, etc.

HAR Title 11 Chapter 25 Rules Relating to Certification of Public Water System Operators	♦ Contents: purpose; definitions; public water system operation & management; classes of certification; education & work experience requirements for certification; continuing education units; application for certification; examination for certification; issuance and renewal of certification; revocation, suspension & refusal to renew certification; schedule of fees for certification; classification of water treatment plants; classification of distribution systems; procedures of the board; penalties & remedies; severablility clause ♦ Class 1 distribution systems <or= 1,500 persons; Class 2 systems 1,501-15,000 persons; Class 3 systems 15,001 -50,000 persons; Class 4 systems >50,000 persons ♦ Class 1 water treatment plant includes any chemical addition such as chlorination, flouridation; pH control or corrosion control; slow sand filtration, granular activated carbon filtration, or packed aeration towers or air stripping towers. Class 2 treatment plant includes membrane filtration, cartridge filtration, or desalinization (incl. distillation, electrodialysis, reverse osmosis. Class 3 treatment plant includes diatomaceous earth filtration, or package water treatment plants with processes similar to diatomaceous earth filtration; Class 4 water treatment plants use conventional treatment (coagulation with rapid mixing, flocculation, sedimentation and filtration); or direct filtration (conventional treatment without sedimentation); or package plants with features similar to those of conventional treatment or direct filtration. ♦ Applies to all community and non-transient non-community water systems. ♦ Each public water system covered by this chapter shall be under the responsible charge of an operator(s) holding valid certification equal to or greater than the classification of water treatment plant or distribution system. ♦ All operating personnel making daily process control or system integrity decisions about water quality or quantity that affect public health shall be certified. ♦ A designated certified operator shall be available for each operating shift
HRS 340E	Safe Drinking Water ♦ Part I - Drinking Water Regulations - I. Definitions; 2. Drinking Water Standards; 2.5. Capacity Development; 3. Variances & Exemptions; 4. Imminent Hazard; 4.5. Tampering with Public Water Systems; 4.6. Inspection of Premises; 4.7. Notification to Users of Potential Lead Contamination; 4.8. Water Catchment Systems; 5. Plan for Emergency Provision of Water 6. Notification of Users and Department; 7. Prohibited Acts, 8. Penalties and Remedies; 9. Administration ♦ Part II - State Interim Action Levels for Contaminants in Water - 21. Definitions; 22. Establishment of Interim Action Levels; 23.Rules; 24. Notification of Contamination of underground sources of drinking water and other sources of public drinking water; 25. preemption ♦ Part III - Drinking Water Financing - 31. Definitions; 32. Declaration of Policy; 33. Powers & Duties; 34. Grants; 35. Drinking water treatment revolving loan fund, establishment and purpose; 36. drinking water fund, uses & limitations; types of assistance; 37. drinking water fund, conditions; 38. drinking water fund deposits; 39. drinking water fund fees; 40. drinking water fund interest and investments on accounts; 41. compliance ♦ Definition of "lead free" plumbing revised to NSF Standard 61 section 9 pursuant to 62FR 44684 08/22/1997

HAR Title 11 Chapter 19 Emergency Plan for Safe Drinking Water	♠Defines two types of emergencies: "Type A" disasters include major state or county disasters, such as nuclear disasters, tsunamis, earthquakes, floods, volcanic eruptions, hurricanes and tornadoes. "Type B" disasters are limited situations affecting only water systems, and include drought, major contamination of a system's basic water source, or major destruction or impairment of a system's physical facilities which substantially interferes with quantity and quality of water delivered to the public. ♠DOH responsibilities in a disaster include primarily coordination, sampling, and approval of alternate or emergency sources, aid in notification, etc. ♠No person or agency shall provide emergency supplies of water until and unless they have been deemed safe by DOH. (except in Oahu, where the Department of Water Supply and City & County have dispensation to determine whether an emergency supply is "safe". All other counties must contact DOH through their local District Health Officer. Contact list provided in regulation. ♠All state and county governments shall have an emergency response plan to deal with drinking water emergencies ♠ Each county Department of Water Supply shall have an emergency plan, updated at least annually, which includes: ♠ Designation of key personnel & contact #s ♠ Lists of resources (manpower, equipment, facilities etc.) to help deal with emergencies ♠ Designation of supporting agencies and utilities ♠ Description of alert procedures ♠ Responsibilities of specified department members ♠ Methods of communication to be utilized in an emergency ♠ Private systems shall respond to the extent of their ability, but primary initial support for emergencies will be from the county DWSs. Civil Defense agencies may also provide support. Provision of support by Civil Defense Agencies may require a declaration of emergency by a county Mayor. Either District Health Officer or DWS may request mayor to declare emergency. ♠ Civil defence agencies shall develop and maintain preparedness plans that establish emergency responsibilities and government functions. These plans shall provide for emergency public notification procedures coordinated with the civil defense system, civ-alert emergency radio, television announcements, and the use of fire and police department mobile public address systems as appropriate / necessary.
HRS 179-D 1987 "Dams and Reservoirs" & HRS 179-D-30 Hawai'i Dam & Reservoir Safety Act of 2007	Dam regulation in Hawai'i was initially part of the Federal Dam Inspection Act, Public Law 92-367, passed in August of 1972. In Act 179 D Session Laws of Hawai'i 1987, the State adopted HAR Title 13 - DLNR -Subtitle 7 - Water and Land Development - Chapter 190 "Dams and Reservoirs" which was signed into law April 9, 1990 and became effective April 19, 1990. Federal dams were exempted. Report R88 of DLNR established guidelines under these rules, entitled "Guidelines for the Design and Construction of Small Embankment Dams". Small embankments dams were defined as those under 50' in height. Dams and reservoirs of all sizes should comply with these construction guidelines as updated or amended by DLNR. Dams and reservoirs that have artificial barriers, together with appurtenant works which are 25 feet or more in height, or have an impounding capacity of 50 acre feet (~16.3 MG) or more, and height, together with appurtenant works, of 6' or more are required to meet certain requirements. These include preparation of an emergency action plan, operation and maintenance plan, inspections, reporting, access requirements and others. Dams must be inspected every five years. In 2007, the Hawai'i Dam and Reservoir Safety Act of 2007, established inspections of all of the State's 136 regulated dams. Non-regulated dams are also inventoried and will be inspected to verify whether these flagged bodies of water should be regulated. A reservoir safety special fund was established. Dams constructed prior to July 6, 2007 were required to obtain certificates of approval to impound. Dam and reservoir owners were required to maintain operation and maintenance plans, emergency action plans, for high and significant hazard potential dams, facilitate access by necessary State agencies or representatives, furnish upon requests plans, specifications, operating and maintenance data for each dam. Fifty-four (54) of one hundred thirty six (136) regulated dams listed are in Maui County. While none of these regulated dams are listed on Lana'i, non-regulated dams and reservoirs may be subject to inspection and verification as part of the non-regulated damn safety research.
HAR Title 13 Subtitle 7 Chapter 190 Dams & Reservoirs	Addresses construction, repair, enlargement, alteration or removal, inspection and completion of dams and reservoirs. Also maintenance and operation, emergency work, emergency preparedness plans. Applices to dams and reservoirs of more than 25' in height, or capable of holding more than 50 acre feet (~16.3 MG) and more than 6' in height. Does not apply to dams or reservoirs less than 6' in height, regardless of size, nor to dams or reservoirs less than 15 acre feet (4.9 MG).

HAR Title 11 Chapter 20 Rules Relating to Potable Water Systems	♦ Sections: coverage; definitions; MCLs for inorganic chemicals (15); MCLs for organic chemicals (33); MCL for turbidity (0.5 NTU in general, with clarifications under certain circumstances); Maximum Biological Contaminant Levels; MCLs for radionuclides; sampling & analytical requirements (chemical, microbiological, turbidity, etc.); alternative analytical techniques; approved laboratories; monitoring of consecutive water systems (those served by other water systems); reporting requirements; public notification; records maintenance; requirements, procedures & consideration for variance requests; requirements, procedures and consideration for exemption requests; disposition of variances & exemptions; public hearings on variances & exemptions; final schedule re: variances; use of new sources of raw water for public water systems and preliminary engineering report (PER) requirements for new sources; capacity demonstration & evaluation (technical, operating, infrastructure, financial, managerial, budgetr, credit-worthiness, internal policies, emergency response, backflow & cross-connection prevention; ownership, etc.); rules for new & modified public water systems; use of trucks to deliver drinking water; penalties & remedies; entry & inspection; special monitoring for sodium and for corrosivity characteristics; sampling, reporting and notification for certain unregulated contaminants; special monitoring for inorganic & organic chemicals; additives (must meet ANSI Standard 60); time requirements; criteria and procedures for public water systems using point-of-entry devices; use of other non-centralized treatment devices; bottled water and point-of-use devices; variance from the maximum contaminant levels for synthetic organic chemicals; total trihalomethanes sampling, analytical and other requirements; filtration and disinfection requirements (surface water treatment rule); treatment techniques for acrylamide and epichlorydrin; adoption of the national primary drinking water regulations for lead and copper; consumer confidence reports; severability ♦ §11-20-9(d)(2) in conducting a sanitary survey of a system using groundwater in a site having an EPA approved wellhead protection program under §1428 of the Safe Drinking Water Act, information on sources of contamination within the delineated wellhead protection area that was collected in the course of developing and implementing the program should be considered instead of collecting new information, if the information was collected since the last time the system was subject to a sanitary survey. ♦ §11-20-35 community water systems shall identify whether the following construction materials are present in their distribution system and report to the Department (DOH): 1) lead from piping, solder, caulking, interior lining of distribution mains, alloys, home plumbing; 2) copper from piping, solder, caulking, interior lining of distribution mains, alloys, home plumbing; 3) galvanized piping, service lines & home plumbing; 4) ferrous piping materials such as cast iron and steel; 5) asbestos cement pipe; 6) others, including but not limited to a) vinyl-lined asbestos-cement pipe; b) coal-tar lined pipes and tanks. ♦ Other requirements are described with individual rules under the Safe Drinking Water Act
HAR Title 11 Chapter 21 Cross Connection and Backflow Control	♦ Contents: purpose, definitions; right to inspect; approval of devices; installation & location; existing cross-connections; irrigation systems; maintenance requirements; violations and penalties; effect of county government ordinance; severability ♦ DOH may enter any building or premise at any reasonable hour to inspect plumbing for cross-connections or other structural or sanitary hazards including violations ♦ Devices must meet AWWA standard AWWA C506-78; and must meet the laboratory and field performance specifications of the Foundation for Cross Connection Control and Hydraulic Research of the University of Southern California - FCCC & HR ♦ Specifies vacuum breakers, double check valve assemblies and reduced pressure principal backflow preventers for irrigation systems ♦ All existing cross connections to public water systems shall be removed or the system protected by means of an approved backflow preventer

HAR Title 11 Chapter 23 Underground Injection Control	♦Underground Injection Control (UIC) maps to be updated once every three years ♦"inject" means to dispose of or emplace fluids, either under pressure or by gravity flow, into a subsurface formation or formations. "well" means a bored, drilled, or driven shaft, or a dug hole, whose depth is greater than its widest surface dimension. ♦Contents: purpose, scope, definitions, classification of exempted aquifers & underground sources of drinking water; identification of underground sources of drinking water; classification of injection wells; prohibition; construction conditions; siting & pre-construction conditions; provision for artesian aquifer protection; operating conditions; procedures for UIC permit, submission of data, public notice of proposed wells injecting into underground sources of drinking water; public hearings; permit issuance; existing injection well regulation; monitoring & reporting requirements; plugging & abandonment requirements; revocation, suspension or revision of UIC permits; inspection & entry ♦ 5 classes of injection wells: Only Class V wells are allowed in Hawai. 1) Class I : wells which inject fluids beneath the lowermost formation containing, and within 1/4 mile of the well bore, an underground source of drinking water and which are used by: a) generators of hazardous waste or owners or operators of hazardous waste management facilities; b) disposers of industrial and municipal waste fluids; 2) Class II: a)wells which inject fluids which are ground to the surface in connection with conventional oil or natural gas production and may be comingled with waste waters from gas plants which are an integral part of production operations, unless those waters are clasified as a hazardous waste at the time of injection; b)for enhanced recovery of oil or natural gass; c)for storage of hydrocarbons which are liquid at standard temperature and pressure; 3)Class III: wells which inject for extraction of minerals, including a)mining of sulfur by the Frasch process; b)in-situ production of uranium or other metals, using unconventional techniques to mine ore bodies; and c) solution of mining of salts or potash; 4) Class IV: wells used by generators of hazardous waste or of radioactive waste, by owners or operators of hazardous waste management faciliites, or by owners or operators of radioactive waste disposal sites to dispose of hazardous waste or radioactive waste into any geohydrologic formation or a formation which, within 1/4 mile of the well, contains an underground source of drinking water, even if exempted; 5) Class V: Subclass A - injection wells which inject fluids into an undergound source of drinking water, including a) sewage injection wells, b) industrial disposal wells other than those classified under other subclasses; Class V: Subclass AB - injection wells which inject only into exempted aquifers. Subclass AB wells include sewage injection wells, and industrial disposal wells, other than those classified under subclass B such as brine disposal wells used in a desalinization process; Class V: Subclass B - injection wells which inject non-polluting fluids into any geohydrologic formation, including underground sources of drinking water, including a) air conditioning return flow wells used to return the water used for heating or cooling in a heat pump; b)cooling water return flow wells used to inject water previously used for cooling; c)recharge wells used to replenish, augment or store water in an aquifer; d)salt water intrusion barrier wells, used to prevent the intrusion of salt water into fresh water, if they inject water of equal or lesser chloride concentrations as that portion of the aquifer into which injected; e)wells used in aquaculture, if the water in the receiving formation has either an equal or greater chloride concentration as that of the injected chloride, or a total dissolved solids concentration in excess of 5000 mg/L; f)injection wells used in an experimental technology, which is one that has not been proven feasible under the conditions in which it is being tested, and g) all wells not included in any of the other classes or subclasses; Class V: - Subclass C - injection wells wich inject surface fluids, i.e. storm runoff, into any geohydrologic formation; Class V: Subclass D - injection wells which inject overflows, or relief flows, from potable water systems into any geohydrologic formation; Class V: Subclass E - injection wells associated with the development and recovery of geothermal energy, provided that the geothermal effluent will be injected at a depth that will not be detrimental to underground sources of drinking water. If injection is to occur below the basal water table, the receiving formation water shall be tested and injection allowed if the receiving water has either: an unequal or greater chloride concentration as that of the injected fluid; or a total dissolved solids concentration in excess of five thousand mg/L or an equivalent or lesser water quality than the injected fluid. Subclass E wells include brine injection wells for the disposal of excess water from the steam-flashing process, condensate injection wells for the disposal of condensate from electric generators, and gas injection wells for the disposal of non-condensible gases entrained in an aqueous solution.

HRS 342 B Hawai'i Air Pollution Control Act	Air Pollution ♦ § 1) A "stationary source" is any piece of equipment or activity at a building, structure, facility, or installation that emits or may emit any air pollution. A "variance" is special written authorization from the director to cause or emit any regulated air pollutant in a manner or an amount in excess of applicable standards, or to do an act that deviates from the requirements of rules or standards adopted pursuant to this chapter. A "permit" is written authorization from the director to construct, modify, relocate, or operate any regulated air pollutant source, and authorizes the permitee to cause or allow the emission of a regulated air pollutant in a specified manner or amount or to do an act that is not forbidden by this chapter or rules prior to this chapter .♦ § 11) No person, including any public body, shall engage in an activity that causes air pollution or emissions of any regulated air pollutant without first securing approval from the director .♦ § 14) Variance applications shall be made on forms provided by the department, and shall be accompanied by a complete and detailed description of present conditions, how conditions do not conform to applicable standards, and any other information that the department may require. Applications will be reviewed in light of descriptions, statements, plans, histories, other supporting information, and any information requested by the department. For a variance to be approved, the application and supporting information must show that; the continued operation of the cause of the discharge is in the publics interest; does not substantially endanger human health or safety; and that compliance with applicable standards would cause serious hardship without equal or greater benefits to the public. All variances are approved with the requirement that the grantee performs an air or discharge sampling and report back to the department, and all variances are applicable for a period of no more than five years. ♦ § 22) A permit is required to begin construction, relocation, or modification of any air pollutant source. Owners and operators of a source are required to obtain a permit. ♦ § 23) Permit applications will be in a form prescribed by the director, and require a compliance plan. The department may also require other plans, specifications, meteorological monitoring data, ambient air quality monitoring data, best available control technology analysis, as well as any other information required to identify the source, the air emissions, and the air quality impact, and to determine whether the proposed source will be in accord with rules and standards. ♦ § 25) Permits may be subject to reasonable conditions as the director may prescribe, and the director shall not deny an application for the issuance or renewal of a permit without affording the applicant an opportunity for a hearing .♦ § 28) The director may require an owner or operator of a source on a continuous, sporadic, or one-time basis to; establish, maintain, and submit records; draft reports; install, use, and maintain monitoring equipment; sample emissions; keep records on the source and the control equipment parameters, production variables, or other indirect data when direct monitoring is impractical; sample and analyze the substance being burned; submit compliance certificates; and provide any other information the department may require. ♦ § 33) A permit requires the permitee to, minimum, submit to the director the results of any required monitoring, no less than six months, submit a compliance certificate, no less than yearly, and disclose the annual emissions of hazardous air pollutants.

HRS 342 D Water Pollution	Water Pollution •§ 1) Permits are written authorization from the director to discharge waste or to construct, modify, or operate any water pollution source in a manner and amount that is not forbidden by this chapter. • 6) Permits are issued by the director for a maximum term of five years, and no permits will be issued or denied without the applicants being given an opportunity for a hearing. The department may require that plans, specifications, or other information accompany permit applications. The director may modify, revoke, or suspend a permit after allowing the opportunity for a hearing has been granted and a violation has been found. •§ 14) Reports on discharges of waste shall be available to the public during established office hours unless the report contains confidential material. Any employee of the department who divulges classified information shall be fined a maximum of $1,000, except under authorized circumstances, as ordered by a court, or at an administrative hearing on an alleged violation. •§ 17) All state and county health authorities and police officers shall enforce this chapter and the rules and orders of the department. •§ 32) Any who negligently violates this chapter or introduces water pollutants into the sewer system or a publicly owned treatment plant shall be fined between $2,500 and $25,000 per day of violation or imprisoned for a maximum of one year, or both. If a violation occurs again after a first conviction, the fine is not more than $50,000 or a maximum of two years in jail, or both. •§ 33) Any who knowingly violates this chapter or introduces water pollutants into the sewer system or a publicly owned treatment plant shall be fined between $5,000 and $50,000 per day of violation or imprisoned for a maximum of three year, or both. If a violation occurs again after a first conviction, the fine is not more than $100,000 or a maximum of four years in jail, or both. •§ 36) A single operational upset that leads to simultaneous violations shall be treated as a single violation. •§ 38) A “hazardous substance” is defined as 1) Any substance designated by the Federal Water Pollution Control Act, section 311. 2) Any element, compound, mixture, solution, or substance designated by the Comprehensive Environmental Response, Compensation, and Liability Act. 3) Any hazardous waste having characteristics identified by the Solid Waste Disposal Act (except those that have been suspended by Congress). 4) Any toxic pollutant identified by the FWPCA section 307. 5) Any imminently hazardous chemical substance or mixture with respect to which the administrator has taken action pursuant to section 7 of the Toxic Substances Control Act. •§ 50) No person, public body, or industrial group shall discharge any water pollutants into state waters or publicly owned treatment plants in violation of this chapter or the rules of the director. No person or public body shall alter any system of drainage, sewage, or water supply. •§ 51) Any person who has caused an unlawful discharge must report the incident to the director within 24 hours, unless a permit has been issued for the specific discharge specifying another reporting period. •§ 52) The director may test any water and aquatic or other life that has been subjected to any form of water pollution and assess the environmental effects of the pollution. If the effects are hazardous, the public will be immediately notified. •§ 55) The director may require the owner or operator of any effluent source, works, system, or plant to establish and maintain records; make reports and plans that cover existing situations are proposed additions, modifications, or repairs; install, use, and maintain monitoring equipment or methods; sample effluent, state waters, sewage sludge, and recycled water; and provide any information that the department might require. •§ 70) The department may authorize any county to use a gray water recycling program. The gray water shall be limited to the use of water from residential units for the purpose of irrigating lawns and gardens. Gray water is any water from domestic plumbing systems except the toilet, provided the water is not contaminated with household hazardous waste.

HAR Title 11 Chapter 54 Water Quality Standards	♦Contents: Definitions, General Policy of Water Anti-Degradation; Classification of State Waters; Classification of Water Uses; Basic Water Quality critieria applicable to all waters; uses and specific criteria applicable to inland waters:definitions; Inland water areas to be protected; inland water criteria; uses and specific criteria applicable to marine waters; uses and specific criteria applicable to marine bottom types; Specific criteria for recreational areas; zones of mixing; water quality certifications (for discharge resulting from activity) ; contents of certification; contents of application; notice and hearing; waiver; adoption of new water quality standards; inspection of facility or activity before operation; notification to licensing or permitting agency; termination or suspension; review and advice; water quality analyses; revision; severability ♦Basic criteria: all waters shall be free of ... 1) materials that will settle to form objectionable sludge or bottom deposits; 2) floating debris, oil grease or scum; 3) substances in amounts sufficient to produce taste in the water or detectable off-flavor in the flesh of fish, or in amounts sufficient to produce objectionable color, turbidity, or other conditions in receiving waters; 4) high or low temperatures, biodices, pathogenic organisms, toxic, radioactive, corrosive or other deleterious substances at levels or in combinations sufficient to be toxic or harmful to human, animal, plant or aquatic life, or in amounts sufficient to interfere with any beneficial use of the water; 5) substances or conditions or combinations thereof which produce undesiriable aquatic life; 6) soil particles resulting from erosion on land involved in earth work, such as the construction of public works, highways, subdivisions, recreational, commercial or industrial developments, or the cultivation and management of agricultural lands ♦ Acute toxicity, chronic toxicity and human health standards are set. Numeric standards are set for 97 contaminants. In addition, criteria for various classes of waters are set for total nitrogen, total dissolved nitrogen, amonia nitrogen, nitrate and nitrite nitrogen, total phosphorous, total dissolved phosphorous, total suspended solids, turbidity and chlorophyll ♦ Various types of waters or ecoystems are identified and classes set - either Class AA or A waters, or Class I or Class II of various other environments, as follows: Class AA Waters - Marine waters surrounding Lana'i are rated Class AA. Class AA waters should remain as close to pristine as possible. No zones of mixing to be permitted in this class. Should have absolute minimum alteration of water quality from any human sources or actions. Class A Waters - Embayments - Maui: Kahului Bay, Lahaina Boat Harbor; Maalaea Boat Harbor; Molokai: Hale O Lono Harbor, Kaunakakai Harbor, Kaunakakai Boat Harbor; Lana'i: Manele Boat Harbor, Kaumalapau Harbor Class I Sand Beaches - none listed in Maui, Molokai or Lana`i. those listed are mainly in Northwest Hawai'ian Islands Class II Sand Beaches - all beaches Class I Solution Benches - none listed in Maui, Molokai or Lana`i (unless named by DLNR under HRS 190 or HRS 195, or by US F&WS as reserves, sanctuaries or etc. Class II Solution Benches - Maui: Kihei, Papaula Point; Molokai: none listed; Lana`i: none listed Class I Marine Pools - none listed in Maui, Molokai or Lana`i (unless named by DLNR under HRS 190 or HRS 195 or by US F&WS as reserves, sanctuaries or etc.) Class II Marine Pools - Maui: Hana, Keanae, Napili, Puu Olai to Cape Hanamanioa, Kipahulu; Molokai: Cape Halawa, Kalaupapa, South Coast; Lana'i: none listed Shallow Draft Harbors - Class II - Maui: Maalaea Boat Harbor, Lahaina Boat Harbor, Hana Harbor; Molokai: Kalaupapa Anchorage, Kaunakakai Small Boat Harbor, Hale O Lono Harbor; Lana`i: Manele Boat Harbor, Kaumalapau Harbor Deep Draft Commercial Harbors - Class II - Maui: Kahului Harbor; Molokai: Kaunakakai Barge Harbor; Lana`i: none listed Reef Flats & Reef Communities - Near Shore - Class I - Maui: Honolua; Molokai: West Kalaupapa, S.E. Molokai Reef, Honomuni Harbor, Kulaalamihi Fishpond; Lana`i: none listed - again, others may be designated by DLNR or US F&WS (as above) Off Shore Reef Flats - Class I - none listed in Maui, Molokai or Lana`i - (northwest Hawai'ian islands and Oahu have listings) Wave-Exposed Reef Communities - Class I - Maui: Hana Bay, Makuleia Bay, Honolua, Molokini Island; Molokai: Moanui Kahinapohaku Waikolu - Kalawau and Halawa Bay; Lana`i: none listed Protected Reef Communities - Class I - Maui: Honolula, Ahihi-La Perouse, (including 1790 lava flow at Cape Kinau), Molokini; Molokai: S.E. Molokai, Kalaupapa, Honomuni Harbor; Lana`i: Manele, Hulopoe Class II Reef Habitats: Maui: Lahaina Harbor, Kahului Harbor; Molokai: Kaunakakai Harbor, Hale O Lono Harbor, Palaau (1.5 m e of Pakanaka fishpond); Lana'i: Manele

HAR Title 11 Chapter 55 Water Pollution Control	♦Contents: definitions; general policy of water pollution control; general prohibition; application for NPDES permit, notice of intent or conditional "no exposure" exclusion; receipt of federal data; transmission of data to regional administrator; identity of signatories to NPDES forms; formulation of tentative determination and draft permits; public notice of applications; fact sheet; notice to other government agencies; public access to information; public hearings; public notice of public hearings; issuance of NPDES permits; modification or revocation & reissuance of NPDES permits; termination of permits & denial or removal; reporting discontinuance or dismantlement; application of effluent standards and limitations, water quality standards & other requirements; effluent limitations in issued NPDES permits; schedule of compliance in issued NPDES permits; compliance schedule reports; other terms and conditions of issued NPDES permits; national pre-treatment standards and users of publicly owned treatment works; transmission to regional administrator of proposed NPDES permits; transmission to regional administrator of issued NPDES permits; renewal of NPDES permits; monitoring; recording of monitoring activities and results; reporting of monitoring results; sampling & testing methods; malfunction, maintenance & repair of equipment; agency board membership; general permit definitions; general permit policy; general permit authority and adoption; general permit terms; general permit conditons; requiring an individual permit; relationship of general & individual permits; degree of waste treatment; notice of intent; notice of intent review, notice of general permit coverage, additional conditions, terms, renewals, effective dates, and automatic coverage; review of coverage issues & notice of intent and notice of general permit decisions; notice of general permit coverage modification, revocation, reissuance & termination; general permit compliance; penalties and remedies; severability clause ♦ Sets general requirements for NPDES permitting, individual and general permits. not required if discharge is purely storm water with "no exposure" to materials, activities or processes; issued in increments of 5 years or less; effluent guidelines, monitoring, public notification, data,etc. ♦ General permits may apply to a category of sources that involve the same or substantially similar types of operations, dishcarge the same types of wastes or engage in the same types of sludge use or disposal practices; require the same effluent limitations; operating conditions or standards for sludge or disposal; require the same or similar monitoring; or in the opinion of the director (of DOH) are more appropriately controlled under a general permit than an individual permit ♦ Appendices include standard general permit conditions and 8 general permits: A)standard general permit conditions: and B) through I) are NPDES general permit authorizing dishcarges of: B)storm water associated with industrial activities; C)storm water associated with construction activities; D)treated effluent from leaking underground storage tank remedial activities; E) once-through cooling water less than 1 million gallons per day; F) hydrotesting waters; G) construction dewatering; H) treated effluent from petroleum bulk stations and terminals: I) treated effluent from well drilling activities ♦ Appendix F: NPDES general permit authorizing discharges of hydrotesting waters: hydrotesting waters general permit applies to waters used to test the integrity of tanks or pipelines. does not allow discharge into class AA marine waters or Class I inland waters. Notice of Intent (NOI) requirements include overview of proposed activities, time schedule, dates, water quality analysis of hydrotesting effluent (may use system water data if applicable); hydrotesting bmp plan, description of mitigative measures; shall not exceed basic water quality criteria, report problems, retain records for minimum of 3 years ♦ Appendix I: NPDES general permit authorizing discharges of treated effluent from well drilling activities: applies to well drilling slurries, lubricating fluid wastewaters; well purge wastewaters; does not enable discharge to class AA marine waters or Class I inland waters, nor does it cover discharge to sanitary sewer system, other stormwater drainage system, nor discharges not associated with well drilling; NOI to include history of land use at proposed site, potential and existing contaminants at proposed site; proposed corrective measures; pollutants that may be in effluent; estimated timetable of drilling activities; details of proposed discharges, including estimate of quantity, frequency and time frame of proposed discharges, names of chemicals or materials likely to be found in discharges, any quantitative data on pollutants; names, address, phone, fax of laboratories or consultants involved in sampling and analysis; well drilling plan including equipment to be used, treatment design, design concerns, calculations used in treatment design, proposed mitigative measures, well drilling bmp plan including schedule of activities, prohibited practices, O&M procedures, responsible field person, operations plan, maintenance scheduling or action criteria, maintenance program, effluent monitoring procedures, cessationor of discharge procedures; effluent control plan; other practices, documentation plan; treatment requirements, practices to control site run-off, spillage, leaks, sludge or waste disposal or drainage from raw material storage or stockpiles, etc.; discharges are to be limited to effluent limitations specified ; sampling points, collection, reporting & analysis of samples specified; protocols, test procedures, recording and reporting of results specified; discharge monitoring report form to be used in reporting; operator to report in event of unanticipated violation or bypass or upset. Oral report immediately, written within 5 days to DOH. maintenance schedule to be submitted 14 days prior to maintenance activities that could cause violation or bypass; records to be maintained for minimum of 3 years

HAR Title 11 Chapter 62 Wastewater Systems	♦Contents: Prohibitions & General Requirements: preamble; purpose; definitions; county wastewater advisory committee; critical wastewater disposal areas; general requirements; wastewater sludge disposal; specific requirements for wastewater systems: Wastewater Treatment Works: specific requirements for wastewater treatment works; treatment unit requirements; wastewater effluent disposal system; wastewater effluent requirements applicable to treatment works: Individual Wastewater Systems: general requirements for proposed individual wastewater treatment systems; site evaluation; spacing of individual wastewater systems; specific requirements for proposed treatment units; specific requirements for proposed disposal systems; other proposed individual wastewater systems: Variances, Penalties and Severability: variances, penalties and remedies, severability ♦ Purpose is to insure that wastewater disposal does not contaminate or pollute and drinking water or potential drinking water supply, or the waters of any beaches, shores, ponds, lakes, streams, groundwater, or shellfish growing waters; does not encourage the harborage of insects, rodents or other possible vectors; does not give rise to nuisances; does not become a hazard or a potential hazard to public health, safety & welfare; contributes to the achievement of wastewater management goals contained in approved county water quality management plans; and reinforces state and county planning policies ♦ More stringent critieria may be imposed in critical wastewater areas. Criteria for these areas include high water table; impermeable soil or rock formations; steep terrain; flood zone; protection of coastal waters and inland surface waters; high rates of cesspool failure; protection of groundwaters, etc. ♦ All buildings used or occupied as dwelling, public building or place of assembly and generating wastewater shall have a wastewater disposal system, where in proximity to connect to public sewer shall do so. Criteria set for domestic and non-domestic waste water. ♦ Criteria are set for wastewater treatment, including criteria for design, approval; operation; sampling, monitoring & reporting; safety procedures; etc. table of estimated gallons per person per day and wastewater strength is provided for various uses to aid in system design. ♦Criteria are set for subsurface disposal systems incuding design, flow rates, construction, etc. ♦ Criteria are set for individual wastewater systems; including design, land area; flow rates; capacities; construction; etc. also graywater systems; including design, flow rates, disinfection, etc.; septic system design including design, construction, site specs, etc.; and also for each case for site evaluation including percolation tests, spacing, etc. ♦ Minimum distances are set for cesspools, treatment units, seepage pits and soil absorption systems, from structures, property line, trees, seepage pits, other cesspools, potable drinking water wells and streams, ocean vegetation line, ponds or lakes. all must be at least 50 feet from any water body and at least 1000 feet from any potable drinking well.

Guidelines for the Treatment and Use of Reclaimed Water	♦ Published by DOH in 1993. Contents: introduction, definitions, treatment design parameters; approval of permits; compliance, reporting and submittals; defines design parameters, operating parameters, sampling protocols, classes & acceptable uses of water; restrictions, etc. ♦ R3 water is oxidized only; may be used for (see specific restrictions in rule):irrigation of non-edible vegetation in areas with limited exposure drip and subsurface irrigation of fodder, fiber & seed crops not eaten by humans; drip and subsurface irrigation of orchards and vineyards bearing food crops; drip and subsurface irrigation of timber & trees not bearing food crops; and drip and subsurface irrigation of food crops which undergo a pathogen destruction process before consumption. ♦ R2 water is oxidized and disinfected; with 7 day median samples showing <23 cfu/100 ml fecal coliform, and no more than 1 sample in a 30 day period >200 cfu/100ml fecal coliform: may be used for (see rule for specific restrictions): all uses for which R3 is allowable, plus freeway & cemetary irrigation; subsurface irrigation or spray irrigation of golf courses with adequate buffer; subsurface irrigation of parks, elementary schools, athletic fields & landscapes around some residential properties; subsurface irrigation or spray irrigation with sufficient buffer of roadside and median landscapes, subsurface or drip irrigation, or spray irrigation with adequate buffer of non-edible vegetation in areas with limited public use; subsurface, drip, or spray irrigation with adequate buffer of sod farms; subsurface, drip, or spray irrigation with adequate buffer of ornamental plants for commercial use; subsurface irrigation of food crops which are above ground and not contacted by irrigation; subsurface irrigation of pastures used for milking and other animals; drip, subsurface or spray irrigation with adequate buffer of fodder, fiber and seed crops not eaten by humans; drip or subsurface irrigation of orchards and vineyards bearing food crops; drip, subsurface or spray irrigation with adequate buffer of orchards and vineyards not bearing food crops during irrigation; subsurface, drip, or spray irrigation with adequate buffer of timber and trees not bearing food crops; drip, subsurface or spray irrigation with adequate buffer of food crops undergoing commercial pathogen destroying process before consumption; flushing of sanitary sewers, industrial processes without exposure of workers; cooling or air conditioning system without tower, evaporative condenser, spraying or other features that emit droplets; industrial boiler feed, water jetting for consolidation of backfill material around piping for reclaimed water, sewage, storm drainage, and electrical conduits, washing aggregate and making concrete; dampening roads and other surfaces for dust control; dampening brushes and street surfaces in street sweeping ♦ R1 water is oxidized, filtered, and disinfected with 4 log (1 in 10,000) reduction in specific bacteriophage MS2 ; 7 day median <2.2 cfu/100ml fecal coliform; no samples >200 cfu/100 ml fecal coliform; may be used for (see rule for specific restrictions): all uses allowable for R2 and R3 water, plus: spray irrigation of roadside and median landscapes and of orchards and vineyards bearing food crops. Buffer for spray irrigation with R-1 water is less than with R-2 water for other uses indicating spray irrigation with buffer. R1 water is also deemed suitable for basins at fish hatcheries, landscape impoundments with or without decorative fountains, restricted recreational impoundments, flushing toilets and urinals, fire fighting, commercial and public landscapes, cooling saws while cutting pavement, decorative fountains, washing yards, lots and sidewalks, high pressure blasting to clean surfaces, industrial processes with or without exposure of workers, cooling or air conditioning systems with or without tower, evaporative condenser, spraying or other features that emit vapor or droplets, and water jetting for consolidation of backfill material around potable water piping during water shortage. ♦ Groundwater recharge criteria vary with whether potable or non-potable aquifer is affected. Surface or subsurface application rates that exceed the consumptive evapotranspiration of the vegetative cover is considered a recharge project if over a potable aquifer. Reclaimed water for groundwater recharge by surface or subsurface application shall be at all times of a quality that fully protects public health and will be based on all relevant aspects of such project, including: treatment provided, effluent quantity and quality, effluent or application spreading area operation, soil characteristics, hydrogeology, resident time and distance to withdrawal. Applies also to unlined water impoundments.

HAR Title 11 Chapter 65 Water Pollution Control Revolving Fund	♦Contents: purpose; definitions; clean water state revolving loan fund; safe drinking water state revolving loan fund. And for each of the latter, fees, administrative account, loan default, and penalty & procedures for loan default ♦ Main point of interest, other than establishing a state revolving loan fund is that the fee for a Clean Water State Revolving Loan is different than that for a Drinking Water State Revolving Loan. For a CWSRF, the interest fee is not to exceed 1% of the outstanding principal balance. For a DWSRF, "..the loan fee shall not exceed the outstanding principal balance of the loan multiplied by an annual rate of the weekly bond buyers twenty year general obligation index bond interest rate, less a percentage rate of up to 1%. In the event that the annual rate of the weekly bond buyers twenty year general obligation index bond interest rate, less a percentage rate of up to 1% falls below 3 and 25 one hundredths of a percent (3.25%), then the loan fee shall be 3.25%".
HRS 269 Public Utilities Commission	♦ §269-7.5 Utilities must have certificate of public convenience and necessity to operate. To grant CPCN, the PUC must find that the utility is fit, willing and able to perperly perform the proposed service. Certficates may be revoked. Government utilities are exempted. PUC is empowered to determine the resasonableness of rates, charges and tariffs. ♦ §269-8 PUC may inspect books, records, maps and other documents, and may rqequire the utility to submit such information including a complete inventory of its propoerties in such form as the commission may direct. ♦ §269-15 If the PUC is of the opinion that a utility is neglecting to comply, that its rates or provisions are not adequate, or that it is not doing what it ought to do, PUC shall inform the utility in writing and institute proceedings as may be necessary to correct the deficiency. Allows citations, civil penalties, etc. Sets forth appeal process. ♦ All rates, fares, charges, classifications, rules, practices made, charged or observed shall be filed with the PUC ♦ §269-26 PUC to investigate charges for water supplied to consumers for domestic purposes where the water is supplied by virtue of a lease from the State ♦ §269-27 if rates for such lesees are found to be unreasonable, attorney general shall take action to cancel the lease ♦ §269-51 Provides for a consumer advocate ♦ §269-54 Sets forth powers and authorities of consumer advocate Lanaʻi utilities are regulated by the PUC.
HRS 342 E	Non-Point Source Pollution Management - Hawaiʻi administrative rules not yet finalized. DOH has 16 MOUs with SWCDs to implement specific run-off control programs. Hawaiʻi's Coastal Non-Point Source Water Pollution Control Plan specified 57 management measures for non-point pollution. For this and other pollutant sources below, see Wellhead Protection Chapter.

HRS 342 F Noise Pollution	Noise Pollution ♦ In the past, the Environmental Protection Agency (EPA) coordinated all federal noise control activities through its Office of Noise Abatement and Control. However, In 1981, the Administration at that time concluded that noise issues were best handled at the State or local government level. As a result, the EPA phased out the office's funding in 1982 as part of a shift in federal noise control policy to transfer the primary responsibility of regulating noise to state and local governments. However, the Noise Control Act of 1972 and the Quiet Communities Act of 1978 were not rescinded by Congress and remain in effect today, although essentially unfunded. ♦ § 1) A "permit" is written authorization from the director to construct, modify, or operate any excessive noise source. The grantee is permitted to cause or emit excessive noise in a manner or amount, or to do any act, not forbidden by this chapter, but requiring review from the department. A "variance" is special written authorization by the director to cause or emit excessive noise in a manner or amount, or to do any act, not forbidden by this chapter, but requiring review from the department. ♦ § 4) Permit applications will be in a form prescribed by the director, and shall be accompanied by plans, specifications, and other information as deemed necessary by the department. A permit shall not be issued for a term of more than five years, and the director shall not deny an application for a permit without affording the applicant an opportunity for a hearing. ♦ § 5) Variance applications shall be done on forms provided by the department and shall be accompanied by a description of present conditions, how present conditions do not conform to standards, and any other information required by the department. Application must clearly show that it is in the public's best interest, does not substantially endanger human health or safety, and complying with standard rules would cause undue hardship without equal or greater benefit to the public. Also, if a variance is granted on the grounds that there is no practical way to control excessive noise, the variance will only be in effect until a practical method is found to control the excessive noise. No variance shall be for a period greater than five years. ♦ § 30) No person, including any public body, shall engage in activity which produces excessive noise without first securing approval in writing from the director. This does not apply to schools. ♦ § 30.5) There are different noise level standards between urban and non-urban areas, and in different counties. Should this section conflict with section 46-17, 46-17 governs.
HRS 342 G Integrated Solid Waste Management	Integrated Solid Waste Management ♦ Covers the establishment and maintenance of a system to manage waste disposal.
HRS 342 H Solid Waste Pollution	Solid Waste Pollution ♦ § 1) A "permit" is written authorization from the director to construct, modify, and operate any solid waste management system or any component of any solid waste management system. A "solid waste management system" is a system for the storage, processing, treatment, transfer, or disposal of waste material. "Disposal" means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste onto any land or water so that it may enter the environment, be emitted into the air or the water, including ground water.
HRS 342 I Special Wastes Recycling	Special Wastes Recycling (lead-acid batteries, tires, etc.) ♦Covers proper procedures for the disposal of lead batteries and old tires.
HRS 342 J Hazardous Waste	♦ Sets standards for generators, transporters, treatment, storage or disposal of hazardous waste, provisions for hazardous waste release incidents, notification, record keeping and more.

HRS 342 L Underground Storage Tanks	♦ Sets standards for tanks and tank design, permits, release detection, reporting and response, permitting, closure requirements etc. for Underground Storage Tanks ♦Establishes fund for leaking tanks
HRS 342 P Asbestos & Lead	♦ Empowers the Director of Health to establish emission and hazard exposure standards and procedures for abatement of asbestos & lead hazards ♦ Powers include work practice standards and notification for demolition of facilities containing asbestos or lead
HRS 343 Environmental Impact Statements	♦ Contents; purpose, definitions, periodic bulletin, applicability, determination of sgnificance, preparation of draft and final EIS, appeals, NEPA actions; supplemental statements, severability ♦ All agencies and applicants submitting draft environmental assessments, environmental impact statements, acceptance or nonacceptance determinations, addenda supplemental statements, supplemental preparation notices, revised documents, withdrawals or other notices to be published in the bulletin ♦ Triggers include agency actions, actions requiring amendment to general or community plans, amendment to designations within these plans other than for preservation, conservation or agricultural use; use of state or county lands, use of conservation district lands, use of shoreline areas use within historic sites, use involving reclassification of conservation district lands, etc. ♦Exempt actions include operation, repair or maintenance of existing structures and facilities involving no or negligible expansion; replacement or reconstruction of facilties where the new facilities will be located on generally the same site and used for generally the same purpose; construction of single, small structures and facilities in certain conditions where other criteria are not triggered; such as single family homes of less than 3,500 square feet, single multi-unit structure of not more than 4 dwelling units; one store, office or restaurant designed for total occupant load of 20 persons or less, water, sewage, gas, telephone and other essential public utility services extensions to serve such structures or facilities, certain appurtenant structures, minor alteration in the condition of land water or vegetation, basic data collection, research, experimental management and resource evaluation activities which do not result in serious or major disturbance to an environmental resource, construction or placement of minor structures accessory to existing facilities; interior alterations involving partitions, plumbing, electrical conveyances, etc. deomlition of structures not located on any historic site nor designated in any historic register; zoning variances excep;t us, density, height, parking requirements and shoreline set-back, continuing administrative activites including purchase of supplies, personnel related actions and the adoptions, amendment or repeal of rules. ♦Applicant should prepare Environmental Assessments as close to acceptable Environmental Impact Statements as possible with public consultation as early as possible ♦Statements should review impacts, significance criteria, implications of proposed actions, alternatives, etc. File with either anticipated negative declaration or EIS preparation notice, distribute per regulations, respond to public comments and revise assessment as appropriate and append comments and responses to final filing of either negative declaration or EIS preparation notice. ♦For EIS upon publication of preparation notice, public has 30 days to become consulted party. Upon receipt of request to be consulted party, proposing entity shall provide the requestor with a copy of the assessment, respond to all commenters, acknowledgement & response to be published in draft, upon publication of draft, public has 45 days to comment, acknowledgement & response to comments to be publiished in final document with addenda if applicable. If acceptable, accepting agency files notice of acceptance. If not acceptable, accepting agency files notice of non-acceptance with reasons, and proposing agency revises or withdrws. Revisions and notice of withdrawal must notify publiic. ♦ Required contents include description of the action, significant beneficial and adverse impacts, including secondary and cumulative impacts, proposed mitigation measures, alternatives considered, unresolved issues, compatibility with land use plans and policies, listing of permits and approvals, table of contents, statement of purpose and need for proposed action, map, statement of objectives, description of the actions' technical, economic, social and environmental characteristics, use of public funds, phasing and timing of actions, summary of technical data, diagrams and other information necessary to permit any reviewer to genuinely evaluate potential impacts, historic perspectives, alternatives which could obtain the same objectives or benefits but with different impacts, alternative of postponement for futher study, no-action alternative, alternate locations, all alternatives considered to be discussed in sufficient detail to explain why they were rejected; detailed description of environmental setting; relation to land use plans, policies and standards, detailed description of impacts to environment and community, including secondary and cumulative impacts, short term vs. long term impacts and benefits, irreversible impacts or commitments of resources, unavoidable impacts, mitigative measures, unresolved issues, consulted parties and including all substantive comments.

HAR Title 11 Chapter 200 Environmental Impact Statement Rules	♦ Contents: purpose; definitions; periodic bulletin; applicability; determination of significance; preparation of draft and final EIS; appeals; NEPA actions; supplemental statements: severability ♦Pursuant to National Environmental Policy Act (NEPA) of 1969; Public Law 91-190; 42 U.S.C. §§4321-4347, as amended and to HRS chapter 343 ♦ All agencies and appliccants submitting draft environmental assessments, negative declarations, preparation notices, environmental impact statements, acceptance or nonacceptance determinations, addenda, supplemental statements, supplemental preparation notices; revised documents, withdrawals or other notices required to be published in the bulletin shall submit before the close of business eight working days prior to the publication date. Publication dates are the 8th and 23rd of each month. (one day earlier in event of holiday) ♦Triggers include: agency actions; actions requiring amendment to general or community plans, or any amendment to designations within these plans other than preservation, conservation or agricultural; use of state or county lands; use of conservation district lands; use of shoreline areas; use within historic sites; any use involving reclassification of conservation district lands; etc. ♦ Exempt actions include operation, repair or maintenance of existing structures & facilities involving no or negligible expansion; replacement or reconstruction of facilities where the new facilities will be located on generally the same site and used for generally the same purpose; construction of single, small structures and facilities in certain conditions (not where other criteria are triggered) including; one single family residence of less than 3,500 sq feet; one multi-unit structure of not more than 4 dwelling units; one store, office or restaurant designed for total occupant load of 20 persons or less; water, sewage, electrical, gas, telephone & other essential public utility services extensions to serve such structures or facilities; appurtenant structures incuding garage, car port, patio, pool, fences; minor alteration in the condition of land water or vegetation; basic data collection, research, experimental management and resource evaluation activities which do not result in serious or major disturbance to an environmental resource; construction or placement of minor structures accessory to existing facilities; interior alterations involving partitions, plumbing, electrical conveyances, etc.; demolition of structures not located on any historic site nor designated in any historic register; zoning variances except use, density, height, parking requirements & shoreline set-back; continuing administrative activities including purchase of supplies, personnel related actions, and the adoption, amendment, or repeal of rules ♦ Entity should endeavor to prepare an EA or as close to an acceptable EIS as possible with public consultation as early as possible, reviewing impacts, significance criteria, implications of proposed actions, alternatives, etc. as early as possible. file with either anticipated negative declaration or EIS preparation notice; distribute per regulations, respond to public comment; revise assessment as appropriate and append comments and responses to final filing of either negative declaration or EIS; ♦ For EIS: publish prep notice; upon publication of prep notice public has 30 days to become consulted party; upon receipt of request to be consulted party, proposing entity shall provide the requestor with copy of the assessment; respond to all commenters; (acknowledgement/response must be in draft EIS); publish draft EIS, public has 45 days to comment; acknowledgement and point-by-point response to commenters must be in final EIS, with addendum if applicable; if acceptable, accepting agency files notice of acceptance. If not, it files notice of non-acceptance with reasons, and proposing agency revises or withdrawals. Revisions subject to same public notification process. Notice of withdrawal also must be published. ♦ Content requirements include: description of the action; significant beneficial & adverse impacts, including secondary and cumulative impacts; proposed mitigation measures; alternatives considered; unresolved issues; compatibility with land use plans & policies; listing of permits and approvals; table of contents; statement of purpose & need for the proposed action; map; statement of objectives; description of the actions' technical, economic, social and environmental characteristics use of public funds; phasing and timing of action, summary of technical data, diagrams & other information necessary to permit any reviewer to genuinely evaluate potential impacts; historic perspective; alternatives which could obtain the same objectives or benefits but with different impacts; alternative of postpoining for further study; no-action alternative; alternate locations; all alternatives considered to be discussed in sufficient detail to explain why they were rejected; detailed description of environmental setting; relation to land use plans, policies and standards; detailed description of impacts to environment and community, including secondary and cumulative impacts; short term vs. long term impacts and benefits; irreversible impacts; unavoidable impacts; mitigative measures; unresolved issues; consulted parties; and including all substantive comments

GASB34	♦Passed by Government Standards Bureau in 1999. Small systems like Lana'i must comply by July 01, 2003. ♦ Systems must report the value of their assets on consolidated annual financial reports two acceptable methods 1) depreciation, or 2) "modified" method. Modified method requires inspection of condition rather than just dates. ♦ Requires systems to know the date installed, costs and useful life of all assets as a minimum, ♦ In order to comply with modified method, many utilities are developing asset management plans . Implementing such plans could have the potential to help prolong the life of infrastructure by pre-planned and documented inspection and thereby cutting dramatic replacement costs.

CHAPTER 3

Existing Resources & Systems

In This Chapter

Key Points:

- Lanaʻi has an estimated 6 Million Gallons Per Day (MGD) sustainable yield. Fresh water is found only in high level dike confined compartments in the Central Sector. The Central Sector is divided into two aquifer systems, the Windward and the Leeward, with 3 MGD sustainable yield in each.
- Total pumpage during 2008 was about 2.24 MGD.
- All pumping sources but one are currently located in the Leeward aquifer system, with about 85% of total pumpage, just over 1.9 MGD, coming from this system.
- There are currently 7 pumped sources, with one pumped at only 2,000 GPD. At 2008 pumping rates and distribution, water levels in Wells 1, 9, 14, 6 and, to a lesser extent 8, were declining.
- For comparision, the 1996 document, "*A Numerical Ground-Water Model for the Island of Lanaʻi, Hawaii*" (CWRM-1, 1996) modeled withdrawals between 13 sources, 11 of them pumping. It concluded that with the modeled distribution of withdrawals, the aquifer should be able to yield 3.52 MGD without undue damage, though some additional distribution or deepening may be required.
- No surface sources remain on Lanaʻi, although historical evidence points to the fact that the island once had springs, streams and even taro loʻi. Lanaʻi has 13 ahupuaʻa. Of one hundred and ten kuleana claims made within these ahupuaʻa, fifty-six were awarded.
- Lanaʻi has five water systems, two drinking water systems, one brackish water system used for irrigation, and two reclaimed water systems, also used for irrigation. Collectively, these systems include about 79 miles of active pipe, 35 MG of storage, of which about 4.8 MG is potable, and about 6.394 MGD installed well capacity of which 5.04 is potable.

- Average day capacity of potable systems in use, by *System Standards*, equates to about 2.24 MGD.
- Existing potable water rates are $1.10 for the first 25,000 gallons and $1.62 for every 1,000 gallons thereafter. Although non-potable rates are higher, (provided in System Finance and Economics Section), existing rates and fees are not sufficient for the utility to be self-supporting. The cost of well operation, not including the full cost of running the system - is estimated at roughly $2.17 per thousand gallons for the Lana‘i City and Koele areas, and $1.77 for the Manele and Palawai Irrigation Grid areas. Declining water levels could exacerbate that shortfall. For example, if water levels were to reach designation trigger elevations, assuming the same pumpage rates and electricity costs, the cost of pumping wells for the Manele and the Palawai Grid could reach as high as $3.07 per Kgal.

Geology

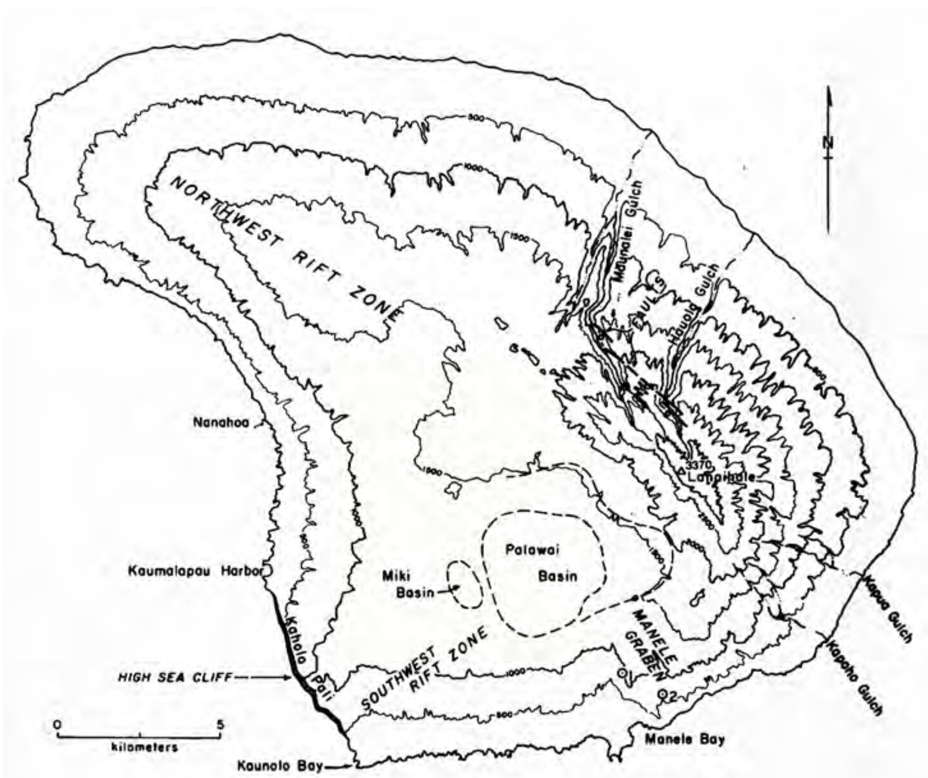


FIGURE 3-1. Map of Lana‘i Showing Rift Zones, Palawai & Miki Basins, & Locations of Fossiliferous Deposits. Source: MacDonald, Abbott & Peterson *Volcanoes in the Sea*: the Geology of Hawaii, University of Hawaii Press, Honolulu, 1983.

Lana‘i is 18 miles (30 km) long, 12 miles (21 km) wide, and has an area of 141 sq. miles (366 sq. km). The island is 3,370’ tall at its highest point. Lana‘i was created by a single shield volcano during the Tertiary period. Potassium argon dating places the age of Lana`i between 0.81 and 1.46 million years.

Lana‘i was built by eruptions along three rift zones, running northwest, southwest and south, with possibly a fourth, more ancient rift zone running either north or northwest.

Geology

Near the end of volcanic activity, during the subaerial shield building stage, a major collapse occurred around the intersection of the rift zones, to the southwest of Lana‘ihale. Subsequent lava flows ponded in the collapsed caldera, with some outpouring through the south rift trough. The Palawai basin is a remnant of the original caldera.

Lana'i was submerged at various times during its geologic history, with evidence of previous shorelines at the 170 meter (558’) elevation, and possibly also at the 190 meter (623’) elevation. Fossiliferous marine limestone as much as 45 meters (148’) thick extends up to 165 meters (541’) altitude in Kawaiu gulch, with calcerous conglomerate containing many shell fragments and foraminifera as high as 167 meters (548’).

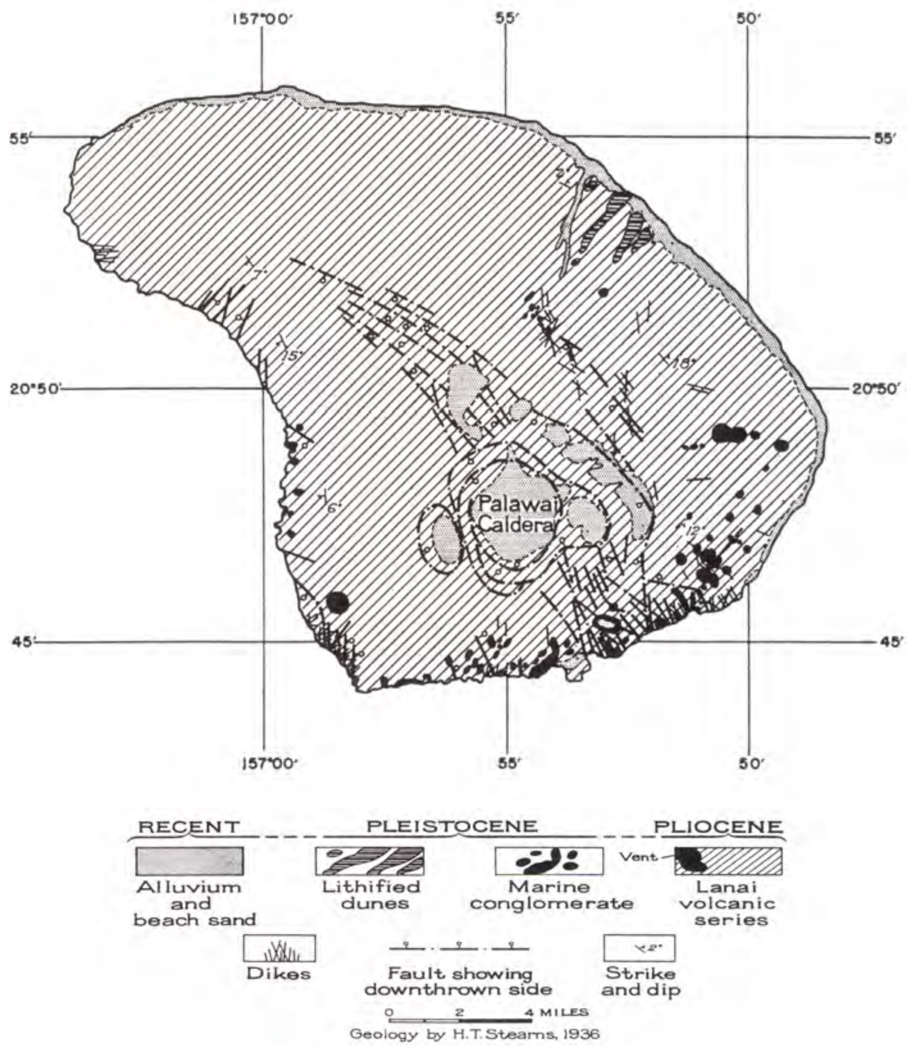


FIGURE 3-2. Geologic Map of Lana‘i. Source: MacDonald, Abbott & Peterson *Volcanoes in the Sea: the Geology of Hawaii*, University of Hawaii Press, Honolulu, 1983

Harold Thornton Stearns, a well-published geologist who was in charge of Hawaiʻian groundwater investigations for the United States Geological Survey in the territory of Hawaiʻi during the 1930s and 1940s, thought that the island had at one time been submerged to what is now the 360 meter (1,181') elevation. Evidence for this lies in thin veins of limestone in the basalt at 321 meter (1,053') altitude, which contain fragments of coral, coralline algae and marine mollusk shells, probably formed from calcerous sand which sifted into cracks in the basalt, and in the divergent nature of soils above and below the 360 meter (1,181') level. Dune formations are also found at 306 meters (1,004') high on the southeastern shore, and 285 meters (935') high on the ridge east of Maunalei, and in Kupaʻa gulch along the northeast. Some geologists have speculated that certain marine materials at high elevations could have been deposited by major tsunami events. (Source: *Volcanoes in the Sea: The Geology of Hawaii;* MacDonald, Abbott & Peterson, University of Hawaii Press; ©1983).

Lana`i lavas are theolitic basalts, theolites, oceanites and some phenocrysts of labradorite feldspar. Pahoehoe dominates near the higher elevation vents, and a`a on the lower slopes. Lana`i basalts are highly permeable, except in vertical dike formations. The south side of the island has essentially no caprock, while the north side appears to have either alluvial deposits or caprock which may serve to deter discharge to the ocean.

Lana`i soils are from the Amalu-Olokui; Jaucas-Mala-Pulehu; Kahanui-Kalae-Kanepuu; Molokai-Lahaina; and Very Stony-Rock Land soil associations, with several series within these associations. Most of the soil series are well drained, with permeabilities ranging from 0.63 to 20 inches per hour. Runoff characteristics vary from slow to very rapid.

The hydrogeology of Lana`i is unusual in various respects, among them the predominance of high level water, including the presence of high-level brackish water accompanied by geothermal heating in the area of the Palawai basin. High-level water is found within 3.8 miles of the coast all around the island. Numerous dike and fault boundaries divide the main aquifer into many smaller, relatively independent compartments bounded by vertical walls of lower permeability. Evidence of relative impermeability of confining aquicludes was indicated by a 677' (206 m) difference in water levels between Wells 1 and 2 over a distance of 1 mile, and 733' (223 m) difference between Shafts 1 and 2 over a distance of two miles, noted by V.W. Thalmann in his 1954 report. (Source: *Summary of Lanaʻi Water Development from 1954* Report by V.W. Thalmann, in Anderson, *Water Supply Investigation, Lanaʻi, Hawaii*, Prepared for Hawaiian Pineapple Co. Ltd., By Keith E. Anderson, October 1957).

Lana`i is also anomalous relative to other Hawaiian Islands in that its windward side has low gradual coasts, while its leeward side exhibits high, dramatic sea cliffs such as the 300 meter (984') high Kaholo Pali, south of Kaumalapau. This is in part because Lana`i lies in the rainshadow of Western Maui and Eastern Molokai, and is relatively protected from wind and wave action on its "windward" side, whereas the "leeward", or southern - southwesterly side, has no protection for thousands of miles and is subject to southwesterly "kona" storm winds and waves. Long erosional grooves that run parallel to the prevailing wind direction on the west side attest to the fact that wind has also helped to shape Lanaʻi.

Large scale landslides have helped to shape the southwestern side of Lana`i, as evidenced by the 6100 km^2 (2,355 sq. mile) submarine Clark Debris avalanche formation, which extends 150 km (93 miles) to the southwest of Lanaʻi in two branches (possibly representing two separate events).

Geology

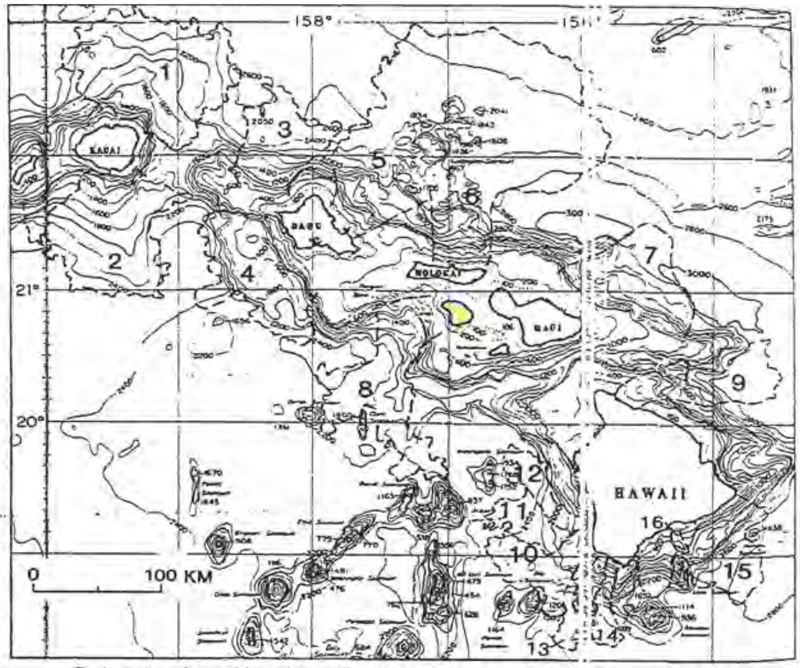


Fig. 1. Bathymetric map of the southeastern Hawaiian Ridge showing major mass wasting features (heavy dashed lines) identified by number in text and Table 1. Contour interval 200 fathoms (366 m). Base from *U.S. Naval Oceanographic Office* [1973].

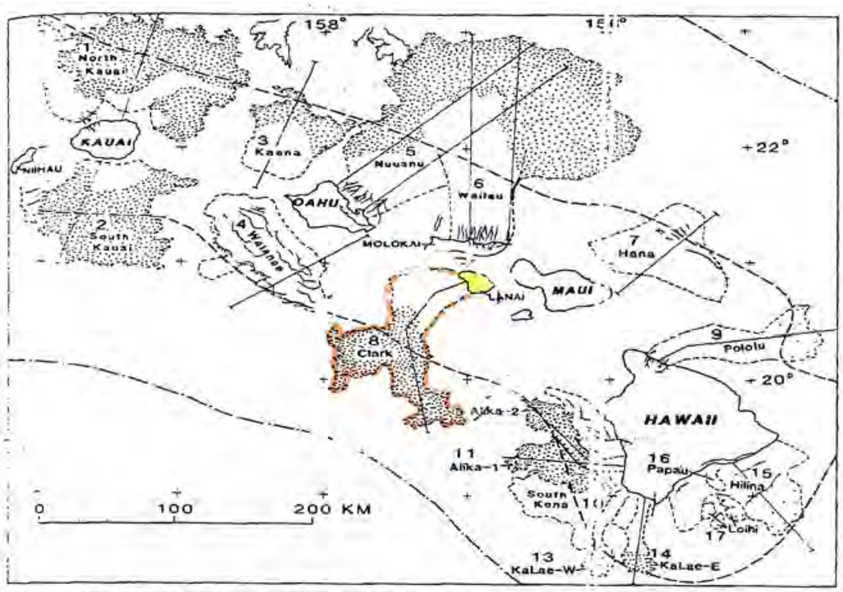


Fig. 2. Map of southeastern Hawaiian Ridge showing major slides bounded by dashed lines identified by number in text and Table 1; compare with Figure 1. Dotted area, hummocky ground (widely spaced where subdued); hachured lines, scarps; thin, downslope-directed lines, submarine canyons and their subaerial counterparts; heavy dashed line, axis of the Hawaiian Deep; dash-dotted line, crest of the Hawaiian Arch.

FIGURE 3-3. Bathymetric Map & Map Showing Major Slides of Southeastern Hawaiian Ridge**, Source: Moore, Clague, Holcomb, Lipman, Normark & Torresan; *Prodigious Submarine Landslides on the Hawaiian Ridge*; <u>Journal of Geophysical Research</u>; Volume 94, No. B12, pgs. 17,465-17,476; Dec. 10, 1989**

Groundwater

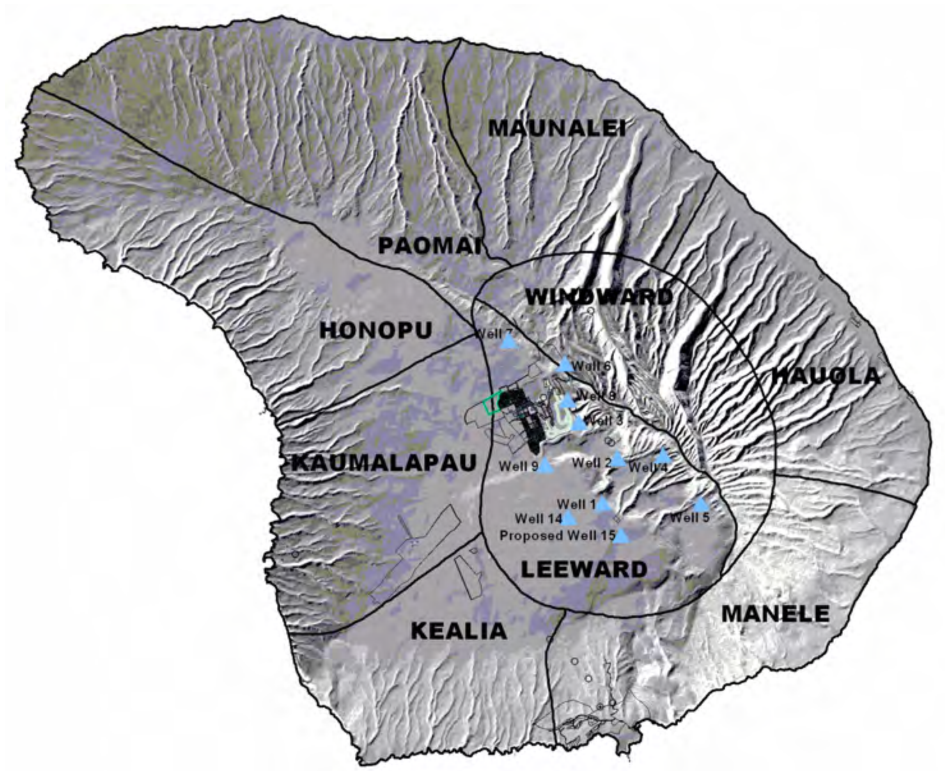


FIGURE 3-4. Lana'i Aquifer Map

Aquifer Systems and Yields

There are nine aquifer systems in four sectors on Lana`i, as follows:

50101 - Windward	50201 - Hauola
50102 - Leeward	50202 - Maunalei
	50203 - Paoma'i
50301 - Honopu	50401 - Kealia
50302 - Kaumalapau	50402 - Manele

Estimates of sustainable yield on the island have varied from about 5 to 10 MGD, with the current regulatory sustainable yield estimate at 6 MGD. Only the Central Aquifer sector is believed to contain fresh water. The island's entire sustainable yield of 6 MGD is found in this region, according to the sustainable yield classification system utilized by the State. By this system, the total area of this aquifer sector is about 24 square miles, (2008 *State Water Resources Protection Plan*) with water levels above 500' found in a 14 square mile area (1990 *State Water Resources Protection Plan*). Time domain elec-

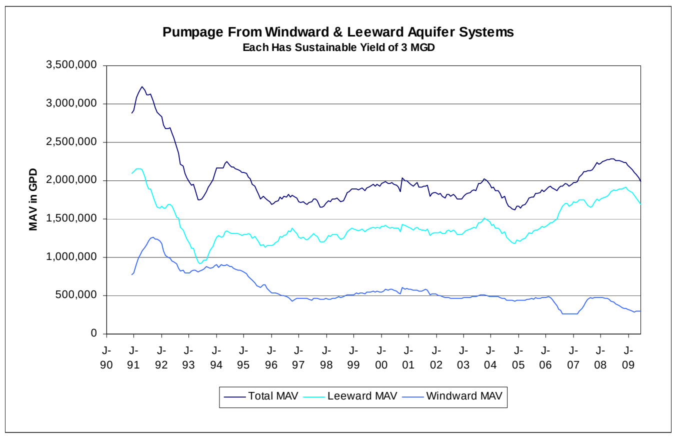
Groundwater

tromagnetic resonance (TDEM) studies undertaken by consultants to Castle & Cooke Resorts in 1993 and 2001 indicated that the impeding structure bounding that aquifer may have an area of twice the regulatory extent. These studies are described later in this chapter. However, neither the regulatory boundary nor the estimated sustainable yield were increased in the 2008 update of the State Water Resources Protection Plan. The State's water model of Lana'i (CWRM-1, 1996), considered water level performance of existing wells using the larger recharge area indicated by TDEM studies. Neither the modeled results nor water level performance to date have appeared to indicate increased sustainable yield.

The sustainable yield of 6 MGD in the Central Aquifer sector is further divided into 3 MGD each in the Leeward and Windward aquifer sectors. All of the currently pumping wells, with the exception of Well 6, are located in the Leeward Aquifer, with a sustainable yield of 3 MGD. Figure 3-5 shows annual MAV pumpage in period 13 from Windward and Leeward aquifers from 1990 through 2008. Of a total MAV of about 2.241 MGD in December of 2008, about 1.913 MGD came from the Leeward Aquifer system, and about 0.328 came from the Windward Aquifer system.

FIGURE 3-5. Lana'i Pumpage in Windward and Leeward Aquifers

Year	Leeward MAV	Windward MAV	Total MAV
1990	2,101,077	774,098	2,875,175
1991	1,643,854	1,213,825	2,857,679
1992	1,233,813	796,911	2,030,724
1993	1,212,182	887,900	2,100,082
1994	1,288,285	820,973	2,109,258
1995	1,158,039	563,115	1,721,154
1996	1,310,474	462,405	1,772,879
1997	1,204,091	456,962	1,661,052
1998	1,378,692	517,096	1,895,788
1999	1,383,930	548,523	1,932,453
2000	1,405,011	590,088	1,995,099
2001	1,320,132	520,288	1,840,421
2002	1,299,692	463,234	1,762,925
2003	1,460,127	493,067	1,953,193
2004	1,226,135	442,593	1,668,728
2005	1,387,184	473,124	1,860,308
2006	1,694,019	258,151	1,952,169
2007	1,736,458	474,741	2,211,199
2008	1,913,310	327,912	2,241,222



Reasonable estimates of potential yield are also dependent upon the configuration of infrastructure and distribution of withdrawals. Here again, estimates have varied. In letters to Lana'i Land Company dated January 23, 1989 and January 25, 1989, respectively, John Mink and Keith Anderson both stated that with the configuration of approximately eight sources at the time, sustainable yield was about 3 MGD. (Sources at the time were Upper and Lower Maunalei Tunnels and Maunalei Shaft 2, and Wells 1 through 5). Both 1989 estimates anticipated an additional 0.8 MGD to be available based on the drilling of Wells 6 & 7. Mink also indicated that neither these nor Wells 9 & 10, also proposed at that time, would prevent the water table from declining to its equilibrium head. In the 1990 *State Water Resources Protection Plan*, although Mink estimated the island's sustainable yield at 6 MGD, he stated that under current conditions of development and operation the sustainable yield was closer to 4 or 5 MGD. (Although Well 6 was not on-line until 1991, it had probably been tested and shown promise as of the time he wrote that document). The 1996 document, *A Numerical Groundwater Model for the Island of Lana'i Hawaii*, (Hardy, CWRM-1, State of Hawaii, 1996) indicated that thirteen sources existing at the time could deliver 3.52 MGD without damage to the aquifer, with the exception that both Maunalei Tunnels would run dry. This scenario included thirteen sources: free flow from the Upper and Lower Maunalei Tunnels (which would run dry in the scenario), and pumpage from Maunalei Shaft 2, Wells 1 through 9 and Well 14. This document is described further below. As of this draft, the Maunalei sources are no longer in use, and Wells 3 and 5 have also failed. Well 2 /Shaft 3 has rarely been used since 1996, though the source is still viable. Although efforts are in progress to restore or replace these sources, this leaves only six sources currently in use. The impacts of these infrastructure changes on safe yields are unclear. Plots of water levels in more recent years seem to indicate some decline, as shown on pages 60-77 of this chapter. Water levels are expected to decline in any case until equilibrium head is reached. The pace at which this occurs, and the amount of decline to equilibrium head, may or may not indicate a concern. In the case of Lana'i, it is not entirely clear whether recent declines are a concern and a function of distribution of withdrawals and aquifer yields, or whether they are simply natural equilibration or even a result of reporting methods.

The 1996 document mentioned above, *A Numerical Groundwater Model for the Island of Lana'i Hawaii*, (Hardy, CWRM-1, State of Hawaii, 1996) was the most recent in-depth examination of potential aquifer responses to different pumpage configurations. This document examined 6 pumping scenarios and gauged the effects of each on the aquifer. All of the scenarios assumed that the Upper and Lower Maunalei tunnels were allowed to flow freely, without pumpage. All of the scenarios but one resulted in some continued decline of water levels in the aquifer until a theoretical equilibrium would be reached. Hardy examined the anticipated drop in water levels to reach equilibrium in each scenario.

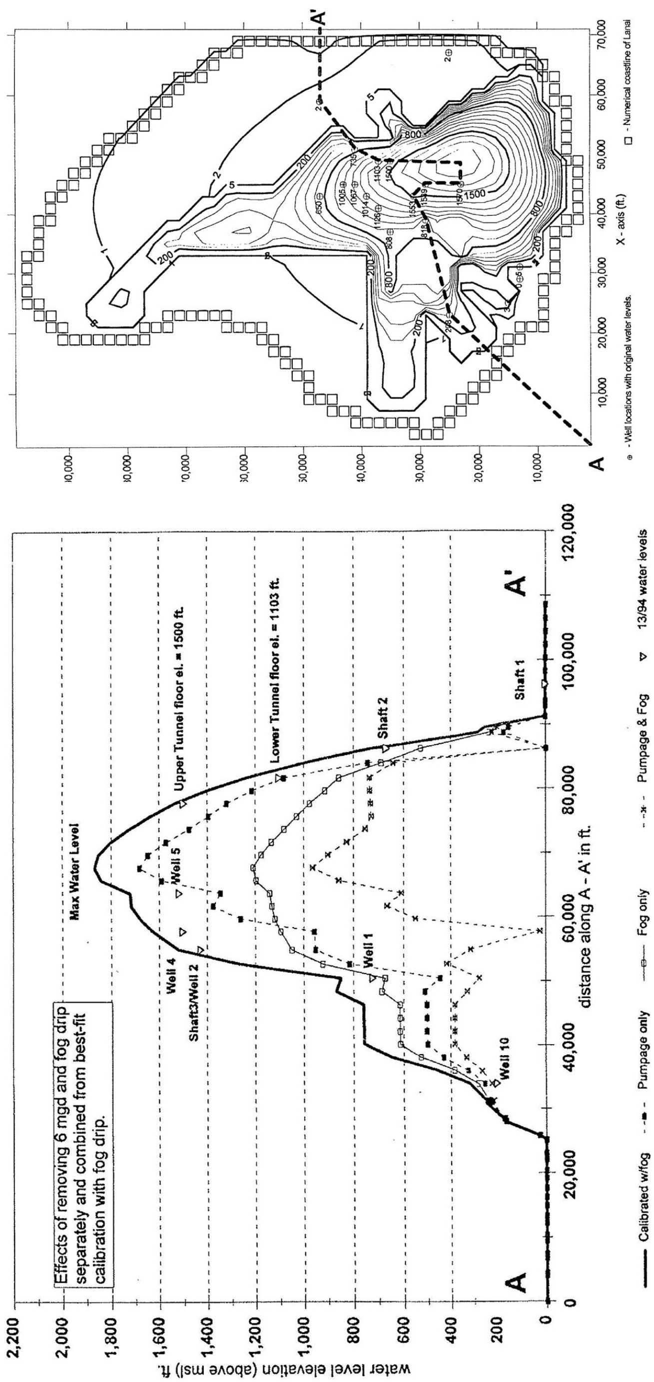
<u>Scenario One</u> involved continued pumping at a rate of about 1.707 MGD using ten sources (the Upper and Lower Tunnels, Maunalei Shaft 2, Wells 1 through 6 and Well 9). In this scenario, the aquifer would remain relatively healthy, though Upper Maunalei Tunnel would cease to flow. This scenario resulted in the second smallest decline in water levels of those tested.

<u>Scenario Two</u> involved no pumping at all, but loss of all fog drip. This scenario had greater impact overall to the aquifer than any pumpage scenario modeled, with water levels in the key recharge area dropping to about half their present levels.

<u>Scenario Three</u> involved pumping from existing wells to 6 MGD using ten sources (the Upper and Lower Tunnels, Maunalei Shaft 2, Wells 1 through 6 and Well 9). This caused regional water level decreases of concern probably due to inadequate distribution of withdrawals for this level of pumpage.

<u>Scenario Four</u> combined loss of fog drip with pumpage to 6 MGD using the same ten sources (the Upper and Lower Tunnels, Maunalei Shaft 2, Wells 1 through 6 and Well 9). This scenario would render many wells useless, with drawdowns over 1,300 feet in some areas. The worst effects were anticipated near the center of the island, in the key recharge area.

FIGURE 3-6. Water Levels as Modeled in *A Numerical Groundwater Model for the Island of Lana'i, Hawaii*; Hardy, CWRM-1, State of Hawaii 1996, showing cross section and aerial view of modeled area.



Scenario Five examined only the effects of pumping two wells in the caldera (Wells 1 and 9). This scenario involved only 0.65 MGD of pumpage. There was little effect on upstream sources.

Finally, Scenario Six involved taking 3.52 MGD (CCR's proposed withdrawals at the time) from thirteen sources (the Upper and Lower Maunalei Tunnels, Maunalei Shaft 2, Wells 1 through 9 and Well 14). The Upper Maunalei tunnel would cease to flow in this scenario. Although water levels would be anticipated to drop in all sources, Hardy stated, "It appears that this pumpage scenario amongst existing wells will not harm the aquifer. However, some changes in the existing well infrastructure may still be necessary as some of the wells specified for future pumping have no track record of water level response to such stresses...".

Hardy concluded that modifications to existing well configuration, including both drilling of additional wells and deepening some, would be necessary in order to realize long term development of groundwater. Updated recharge estimates, developed as part of the modeling effort described above, were higher than those previously estimated. Nevertheless, the State elected to take a conservative approach in estimating sustainable yield, due to the absence of adequate data or studies to corroborate a potentially higher yield. Recharge estimates, though higher, were also very dependent upon the status of the mauka watershed, which has been in decline. Results are shown in Figure 3-6. Distribution of withdrawals used in the model vs. actual for 2008 and recent as of Oct, 2009 are shown in Figure 3-7.

Perhaps the most compelling conclusion resulting from this study was that the reduction of forest cover would affect groundwater levels drastically. The numerical model made a strong case for the maintenance of vegetative cover in the cloudy regions above the 2,000' elevation. The importance of watershed protection and measures contemplated in the plan are discussed further in the watershed protection section of this document.

FIGURE 3-7. Lana'i Wells In 1996 Numerical Groundwater Model vs. Present Day

	AS MODELED IN 1996 CWRM MODEL	CWRM MODEL WELLS IN USE NOW	2008 MAV	* MOST RECENT ACTUAL MAV	* OTHER RECENT ACTUAL MAV	AVG OF NON-ZERO MAVS OVER PUMP RECORD	Comments
Maunalei Shaft 2	500,000	0	0	0	557,385	525,980	*MAV period 13 1994. In the late 1980s, more than 600 KGal came from Maunalei sources. Shaft 2 operated until 1995 with a running MAV of around 526 KGal. Stopped in early 1995.
Well 1	270,000	270,000	393,981	378,074		291,173	*MAV period 7, 2009. Water levels appear to be declining at current pumping rates.
Well 2 / Shaft 3 future "2-A"	300,000		2,418	0	302,468	228,523	*302,468 was MAV period 13, 2006. However, there have not been 13 straight periods of pumping since 1997. Period 8, 1997 MAV was 157,140 GPD.
Well 3	300,000	0	0	0	233,991	191,281	*MAV period 6, 2006. Last 13 period with continuous non-zero pumpage.
Well 4	400,000	400,000	683,867	598,677		532,729	MAV period 7, 2009.
Well 5	400,000	0	0	0	120,030	153,557	*MAV period 12, 1992. This well started in the 200-300 KGal range for 2 years, and then dropped steadily. Period shown is last continuous non-zero MAV use.
Well 6	300,000	300,000	327,912	303,118		432,557	MAV period 7, 2009.
Well 7	200,000	0	0	0			No continuous pumpage record. One monthly number in 1992.
Well 8	300,000	300,000	276,890	255,469		121,459	*MAV period 7, 2009.
Well 9	270,000	270,000	151,440	127,851		224,302	*MAV period 7, 2009.
Well 12	0	0	0	0	14,305	10,316	*MAV period 13, 1995. Started at 17.8 KGal & declined continously. Use stopped in 1997.
Well 14	280,000	280,000	404,714	323,302		336,913	*MAV period 7, 2009.
	-----------	-----------	-----------	-----------	-----------	-----------	
	3,520,000	1,820,000	2,241,222	1,986,491	1,228,179	3,048,790	Average over pump record is high. These wells have not pumped at same time. Difference between 2,238,804 and 2,241,222 is less than 1%, and results from different averaging method.

Groundwater

FIGURE 3-8. Lanaʻi Wells and Water Levels

Well	Initial Water Level (+MSL)	Action Level Nance	Lowest Allowable Level Nance	Trigger Levels for Designation Proceedings CWRM 3/29/1990	Current Level Period 7 2009 (except where noted *)	Notes**
1	818	550	410	414	575	
2 / Shaft 3	1,544 / 1,553	1050	750	772	1441	Initial head per Nance. "0" per CWRM database. Most recent WL reading period 13, 2002. Well rarely used since 1996. Used 8 months in '06, only few months each in '97, '02, '08.
3	1,124	750	562	562	992	Last WL reading from period 7, 2006. Well also not in operation since period 5 of 2006.
4	1,589	1100	750	794.2	1501	Initial head per Nance. "1078" per CWRM database.
5	1,570	1100	750	735	1496	Last WL reading from period 4, 2004. Well not in operation since roughly end of 1994.
6	1,005	750	500	502.5	924	
7	650			325		Initial head per CWRM. Only reported pumpage period 4 of 1992. First WL report - period 5,1999 - 980'. Last WL report period 4, 2004 973'. Not clear why heads are 300'+ higher than that recorded by CWRM.
8	1,014	750	500	507	944	Prior to period 6 of 2002, reported water levels were running in the mid 800s. In Period 6, 2002 they were 867. In Period 7, 2002, they jumped to 970' and have stayed in the 900s thus far. The increase may be due to a reporting method change in 2002.
9	808	550	410	404	650	Minimum reported water level was 566' for periods 3, 4 and 5 of 2006. (Water level corrected by Takasaki survey per Hardy '96)
10	208			104		
11						Well missing from CWRM database or named differently there. Initial Head 95', if same as Palawai Exploratory. Never used.
12	5			2.5		
13	0					
14	551	400	292	275.5	497	Min high water level 418' - period 5, 2004.
15						Well to commence 2010.

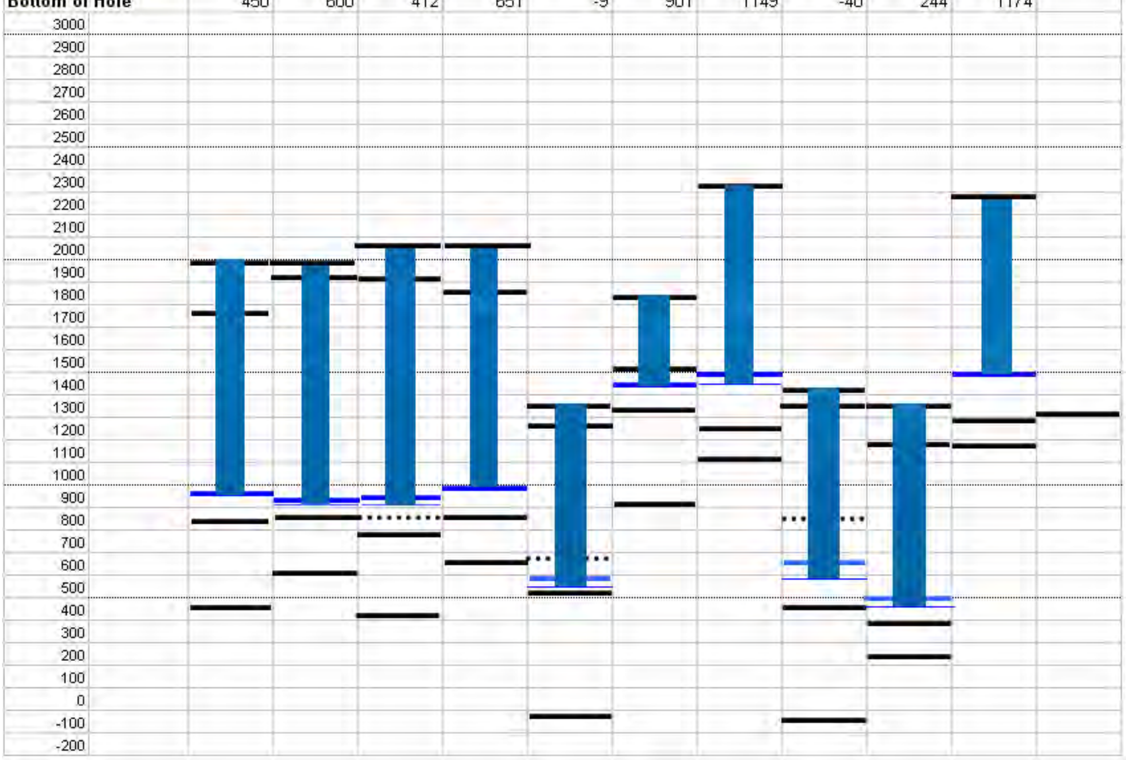
** Current and recent water levels refer to High Water Levels from the Periodic Pumpage Reports & are in elevation above Mean Sea Level. Designation triggers refer to static water levels. High water levels from pumping wells serve as a preliminary indicator for static water levels.

Water Levels

Figure 3-8 shows existing water levels at pumping wells versus water levels set by the CWRM as triggers for designation proceedings in its March 29, 1990 decision on designation, and action levels recommended by Tom Nance in 1996. When water levels reach triggers established by CWRM, designation proceedings are triggered. Based on Nance's 1996 proposal, when an action level is reached, pumpage data will receive a thorough public and scientific review with the aim to determine whether and what further actions, such as lowering the pump or replacing the affected well, distributing withdrawals or other measures, are indicated. When water levels reach the "lowest allowable level" proposed by Nance, pumpage of the affected well is to stop altogether until the well is able to recover. The historical and current status of individual wells are discussed on pages 60 to 77 of this chapter.

FIGURE 3-9. Side View Schematic of Well Water Levels Running North to South.

	Well 7	Well 6	Well 8	Well 3	Well 1	Well 2	Well 4	Well 9	Well 14	Well 5	Well 15
Tank Spillway	1980	1980	2057	2057	1353	1823.5	1823.5	1353	1353		
Well Ground Elev.	1775	1910	1902	1850	1265	1510	2327	1411	1193	2296	1310
High H2O Level P7/09	973	924	944	992	575	1441	1495	650	497	1496	
Low H2O Level P7/09		913	904		555		1457	598	478		
Pump Intake or Elev.	840	863	782	866	516	1335	1253	466	400	1293	
Bottom of Hole	450	600	412	651	-9	901	1149	-40	244	1174	



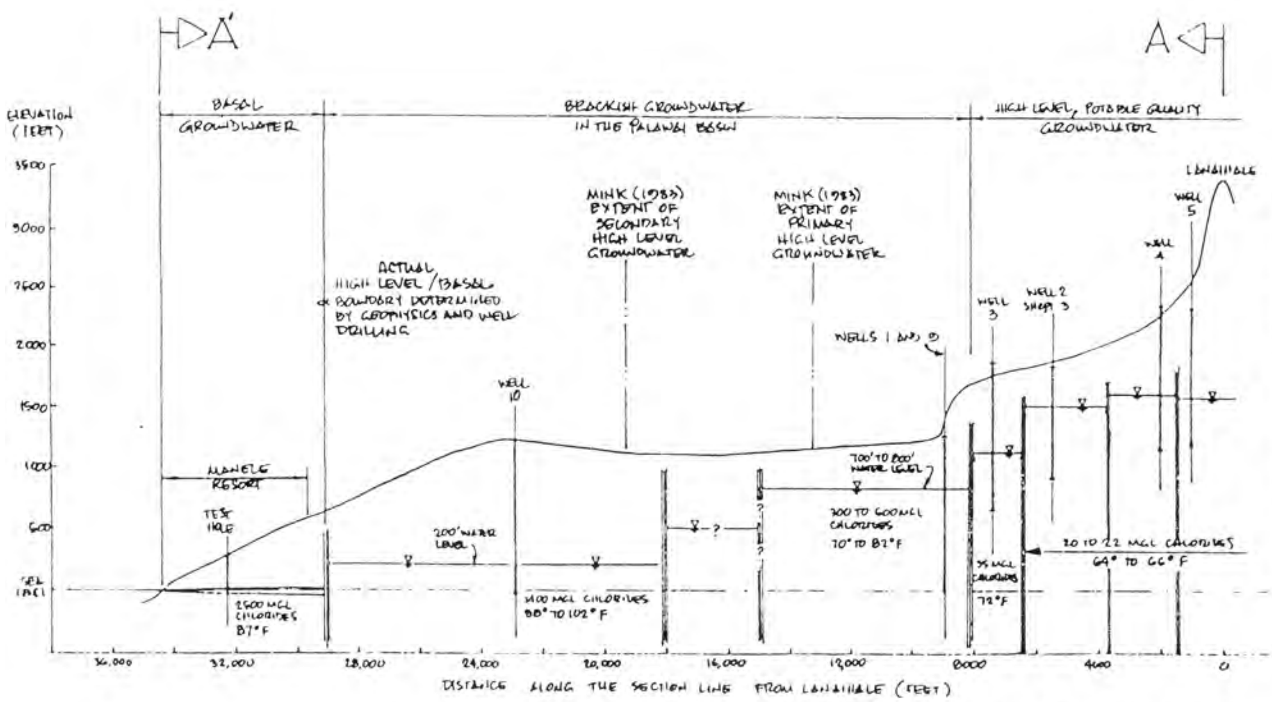
**** Ground elevation for Well 4 higher than tank spillway, so only ground elevation is shown. Wells 1, 9 & 14 used to pump to a control tank at 1,420' with a 1,434.5' spillway. This tank has now been bypassed, so the high point in the line, at 1,353' is the highest point to which Wells 1 & 14 now pump.

Figures 3-9 and 3-10 are recent (3-9) and historical (3-10) snapshots of water levels in pumping wells, running from north to south on Lana‘i.

In Figure 3-9, lines marking elevations read top to bottom. The top black line represents the tank spillway level to which the well pumps, followed in descending order by ground elevation, high water levels in thick blue, low water levels in thin blue, pump intake levels, and the bottom of the hole. Dotted black lines represent past pump elevations. For instance, Well 8 pump level as of period 7, 2009 was 863.17’. The pump was lowered in early September of 2009 to 783.17’ to avoid cavitation, as pumping water levels were within 17’ of the pump.

Figure 3-10 provides the locations of the wells relative to Lana‘i’s topography. Although more recent data regarding depths and water levels are provided in Figure 3-9, and more recent data regarding apparent aquifer extents are provided in the next section, Figure 3-10 provides a useful reference for visualizing such data.

FIGURE 3-10. Hydrogeologic Section from Manele to Lana‘ihale Illustrating the Comparative Locations of the Outer Limit of High Level Groundwater Occurrence. Source: *Lana‘i Company Water Resources Management Plan, 1996*.



Hydro-Geologic Section From Manele to Lanaihale Illustrating the Comparative Locations of the Outer Limit of High Level Groundwater Occurrence

Aquifer Extent - Time Domain Electromagnetic Resistivity Surveys

Water levels at pumping wells are described above. In addition to such measured levels, the depth, nature and extent of an aquifer can be characterized by other methods. Once such method is a time domain electromagnetic resistivity survey.

Time domain electromagnetic resistivity surveys are used to examine subsurface aquifer characteristics, including depth to water, lateral extent of water, degree of salinity and impeding structures or geologic features that would indicate areas where an aquifer may be present.

Electrical resistivity measurements are made by passing weak electrical currents through the ground and measuring the resultant voltage field. The behavior of the currents in the ground is sometimes compared to "smoke rings". After the initial "puff", the "smoke rings" expand, weaken, and travel down through the earth. The rate of diffusion depends on the conductivity or resistivity of the layers below. In resistive media, the currents diffuse rapidly, so the voltage drops quickly. In conductive media, they diffuse more slowly. After the initial pulse, the transmitter is turned off, and timed measurements are made of the resulting currents or "smoke rings". By making measurements at different time increments, a resistivity survey can identify variations in resistivity with depth, indicating different layers in the subsurface material. A series of soundings at different positions along a profile line can reveal lateral changes in resistivity, or changes across a section of ground. Changes in resistivity can reveal the presence of groundwater as well as provide some indication of the degree of salinity of water found.

Resistivity surveys were conducted as early as 1935. In *A Numerical Groundwater Model for the Island of Lana`i, Hawaii* (Hardy, State of Hawaii, CWRM-1996), Hardy discusses historical resistivity surveys of the island of Lana`i. Results vary but certain key points emerge. The island is characterized by high level water within 3.8 miles of the coast from any direction; the basal lens around the outside of the island is extremely thin; there is effectively no caprock on the southern side of the island but alluvium deposits on the north side may act as a sort of low permeability caprock; and finally, the presence of dikes and faulting in the main recharge area renders interpretation of resistivity studies for Lana`i a complex and uncertain undertaking. Even so, valuable data has been gained with regard to the general location of the confined high water boundary.

The most recent resistivity studies were performed in 1993 and 2001 by Blackhawk GeoSciences. Time Domain Electromagnetic Resistivity surveys (TDEM) were utilized to determine the location of the groundwater damming structure bounding the high level water, and to explore for anomalous basal groundwater occurrences. Data from the 2001 study are presented in Figures 3-11 through 3-13. Study areas referred to in Figure 3-13 are shown on the map in Figure 3-12. A larger version of this map is available on line in the large exhibits section of the Lana‘i WUDP page.

Both the 1993 and 2001 TDEM surveys found that the aerial extent of the high level damming structure was broader than that originally estimated. The 2001 study also sought anomalous basal groundwater occurrences outside the damming structure. Results in the areas of Maunalei gulch, Haua gulch and an un-named gulch east of Manele Road indicated poor water resources in these areas. Possible basal lens occurrences were identified in Kahea gulch and Hauola Gulch. However, both of these sites were anticipated to yield low production wells. To date, CWRM has not elected to adjust the sustainable yield of the island based on these findings.

FIGURE 3-11. Cross Section of Lana'i showing inferred extents of high level water, basal water & damming structure

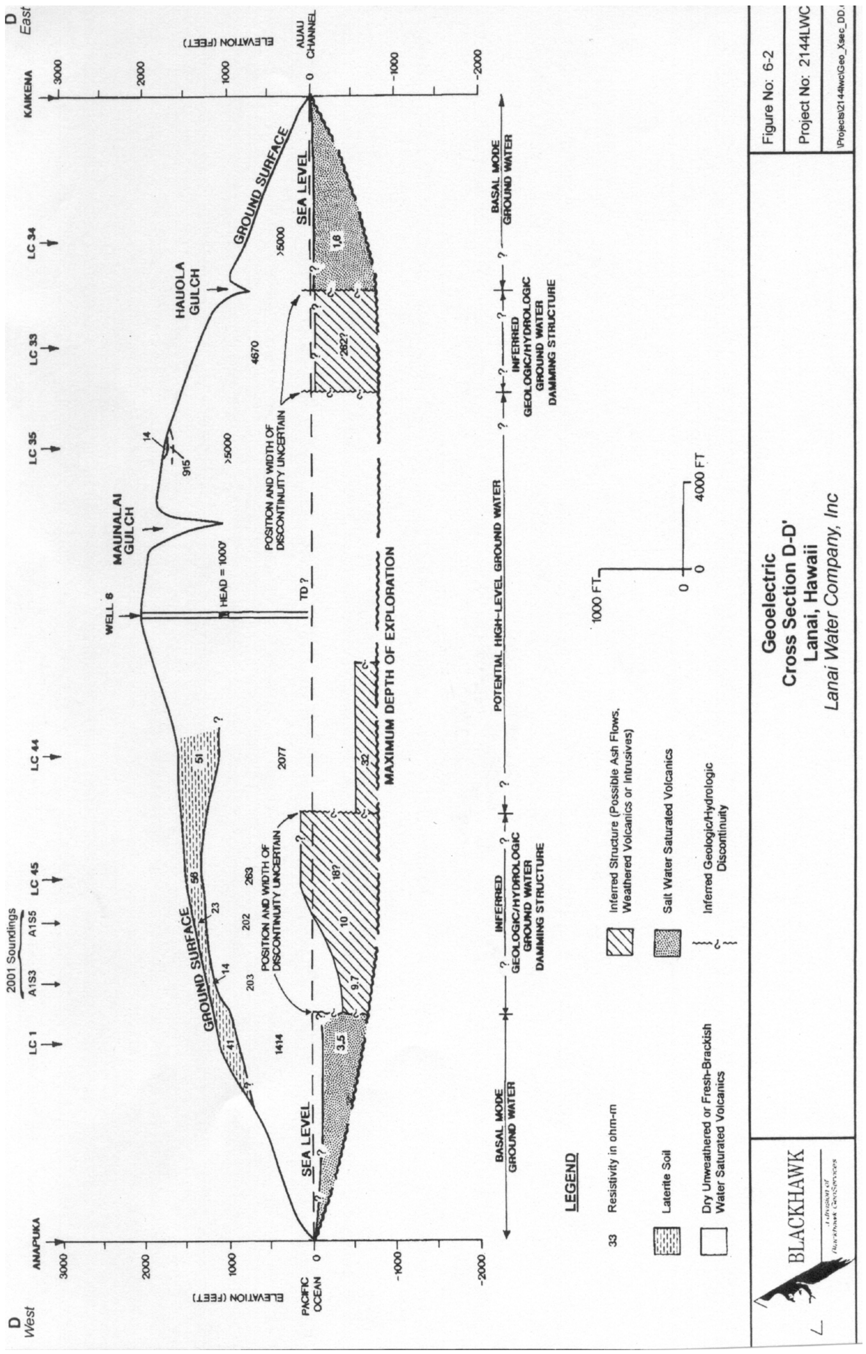


FIGURE 3-12. Blackhawk GeoSciences TDEM Sounding Location Map, August, 2001. Red crosshatch = inferred geologic/hydrologic discontinuity. Blue = soundings in which groundwater is expected to be basal. Green = soundings interpreted to be in the groundwater barrier. Gold = soundings in which groundwater is expected to be controlled by geologic structure, or potential high-level water**.**

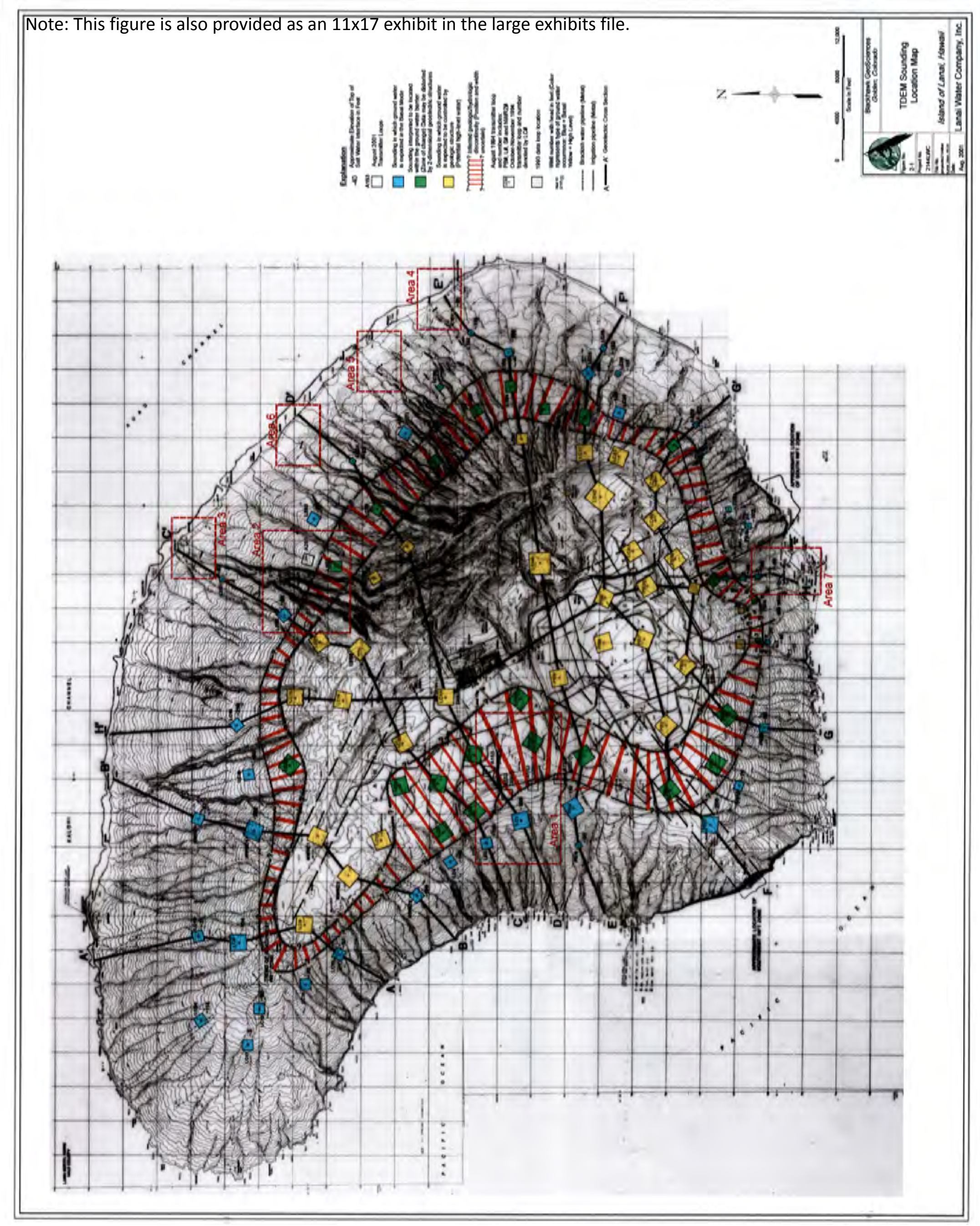


FIGURE 3-13. 2001 TDEM Results - Blackhawk GeoSciences

Time Domain Electromagnetic Survey of Lana`i Groundwater
by Blackhawk Geosciences, Sept 2001

		Resistivity (ohm-m)	Thickness (meters)	Elevation (meters)	Conductance (Siemens)	Interpretation / Comments
Area 1						North of Airport
Sounding 2				428		
	Layer 1	12.49	18.9	409	1.51	
	Layer 2	1106.3	346.7	62.33	0.313	Soundings in Area 1 repositioned the
	Layer 3	9.47				previously interpreted groundwater
Sounding 3				405		damming structure 800'-1,000'
	Layer 1	14.4	25.64	379.3	1.78	further seaward than had been
	Layer 2	203.5	456.2	-76.86	2.24	interpreted from previous studies in
	Layer 3	9.69				this area. This move reduced the
Sounding 4				417		available basal groundwater
	Layer 1	23.73	38.58	378.4	1.62	resource estimates in the area,
	Layer 2	95.45	198	180.3	2.07	while increasing estimates of high
	Layer 3	2.87				level water.
Sounding 5				460		
	Layer 1	22.65	31.69	428.3	1.39	
	Layer 2	202.1	380.5	47.74	1.88	
	Layer 3	10.35				
Area 2						Maunalei Gulch
Sounding 1				300		
	Layer 1	13.05	30.29	269.7	2.31	
	Layer 2	924.5	290	-20.37	0.313	Results did not change previously
	Layer 3	2.36				interpreted position of damming
Sounding 2				128		structure. However, results
	Layer 1	114.6	6.97	121	0.0608	indicated a rift zone in the area,
	Layer 2	15.42	25.89	95.13	1.67	and a thin brackish/fresh basal lens.
	Layer 3	160.5	45.83	49.3	0.285	Basal brackish/fresh water resource
	Layer 4	3.97				expected to be poor in this area.
Sounding 3				110		
	Layer 1	94.87	7.06	102.9	0.0745	
	Layer 2	21.69	26.14	76.78	1.2	
	Layer 3	117.1	61.46	15.32	0.524	
	Layer 4	6.13				
Sounding 4				100		
	Layer 1	139	9.33	90.66	0.0671	
	Layer 2	13.46	11.03	79.63	0.819	
	Layer 3	83.85	30.43	49.2	0.362	

Layer 4	17.24				
Sounding 5			78		
Layer 1	199.6	11.9	66.09	0.0596	
Layer 2	5.66	3.3	62.78	0.583	
Layer 3	422.1	60.81	1.96	0.144	
Layer 4	5.24				
Sounding 6			70		
Layer 1	153.2	5.57	64.42	0.0363	
Layer 2	42.47	50.18	14.24	1.18	
Layer 3	148.8	11.08	3.15	0.0744	
Layer 4	3.93				
Area 3					Maunalei Gulch - More Detailed Surveys
Sounding 7			17		
Layer 1	78.04	6.56	10.43	0.0841	
Layer 2	2.2	17.2	-6.77	7.81	
Layer 3	0.812				Interpreted results indicated streambed gravels, underlain by laterite and altered volcanics, underlain by fresh/brackish water saturated volcanics below sea level underlain by saltwater saturated volcanics. Still indicates thin brackish/fresh water lens. Poor groundwater resources anticipated.
Sounding 8			19		
Layer 1	91.6	6.13	12.86	0.0669	
Layer 2	3.56	16.85	-3.98	4.72	
Layer 3	1.8				
Sounding 9			15		
Layer 1	85.02	2.43	12.56	0.0286	
Layer 2	3.04	16.6	-4.03	5.45	
Layer 3	1.23				
Sounding 10			13		
Layer 1	101.3	1.74	11.25	0.0172	
Layer 2	2.4	26.53	-15.28	11.03	
Layer 3	0.973	22.51	-37.79	23.13	
Layer 4	18.09				
Sounding 11			12		
Layer 1	98.25	4.36	7.63	0.0444	
Layer 2	3.01	15.83	-8.19	5.24	
Layer 3	1.53	52.21	-60.41	34.07	
Layer 4	11.97				
Sounding 12			11		
Layer 1	74.68	2.39	8.6	0.032	
Layer 2	5.84	20.79	-12.19	3.55	
Layer 3	1.39	173.2	-185.4	124.5	
Layer 4	11.83				
Sounding 13			17		
Layer 1	39.4	9.85	7.14	0.25	
Layer 2	9.83	19.44	-12.29	1.97	

Groundwater

	Layer 3	1.77	128.2	-140.5	72.04	
	Layer 4	11.64				
Area 4						Kahea Gulch / Club Lana`i Area
Sounding 1				8		
	Layer 1	36.1	44.39	-36.39	1.22	
	Layer 2	2.12				Basal conductive layer found at
Sounding 2				7		unexpectedly great depth
	Layer 1	6.82	2.32	4.67	0.34	considering that sites were only
	Layer 2	35.78	36.89	-32.22	1.03	600'-700' inland from ocean.
	Layer 3	2.13				Apparently anomolous basal lens.
Sounding 3				6		Could indicate better than usual
	Layer 1	117	6.05	-0.0558	0.0517	groundwater resources. However,
	Layer 2	19.08	33.93	-33.98	1.77	anomalous readings could also be
	Layer 3	2.27				caused by low-permeability area or
Sounding 4				8		altered volcanics.
	Layer 1	161	13.86	-5.86	0.0861	
	Layer 2	25.18	30.22	-36.09	1.2	
	Layer 3	2.81				
Sounding 5				15		
	Layer 1	165.9	16.88	-1.88	0.101	
	Layer 2	34.02	32.86	-34.74	0.965	
	Layer 3	2.39				
Area 5						Haua Gulch
Sounding 1				28		
	Layer 1	36.81	46.98	-18.98	1.27	
	Layer 2	1.6	16.62	-35.6	10.35	Results indicate poor basal
	Layer 3	2.5				groundwater resources. Basal
Sounding 2				26		conductive layer at modest depth
	Layer 1	66.71	24.93	1.06	0.373	considering that the tests were
	Layer 2	20.63	23.39	-22.33	1.13	2,000' inland from the ocean.
	Layer 3	1.95				
Sounding 3				26		
	Layer 1	41.07	42.28	-16.28	1.02	
	Layer 2	2.76	42.47	-58.76	15.33	
	Layer 3	9.61				
Sounding 4				29		
	Layer 1	49.16	44.39	-15.39	0.903	
	Layer 2	2.52	40	-55.4	15.83	
	Layer 3	6.95				
Sounding 5				50		
	Layer 1	343.2	64.8	-14.8	0.188	
	Layer 2	2.42				

Area 6						Hauola Gulch
Sounding 1				20		
	Layer 1	75.7	3.29	16.7	0.0435	
	Layer 2	15.95	29.27	-12.56	1.83	Unexpected depth to basal seawater
	Layer 3	1.78				may indicate better than normal
Sounding 2				18		basal brackish/fresh groundwater
	Layer 1	85.02	5.57	12.42	0.0655	resources in this area. However,
	Layer 2	13.29	31.79	-19.36	2.39	this could also be caused by a low-
	Layer 3	1.93				permeability formation or altered
Sounding 3				16		volcanics.
	Layer 1	83.91	3.89	12.1	0.0464	
	Layer 2	14.82	33.02	-20.91	2.22	
	Layer 3	1.84				
Sounding 4				14		
	Layer 1	85.24	4.67	9.32	0.0548	
	Layer 2	15.75	32.72	-23.4	2.07	
	Layer 3	1.95				
Sounding 5				12		
	Layer 1	78.22	3.79	8.2	0.0485	
	Layer 2	13.99	33.04	-24.84	2.36	
	Layer 3	1.5				
Sounding 6				12		
	Layer 1	57.71	1.32	10.67	0.0229	
	Layer 2	18.6	33.9	-23.23	1.82	
	Layer 3	1.45				
Sounding 7				20		
	Layer 1	172.6	8.71	11.28	0.0504	
	Layer 2	18.65	29.22	-17.94	1.56	
	Layer 3	1.61				
Area 7						Gulch East of Manele Road
Sounding 1				102		
	Layer 1	79.4	113.2	-11.23	1.42	
	Layer 2	0.117				Significant geologic structure
Sounding 2				101		identified in this area. Groundwater
	Layer 1	380.7	102.3	-1.39	0.268	resources expected to be poor.
	Layer 2	3.42				
Sounding 3				95		
	Layer 1	60.37	59.79	35.2	0.99	
	Layer 2	0.0152				
Sounding 4				85		
	Layer 1	176.9	86.06	-1.06	0.486	

Precipitation

Layer 2	2.49			
Sounding 5			80	
Layer 1	118.7	37.65	42.34	0.317
Layer 2	0.00241			
Sounding 6			90	
Layer1	94.06	69	20.99	0.733
Layer 2	0.0607			

Precipitation

Rainfall is a major source of recharge to aquifers, streams and springs, as well as being an indicator of the effects of climate change. Rainfall measurements have been taken at 52 rain gauges on Lana`i since 1914. Eight rain gauge stations are still in service and are followed by the National Weather service. The longest rain station records are those for Lana`i City and Koele. (Koele station # 693, not included in Figure 3-14 below, monitored from 1949 to 1963, showed an average annual precipitation of 37.3 inches.)

FIGURE 3-14. Lana‘i Monthly Mean Precipitation

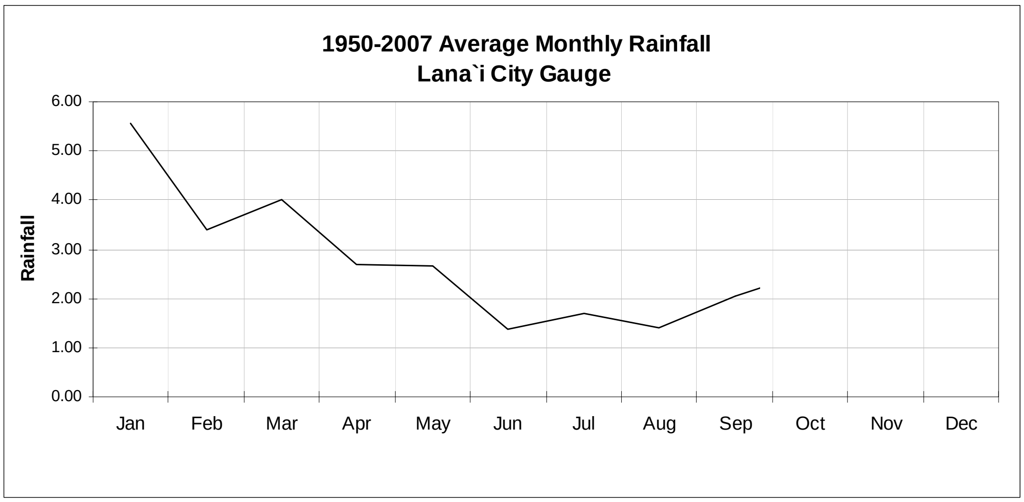
Lana`i Monthly Mean of Precipitation (01/1970-02/2002)														
Station Name	**Sta. No**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**Annual**
Kanepuu	690	4.44	3.04	2.65	1.58	1.31	1.24	0.71	0.87	1.05	1.81	2.51	3.21	23.32
Kaumalapau Harbor	658	2.02	2.42	1.46	1.41	1.34	1.1	1.01	0.89	1.01	1.47	2.14	2.6	10.71
Lana`i Airport	656	2.85	2.16	1.24	0.9	0.83	0.78	0.55	0.5	0.76	1.29	2.22	3.25	15.86
Lana`i City	672	5.24	3.81	2.73	2.53	2.12	1.63	1.64	1.42	1.99	2.45	3.39	4.16	33.83
Lanai`hale	684	5.62	4.5	3.82	2.42	2.46	1.84	1.57	1.97	2.17	2.78	4.2	3.03	41.65
Mahana	694	4.51	3.29	2.65	1.27	1.19	0.79	0.44	0.42	0.82	1.71	2.74	3.06	20.69
Malauea	676	3.16	2.34	1.56	0.98	0.5	0.45	0.27	0.18	0.81	1.1	1.98	2.73	14.16
Waiakeakua	685	3.66	3.31	2.17	1.81	1.28	0.73	0.49	0.41	1.08	1.61	2.02	3.39	21.22
Source: School of Ocean & Earth Science & Technology http://www.soest.hawaii.edu/MET/Hsco/upt/ppt/ppt4.html												*Unit: Inches*		
* note annual numbers do not match totals due to method of handling missing data days - totals given are those reported by SOEST														

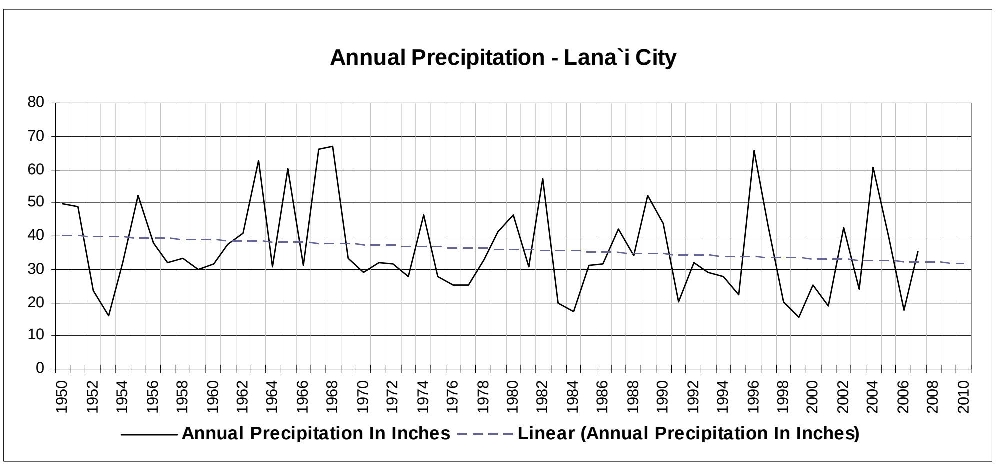
Most sources estimate that rainfall on Lana`i averages less than ten inches per year along the coast, (generally 6 to 8 inches), and thirty-five to forty (35-40) inches at the summit along the main ridge from Lana‘ihale to Koele. Much of this rainfall comes from orographic lifting of the northeasterly trades over the central ridge.

Fog-drip is also a major contributor to recharge on Lana‘i. The island experiences frequent cloud cover above the 2,000 to 2,500 foot range. Despite the relatively low rainfall, a 1967 state Land Bureau study investigating soils and vegetation on Lana‘ihale concluded that they were more typical of an area receiving 60" per year than the 35" - 40" that actually fall on the summit. This seeming anomaly was attributed to the importance of fog drip from the watershed. (Mirabayashi, Ching, Kuwahara, Fujimura, Awai & Baker, *Detailed Land Classification - Island of Lana‘i*, Bulletin No. 8, Land Study Bureau, 1967).

A 1964 paper by Paul Ekern reached a similar conclusion about the importance of fog drip. Ekern monitored a network of rain gauges beneath a Norfolk Island Pine tree and compared rainfall in these gauges to that collected by a network in the open for three years. (*“Direct Interception of Cloud Water on Lana‘ihale, Hawaii”*, Ekern, Paul C., Soil Physicist, Pineapple Research Institute of Hawaii, Honolulu, Soil Science Society of America Journal, Wisoncsin, © 1964, & Technical Paper No. 294 of the Pineapple Research Institute of Hawaii, Honolulu.) More recent studies have borne out such statements about fog drip. The 2009 Lana‘i Fog Drip Study, by Pacific Environmental Planning, found that precipitation caused by fog drip and through-fall under Cook Pines was substantially higher than estimated in 1964, possibly due to the increased stature of the trees, and substantially higher than precipitation from rainfall alone.

FIGURE 3-15. Monthly and Annual Precipitation - Lana‘i City

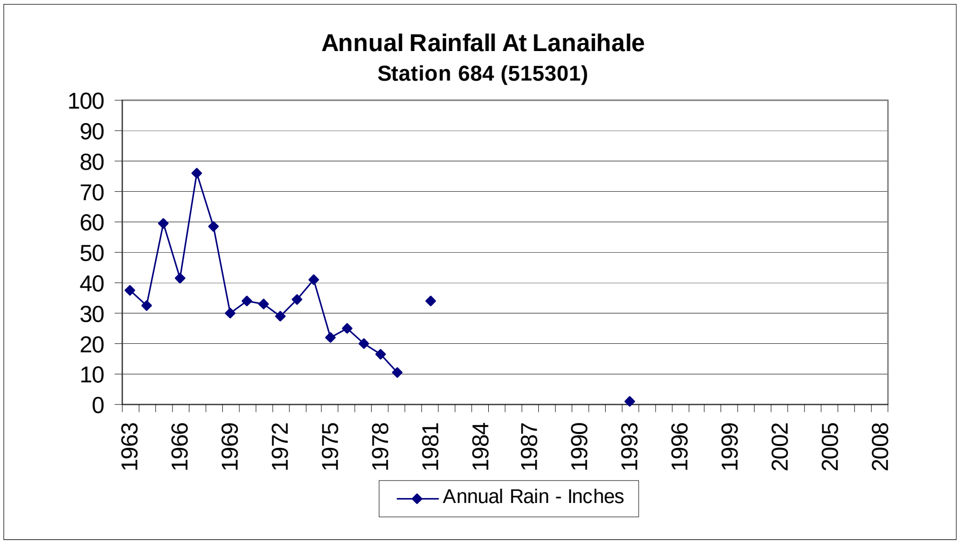




Being in the rain-shadow of Maui, Lana‘i’s seasonal variation is somewhat more subtle than other islands, but there is still a notable seasonal pattern as shown in Figure 3-15.

Data from the Western Regional Climate Center for Lana‘i City and Lana‘ihale are plotted above and below, respectively. (Source: http://www.wrcc.dri.edu/cgi-bin/cliMONtpre.pl?hi5301). Lana‘i City plots seem to reveal a slight declining trend, though data from both this and the Lana‘ihale gauge plotted below are inadequate to say whether such trends reach the level of statistical significance.

FIGURE 3-16. Rainfall at Lana'ihale Source:Western Regional Climate Center Source: http://www.wrcc.dri.edu/cgi-bin/cliMONtpre.pl?hi5301 Note: Although measurements at the rain gauge continued until 2004, there isan inadequate number of measured rain daysreported on the web to accurately plot this data.



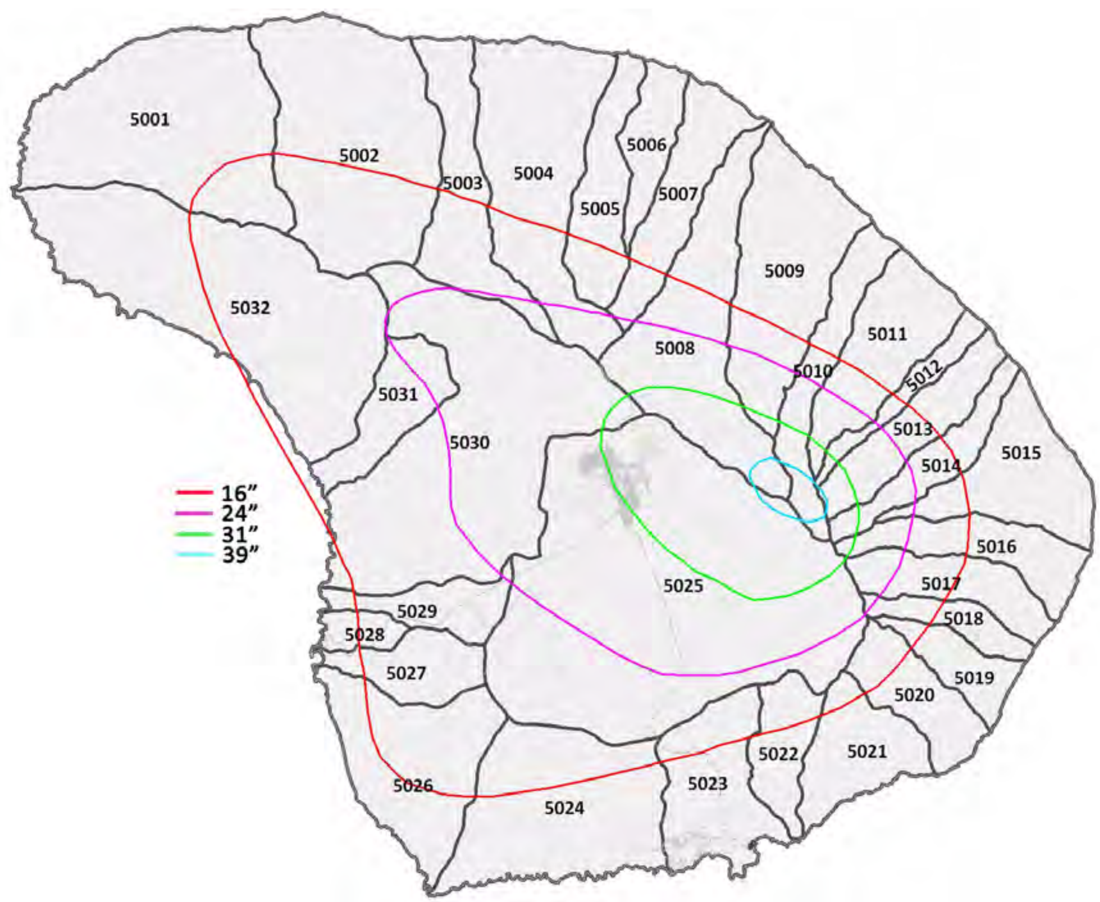
Surface Water Hydrologic Units

The 2008 update of the State Water Resources Protection Plan divides Lana'i into 32 hydrologic units, shown below. Despite having units identified, no stream flows, stream flow standards, diversions or gauges are present on Lana'i.

FIGURE 3-17. Lana'i's Surface Water Hydrologic Units

Unit	Name	Unit	Name
5001	Puumaiekahi	5017	Awehi
5002	Lapaiki	5018	Kapua
5003	Hawaiilanui	5019	Naha
5004	Kahua	5020	Kapoho
5005	Kuahua	5021	Kawaiu
5006	Poaiwa	5022	Mahanalua
5007	Halulu	5023	Manele
5008	Maunalei	5024	Anapuka
5009	Whane	5025	Palawai Basin
5010	Hauola	5026	Ulaula
5011	Nahoko	5027	Kaumalapau
5012	Kaa	5028	Kalamanui
5013	Haua	5029	Kalamaiki
5014	Waiopa	5030	Paliamano
5015	Kahea	5031	Honopu
5016	Lopa	5032	Kaapahu

FIGURE 3-18. Lana'i Surface Water Hydrologic Units with Isohyets Source: State Commission on Water Resource Management



The only perennial stream known to have existed on Lana'i originated in the upper reaches of Maunalei gulch where it is deeply incised into the dike complex of the northwest rift. This flow was diverted by the Maunalei tunnels. (Source: Keith Anderson, "*Water Supply Investigation: Island of Lana'i, Hawaii*", prepared for Hawaiian Pineapple Co., Ltd., and including a summary of Lana'i Water Development from a 1954 report by V. W. Thalman).

At one time there were also various seeps and springs at Kaiholena, Waipa'a and Waiakeakua, Kaohai and Paliakoa'e Gulch. There are historical accounts of growing rice in a kuleana using the watercourse from Paliakoa'e, and even of a deep water hole. (George C. Munro, *The Story of Lana'i*, Honolulu, 2006).

Historical Water Resources

Historical and anecdotal evidence suggest that Lana‘i once had more available water than it has now. Maunalei Stream was once perennial, running to the ocean. It supported taro lo`i in the upper reaches of that ahupua‘a until the late 1800s. During the late 1800s taro production was discontinued because goats had so denuded the cliffs above that work in the lo‘i had become hazardous. The stream stopped running with the development of Maunalei Tunnels in 1940, but even before that time it had stopped running all the way to the ocean.

John Lydgate, in his memoirs of botanizing on Lana‘i with W.F. Hillebrand and W.M. Gibson, noted a small pond, the size of a dining table, that was always full of water regardless of the weather. Stearns (1940) mentioned two seeps upstream of Waipaa tunnel. Munro, in *The Story of Lana‘i*, (2006, Honolulu), notes a water course at Paliakoa‘e Gulch, and mentions a 5 acre kuleana growing rice with that water. He also notes seeps and springs at Kaiholena, Waipa‘a, Waiakeakua and Kaohai.

Kenneth P. Emory, in *"The Island of Lana‘i; A Survey of Native Culture"; (Bernice P. Bishop Museum Bulletin 12; Honolulu, Hawaii 1969)* not only notes the historical cultivation of taro, but provides maps of historic sites which give the location of a number of springs (at least nine), and other water-related features.

Emory created a map of historical houses and heiau, which is presented in Figure 3-19. Note the number of dots, indicating home sites, near to the shore. Such settlements would not have been located at unreasonable walking distances from water. The presence of home sites, as well as several historical dug-wells seems to indicate the likelihood that water along the coast was once fresher, and that water may generally have been more readily available at one time. This is supported by various historical accounts that refer to Lana‘i as a place with abundant water.

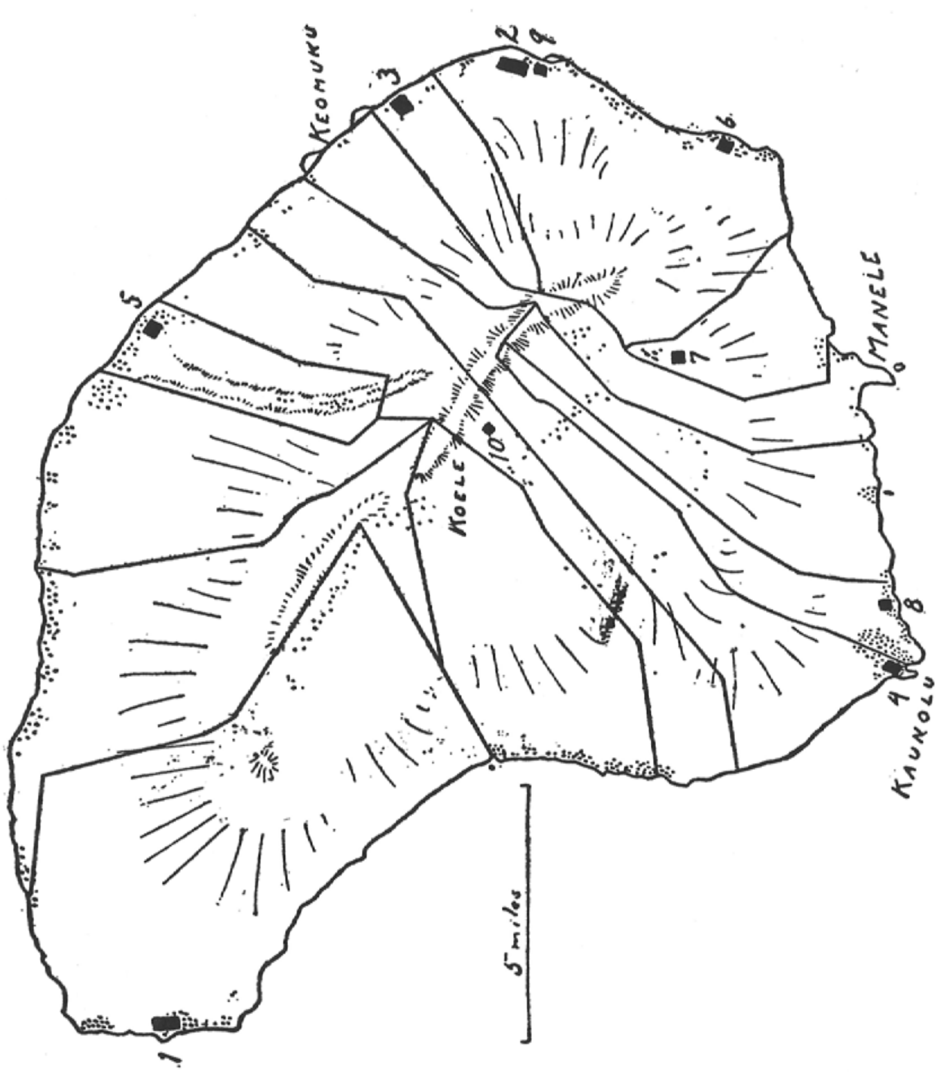
Emory also developed a gazetteer of Lana‘i place names, providing translation from Hawaiian to English and mapping the location of these places. Place names are provided on the map in Figure 3-20. An 11x17 version of this map is also available on the web in the 11x17 pdf section. A list of those place names which seem to refer to water or water-related conditions (such as taro growing) is provided in Figure 3-21. These names are numbered, and can also be located on the map in Figure 3-20. Such names as "Water of the God", "Glistening Water", "Column of Rain" lead one to infer that water was indeed more plentiful at one time. Some of the higher elevation places specifically denoted as springs are shown in Figure 3-22.

A review of the map in Figure 3-22 will prompt one to note that many of the developed wells on Lana‘i are sited at or near of some of these historical water features. The loss of these water features could stem from several factors, including water development, diminished forest cover causing decreased recharge, climate change, cracks in confining rock barriers allowing water to seep out, or various combinations of such factors. Bowles (1974) and Hardy (1996) both noted that a significant portion of drawdown observed in Lana‘i wells may be attributed to changes in the forest cover in the cloudy regions above 2,000'. With regard to Maunalei, V.W. Thalman noted in his 1954 report to the company, "...this flow is now diverted by tunnels and provides part of the domestic water supply for Lana‘i City."

More recently, data from USGS, Tom Giambelluca and others indicate a thinning of the inversion layer and decreases in stream flow and in overall precipitation, affecting all Hawaiian islands, including Lana‘i.

Additional historical data on water is found in the source water protection chapter of this plan, in the table entitled, *A Chronology of Land Use, Conservation and Water in Lana‘i.*

FIGURE 3-19. Settlement on Lana'i - Heiau and House Sites; Source: Emory, K.P.; *The Island of Lana'i: A Survey of Native Culture*; Bishop Museum Bulletin 12; Honolulu, 1969



Map of Lanai. Dots represent visible house sites; rectangles represent heiaus. Figures give the order of the heiaus according to size.

Historical Water Resources

FIGURE 3-20. Map of Lana'i Showing Place Names. Source: Kenneth P. Emory, *The Island of Lana'i; A Survey of Native Culture*, Bishop Museum Bulletin 12; Honolulu; 1969

Note: This figure is also provided as an 11x17 exhibit in the large exhibits file.

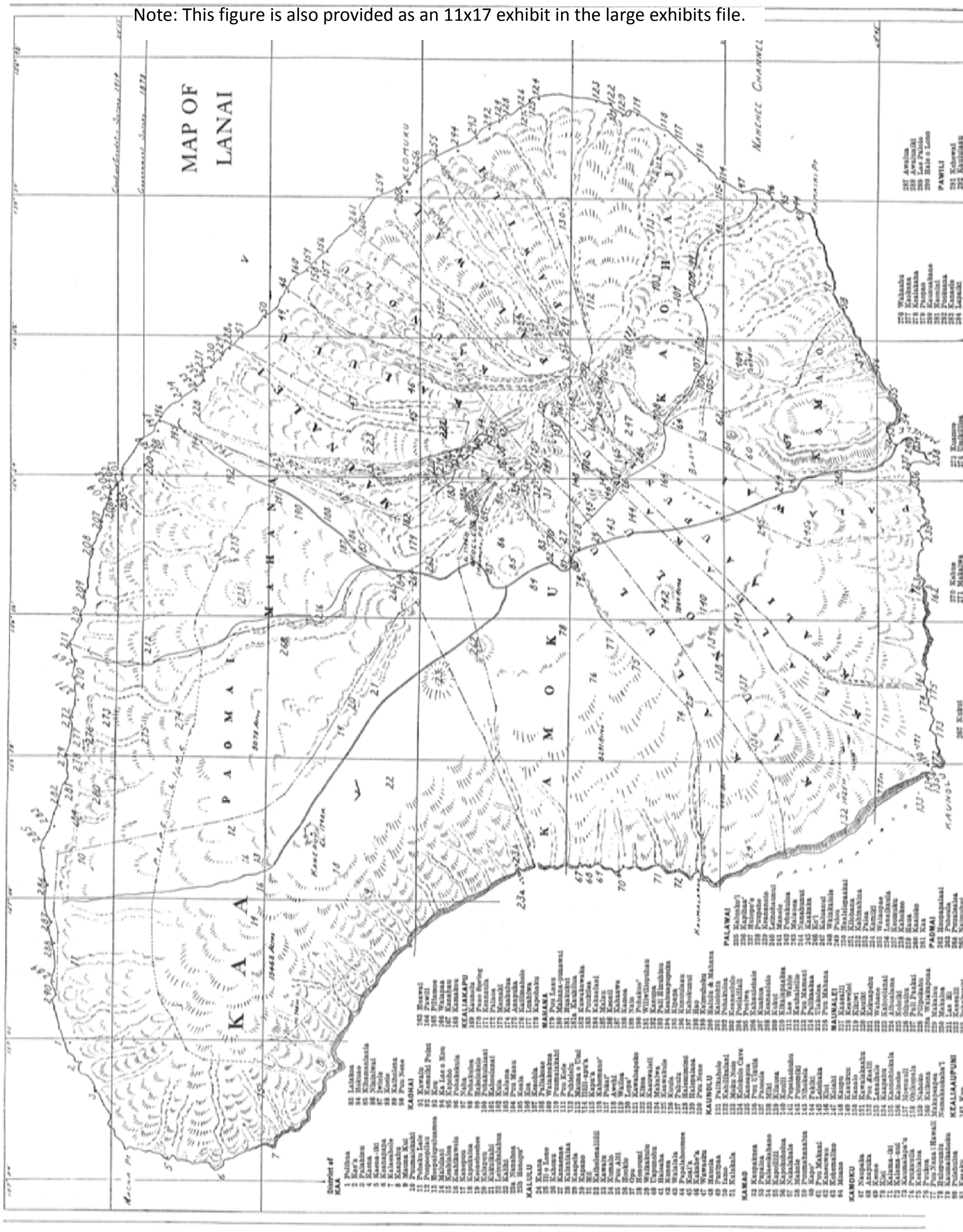


FIGURE 3-21. Water Place Names in Lana'i From Gazetteer of Lana'i in Emory, K.P.; *The Island of Lana'i, A Survey of Native Culture*; Bishop Museum Bulletin 12, Honolulu 1969 **-** *Springs or flowing water highlighted in cyan*

Partial List Lana`i Place Names Related to Water

Name	Meaning
Ai-lau	Leaf eating. Taro land in Maunalei, near Kaaealii, according to Namilimili.
Ana-iki	Little cave. Taro land in Maunalei (26a).
Awa-lua	Deep harbor (descriptive). Bay. 287.
Awa-lua-iki	Lesser Awalua (descriptive). Bay. 288.
Hale-aha	Assembly house (once descriptive). Taro land. Head of water tunnel. 41.
Hale O Lono	House of Lono (once descriptive?) Bay. A house of worship to Lono was a common form of heiau. 290.
Hauola	Healing water (descriptive?) Valley mouth. 48.
Hono-umi	Collecting place of Umi, ten stitches. Section of valley. Upper end of Maunalei Valley, against precipice. 38
Hono-wae	Bay. 286
Hua-wai	Water gourd. Bay. 163.
Hulopo'e	Name of a man (personal). Bay. Hulopo'e lived here. 237.
Iamo	A leap feet first into water. Beach. 50.
Ka'a-loko	Pond of Ka'a (descriptive). Bay, fish-pond. 260.
Kaa-pela	Rolling over soft grass (once descriptive). Plateau land. Site of a school house; old name of place close by is Mauipapahu. 29.
Ka-auwai-eli	The dug water course (once descriptive). Small valley mouth. 123.
Kahe'a	Fishing in shallow water (once descriptive?). Beach. 294.
Kahe-mano	Place where sharks habitually run (descriptive). Beach 294.
Ka-hili-ka-lani	Brushing the heavens (descriptive). Cliff. Highest point of Palikaholo and the slope of Kaumalapa'u. 132.
Ka-hoku-nui	The large star (once descriptive?). Beach. A meteor once fell nearby. 197.
Ka-hue	The gourd (once descriptive?). Bay. 270.
Kai-kena	Rustling sea (descriptive). Beach. 160.
Ka-imu-hoku	The star oven (descriptive). Beach. A pit in the sand where a meteor fell. 199.
Kai-nehe	Murmuring sea (descriptive). Beach. 156.
Kai-olohia	Choppy sea (descriptive). Bay. 201.
Kalua-ko'I	The adz pit (descriptive?). Bay. 235.
Kamakou	Lamp with red flame (Andrews), young kou grove (Thrum). Spring. Location approximate. 168
Kanahau	Disagreeable, cold. (descriptive). Spring. Gulch just south of Captain Soule's place. 167.
Ka-piha'a	The driftwood (descriptive). Bay. 236.
Ka-uhi-lua	The double veil (descriptive of rain). Taro land. 181a.
Kau-iki	The small portions (descriptive). Section of valley. This site now marked by a pump. 220.
Ka-ulu-laau	Name of the hero who killed the goblins of Lana'i (legendary). Beach. (See page 13 for story). 292.
Kau-mala-pa-u	Bay. The Kekoewa family say this name should be Kamuela-pa'u; but Mrs. Awili Shaw says that her parents and grandparents called the place Kau-molo-pa'u. None of these names can be translated with any meaning. 73.

FIGURE 3-21. Water Place Names in Lana‘i From Gazetteer of Lana‘i in Emory, K.P.; *The Island of Lana‘i, A Survey of Native Culture*; Bishop Museum Bulletin 12, Honolulu 1969 **-** *Springs or flowing water highlighted in cyan*

Kau-no-lu	To give property on a wager secretly, the akua of Molokai. Bay and district. In this word every vowel is accepted equally. Incorrectly given as Kaunalu and Kaonolu. 169.
Ka-wai-a-ka-ahu	Water of Kaahu. Spring. 151.
Ka-walu	The milk. Valley. 33.
Ka-walu	The milk. Valley mouth. 91.
Ke-ana-puka	The arch (descriptive). A sea cave. In his story of Puupehe, W. M. Gibson calls this cave Malauea. 201.
Ke-awa-kule	The bay of the kule fish (descriptive). Bay. 125.
Ke-awe-loi	Keawe making fun. Section of valley. Site of an old pump station. 218.
Kehe-wai	Rivulet (Mrs. Lahilahi Webb). Ridge. Ridge ending at Waiopae. 291.
Ke-kua-pehu	The swelling god. Small valley. 221.
Keone	The sand (descriptive ?). Bay. A little sand here. 69.
Ke-ono-hau	The six hau (trees). Small bay. 269.
Kiei	High. Bay. 70.
Kikiwi	Bending down (descriptive). Taro land. Kiki (26a).219.
Koa	Koa tree (descriptive). Plateau lands. Area covered by koa forest. 106.
Koai'a	A variety of koa tree (descriptive). Valley. Koai'a forest formerly at this place. 45.
Koai'a	A variety of koa tree (descriptive). Valley. Koai'a forest formerly at this place. 105.
Koele	Place seized by a chief (descriptive?). Village. Koele means also dry, but this is not a dry place. 88.
Kolo-kolo	Loud rumbling (descriptive). Sea cave. Freshwater is supposed to be obtainable here. 134.
Lae Hi	Flowing point (descriptive). Point. A point composed of limestone. 231.
Lana‘i-hale	House hump (descriptive metaphor). Highest point on Lana‘i and spring. Name of spring is Nanaihale. (See 19, p 516). 153.
Mahana-punawai	Spring of Mahana (descriptive). Spring. 181.
Malu-lani	Heavenly shade (legendary). Blend in ridge. Malulani, sister of Pele and Hi‘iaka dwelt here. 14.
Mamaki	Name of bush from which mamaki tapa was made. Old village site on coast. 173.
Mauna-lei	Wreath mountain (borrowed?). Village. From name of valley. 234.
Moena-uli	Blue mat. Beach. 157
Paao	The Kahuna, Paao (legendary). Well, tapu to women. 170. aka Paao Spring.
Pahulu	When the goblin Pahulu was killed by Kaululaau (legendary). Well. Rock lined well now in use. 127.
Pali-hinuhinu	Shining as if anointed with oil (descriptive). Cliff. 193
Po-kai-I	Name of a celebrity from Kahiki (Thrum) (legendary?). Old village site. Name of a land section on Oahu. 117.
Pookeana	Beach. 282.
Poo-lali-lali	Greasy head. Beach. 204.
Pulou	Covered out of sight (descriptive). Spring. Makakehau, lover of the girl, Puupehe, was killed here. 249.
Puu-kilea	Hummock hill (descriptive). Hill. Incorrectly given on government map as Puu Kukai. 183.
Puu-maia-kahi	Hill of dropping bananas (descriptive). Hill. Very prominent crater cone. Gibson, in story of Puupehe, refers to banana groves of Waiakeakua which is below this hill. 110.

FIGURE 3-21. Water Place Names in Lana'i From Gazetteer of Lana'i in Emory, K.P.; *The Island of Lana'i, A Survey of Native Culture*; Bishop Museum Bulletin 12, Honolulu 1969 **-** *Springs or flowing water highlighted in cyan*

Puu Nene	Goose hill (once descriptive). Hill. Feeding ground for geese. 90.
Puu Nene	Goose hill (once descriptive). Hill. Feeding ground for geese. 130.
Ua-punohu	Column of rain (descriptive). Section of valley. 40.
Wai-a-hoo-lai	Calm waters, or water of Hoolai. Beach. 293
Wai-a-ka-pua'a	Pig water. Valley mouth. 228a.
Wai-a-ke-akua	Water of the god (descriptive). Spring. There is another Waiakeakua in Waipaa gulch. 109.
Wai-a-ka-iole	Rat water. Valley. 248.
Wai-alala	Water of Lala, or glistening water (descriptive). Valley. Large tributory gulch to Maunalei on the east. Not Waialala, as given in Andrews Dictionary. 43.
Wai-a-opae	Shrimp polluting waters (Thrum) (descriptive). Valley mouth. 166.
Wai-a-paa	Held water (descriptive?). Valley. 166.
Wai-ka-kulu	Tumbling waters (descriptive). Valley. 39.
Wailoa	Long water (descriptive?). Beach. 119
Wai-lehua	Lehua water. Beach. A landing place on the north shore of Lana'i(19, p. 424)
Wawae-ku	Foot print (Thrum) (descriptive of shape). Hill. 47.
Wili-wili-opu-hau	Grunting of a horse (descriptive). Section of a ridge. At the water trough. A recent name. 191.

FIGURE 3-22. Historical Springs of Lana'i Source: A Survey of Native Culture, Bishop Museum Bulletin 12, Honolulu, 1969 - *Not all of the springs noted in this reference are plotted here. Some are beyond the extent of this map.*

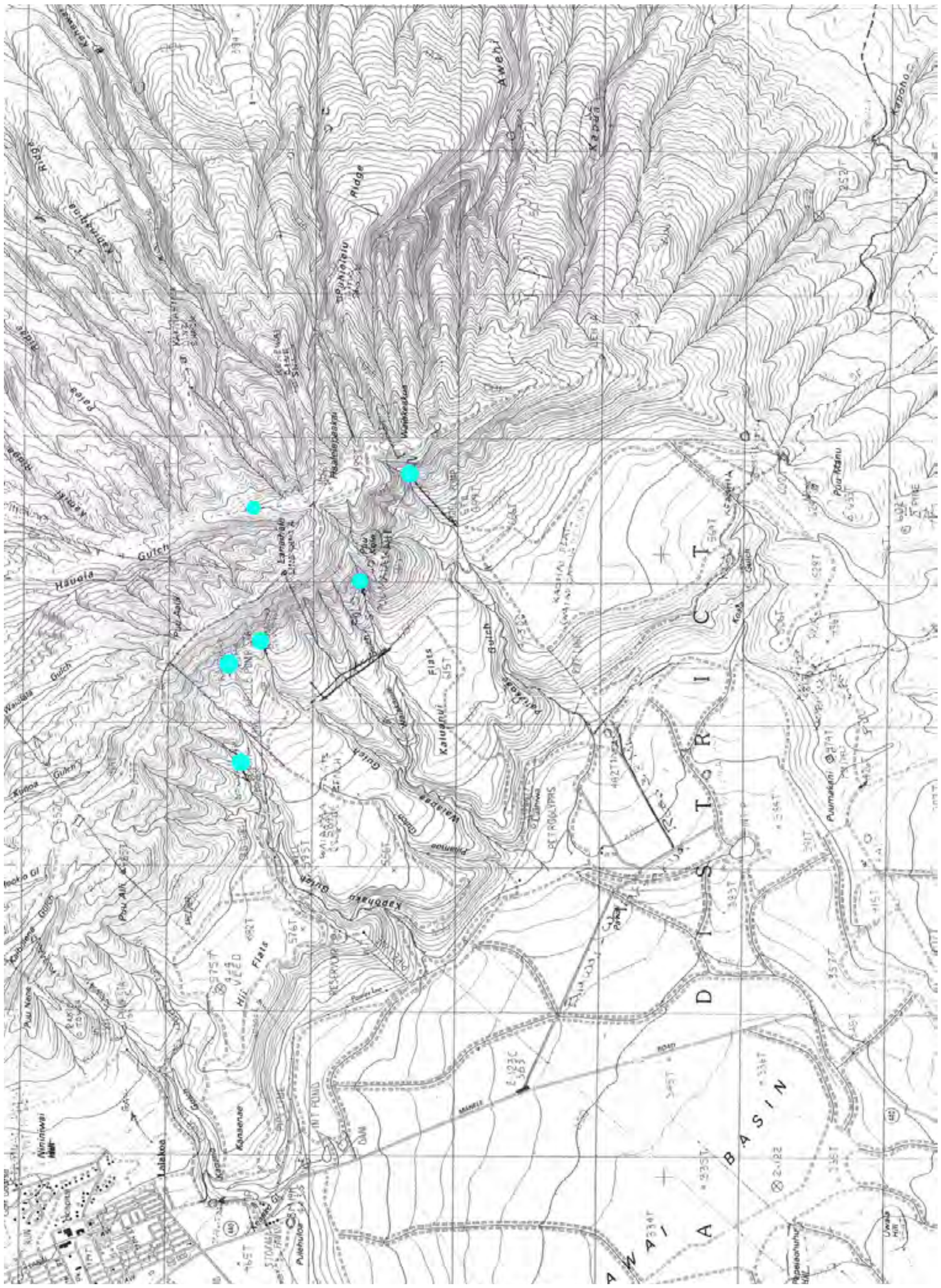
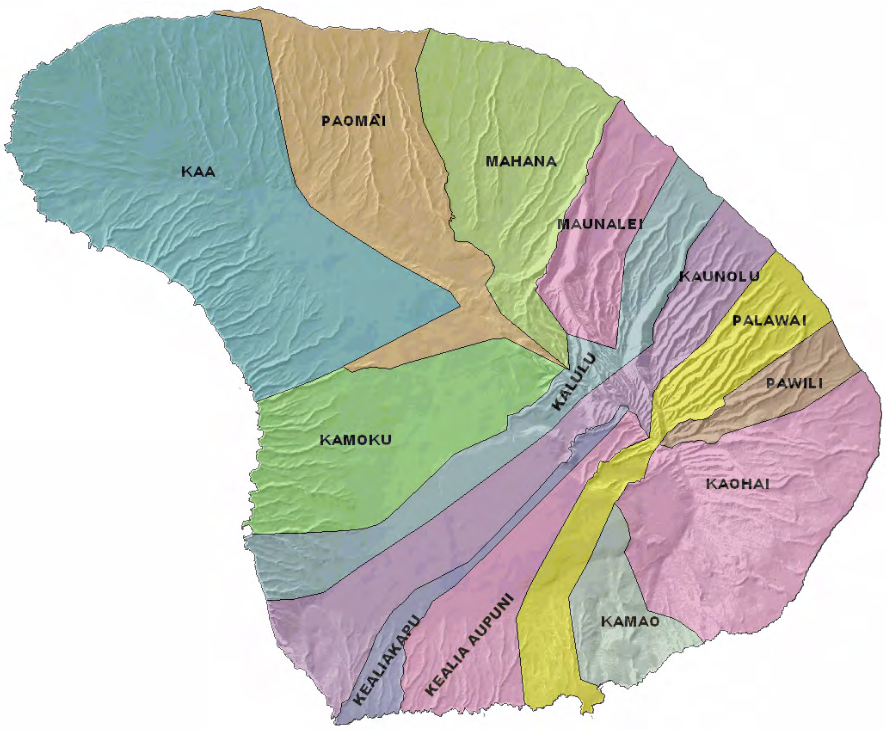


FIGURE 3-23. Ahupua'a of Lana'i - Source: Robert Hobdy



Ahupua'a

The thirteen ahupua'a that make up the island of Lana'i have been described in detail, with comments on place name meanings and traditional uses, in "*The Island of Lana'i: A Survey of Native Culture*" (K.P. Emory, 1924); "The Story of Lana'i" (G.C. Munro, 2007); and "E 'Ike Hou Ia Lana'i: To Know Lana'i Once Again: A Historical Reference and Guide to the Island of Lana'i" (Lana'i Culture & Heritage Center, 2008). The following notes from Kumu Pono Associates summarize their descriptions: (Source: *Kumu Pono Associates LLC, 2008)*

Ka'a (literally, the Rocky area): Ka'a is the largest ahupua'a on Lana'i, comprising some 19,468 acres. It makes up the entire northern end of the island, and hosted many near-shore settlements, from which the rich fisheries were accessed-the turtles of Polihua, once being an important resource of traditional subsistence. In addition to village sites, the near shore lands also hosted many ceremonial sites, including the largest heiau on the island. Near shore springs provided residents with water supplies, and in the uplands, the dry forest zone of the Keahiakawelo-Kanepu'u region supported an extensive dry land agricultural system. Keahiakawelo is one of the most significant storied landscapes on Lana'i, connected with traditions of how people were able to live on Lana'i, and why at one time, Lana'i was noted for purple colored lehua (Metrosideros) blossoms. During the Mahele, Chiefess Victoria Kamamalu, claimed and retained the ahupua'a of Ka'a. Uhu (parrot fish) was identified as the kapu fish, and koko (Euphorbia spp.), identified as the kapu tree. Four awarded kuleana claims were noted in Ka'a.

Kalulu (literally, The shelter): Containing 6,078 acres, Kalulu is one of three unique ahupua'a divisions on Lana'i. On the (kona) leeward side of the island, Kalulu is bounded by Kamoku on the north. It then runs across the island, passing the western banks of Palawai Basin, up the mountain, and then continues to the (ko'olau) windward coast, bounding Maunalei on the north. Along its southern boundary, on both the leeward and windward regions, Kalulu is bounded by Kaunolu Ahupua'a. The leeward and windward coasts of Kalulu take in two significant fisheries-one being a part of the deep sea fisheries of Kaholo (shared with Kaunolu), and the other being the near shore reef-lined fisheries of the windward coast. In the Palawai Basin and mountain lands were extensive agricultural fields, ranging from open kula lands noted for sweet potato plantings, to forest-sheltered dry land field systems. The forest resources included stands of koa and other native woods, and small valleys and gulches where water sources were found. Daniel I'i claimed Kalulu as his personal property during the Mahele, but relinquished it to the King, who retained it as a Crown land. He'e (octopus) was the kapu fish, and 'ahakea (Bobea) was the kapu wood. Seven awarded kulaena claims were noted in Kalulu.

Kama'o (literally, The ma'o (Gossypium tomentosum) plant): Kama'o Ahupua'a is a southerly facing land division, that is bounded by Palawai on the west and Ka'ohai on the east. Comprising 2,751 acres, Kama'o includes two-thirds of Manele Bay. This bay was the site of a major canoe landing-sandy beach, and was watered by springs, some of which were tapped by diving along the shore with gourds to catch water as it escaped from holes in the caprock. The village of Manele (shared between Palawai and Kama'o Ahupua'a) was a major complex on the coast, with residences, ceremonial sites and lowland agricultural features. In the uplands, native tenants also tended dry land crops, and a major nesting area of 'ua'u (petrels) occurred on the upper slopes which the natives tended, and from which they harvested birds as a source of protein. One of the noted mountain heiau on Lana'i and a major burial site also occur in the upper section of Kama'o. Three place names in Kama'o also bear the name "Kapo," a Hawaiian goddess. One site in the uplands, and two forming coves on the shore. The chief Kahanaumaika'i claimed Kama'o as a personal property, but relinquished it to the Government Land Inventory during the Mahele. He'e (octopus) was the kapu fish, and koko (Euphorbia spp.) was the kapu wood. Two awarded kuleana claims were noted in Kama‘o.

Kamoku (literally, The district): Kamoku Ahupua'a contains 8,291 acres, and is situated on the kona (leeward) side of Lana'i. On the north, it is bounded by Ka'a Ahupua'a. On the south, it is bounded by Kalulu Ahupua'a. Kamoku was noted for its upland forest and springs, with areas developed into an extensive forested dry land agricultural system. Along the shore, its sheltered coves were developed into temporary and long-term residences, from which the rich fisheries fronting the ahupua'a were accessed. At the time of the Mahele, Pali was the Konohiki of Kamoku under the King, and the ahupua'a was retained as a Crown Land. Uhu (parrot fish) was the kapu fish, and koko (Euphorbia spp.) was the kapu wood. The important spring watered bay of Kaumalapa'u (an 'ili of Kamoku) was claimed by Oleloa, a woman of chiefly lineage, but relinquished to the government during the Mahele. One awarded kuleana claim was noted in Kamoku.

Ka'ohai (literally, The Sesbania tomentosa plant): Situated in the southeastern region of Lana'i, Ka'ohai contains 9,677 acres. The coastal zone hosted villages and rich fisheries, including fishponds. Springs were developed to supply water along the coast, and the upper valleys provided seasonal water sources. A major spring in the mountain lands also provide upland residents with water for personal use and agricultural purposes. In the years leading up to the Mahele, Chiefess Kekau'onohi claimed Ka'ohai as a personal land. But during the Mahele, Ka'ohai was claimed by Mataio Kekuana'oa, on behalf of his son, Moses Kekuaiwa. The award was confirmed and recorded by the King. He'e (octopus) was the kapu fish, and naio (Myoporum sandwicense) was the kapu wood. Kekuaiwa died prior to closure of the Mahele, and his father received the award in his name. Upon Kekuana'oa's death, Cheifess Ke'elikolani inherited the ahupua'a. Two awarded kuleana claims were noted in Ka‘ohai.

Kaunolu (meaning uncertain): Kaunolu Ahupua'a, like it's northern neighbor, Kalulu, spans both the kona and ko'olau regions of Lana'i. It contains 7,860 acres, and extends from the noted deep sea fishery of Kaholo, passes the steep sea cliffs of Pali Kaholo, crosses through the Palawai Basin, ascends the mountain to Pu'u Ali'i, one of the major peaks of Lana'i Hale, and then continues to the ocean on the windward shore. The leeward coast of Kaunolu hosts the major religious, political and social center of Lana'i, and was supplied by water sources in the Kaunolu-Kealia Kapu gulch. In the basin, a spring occurred at Pu'u o Miki, to which the gods resorted. Further inland, the bench lands and forest zone provided shelter for extensive residency and agricultural pursuits, while the deep valleys and mountain lands provided residents with springs and forest resources. Another of the major mountain heiau occurred in the leeward forest zone. On the windward side Kaunolu shared Hauola Gulch (in which water flowed seasonally), with Kalulu, and extended down to the shore where springs and rich reef-sheltered fisheries supported the native tenants. On its eastern, windward side, Kaunolu is bounded by Palawai Ahupua'a to the mountain peak of Lana'i Hale, where it joins with Kealia Aupuni, Kealia Kapu, and then continues down the mountain, through forest and basin, to the ocean. Kaunolu was originally claimed by Keali'iahonui, but relinquished to the Government Land inventory. No specific records documenting the kapu fish and wood were found for Kaunolu. Traditional accounts do celebrate the kawakawa fisheries of Kaholo, along with documentation of a wide range of other fishes known to the region. Thirteen awarded kuleana claims were noted in Kaunolu.

Kealia Aupuni (literally, The salt beds of the people/nation): This ahupua'a contains 4,679 acres. On its western side, it adjoins Kealia Kapu, and on its eastern side it is bounded by Palawai. It extends from the ocean to the mountain, taking in fisheries, open kula lands that were formerly cultivated, a portion of the basin, bench lands and mountain forest. Along the coast, each little gulch that forms a cove on the ocean is host to formal villages and temporary fishing camps which were used seasonally over the centuries. In the deep mountain gulches springs occurred, and both stone and forest resources were collected. At its summit, Kealia Aupuni meets Pu'u Ali'i and Lana'i Hale. Within the boundaries of Kealia Aupuni there also occurs a lele (an independent land division), which belongs to Pawili Ahupua'a (an ahupua'a found on the windward side of Lana'i). This lele provided residents of Pawili with fertile kula lands that supported dry land sweet potato cultivation. During the Mahele, Kealia Aupuni was relinquished by Kahanaumaika'i to the King, and in turn conveyed to the government inventory. Uhu (parrot fish) was the kapu fish, and koko (Euphorbia spp.) was the kapu wood.

Kealia Kapu (literally, The restricted salt beds): A small ahupua'a, containing 1,829 acres, situated on the kona side of Lana'i. Kealia Kapu is bounded on the west by Kaunolu, and on the east by Kealia Aupuni. Small villages occurred along the shore, where the adjoining western valley also hosted a spring. The kula lands of the basin were noted for sweet potato cultivation, and in the uplands mountain springs provided tenants with water for drinking and irrigation of crops. One point of traditional significance of Kealia Kapu is that it was reportedly the pu'uhonua (place of refuge) on Lana'i. In the uplands of Kealia Kapu a rain-making heiau is found, and a major petroglyph field also occurs. Uhu (parrot fish) was the kapu fish. No kapu wood was recorded by Ka'eo. During the Mahele, Kealia Kapu was claimed by and awarded to the chief, Ka'eo.

Mahana (literally, Warmth): Mahana Ahupua'a contains 7,973 acres, and makes up the central, northern section of the island. Extending from the reef-banked fisheries to the upland forests, Mahana is bounded by Maunalei on the east, and by Paoma'i on the west. Mahana was watered by a number of springs, seasonal streams and near-shore wells. Villages and areas of residence occurred along the coast, on the kula-middle lands and in the forest-mountain region. Ceremonial sites and other cultural features occur across the ahupua'a, and at one time it was host to an expansive dry land forest which was famed for its grove of purple-blossomed lehua trees (the latter of which was exterminated as a result of goat depredation). During the Mahele, Mahana was claimed by William C. Lunalilo, but was relinquished to the Government land inventory. The kapu fish was he'e (octopus), and the kapu wood was 'ahakea (Bobea). Six awarded kuleana claims were noted in Mahana.

Maunalei (literally, Mountain garland): Maunalei Ahupua'a holds the distinction of being the only land on Lana'i where a stream flowed year round. Deep in the upper valley and gorges, dense forest growth once captured rains from the clouds (thus the name, "Mountain garland," describing the cloud banks which nestled the mountain like a lei), and fed small streams that irrigated lo'i kalo (taro pond fields) into the late1800s. Maunalei contains 3,342.38 acres, and on its west side is bounded by Mahana Ahupua'a, while on the east and south sides, it is bounded by Kalulu. Native tenants lived upon and utilized most flat and gently sloping areas of Maunalei, with several major villages occurring along the coast, where springs were also found. Smaller settlements of single and extended families occurred in the uplands, and ceremonial sites occurred at various locations in the ahupua'a. Kamehameha I granted Maunalei to the foreigner, John Young, out of gratitude for service Young had provided him during his quest to unify the islands. In the settlement of John Young’s estate, Maunalei was given to his daughter, Pane (Fanny) Kekelaokalani. In the Mahele, the title of Maunalei was confirmed to Pane, and her kapu fish was he'e (octopus), the kapu tree was kukui (Aleurites moluccana). Pane Kekelaokalani bequeathed Maunalei to her daughter, Queen Emma Kaleleonalani, whose estate sold the ahupua'a to Walter M. Gibson in 1886. Although records note at least 71 claims to lo‘i kalo and one ‘auwai, only twelve awarded kuleana claims were noted in Maunalei.

Palawai (literally, Fresh water moss): The ahupua'a of Palawai is the third of three ahupua'a on Lana'i that spans both the kona (leeward) and ko'olau (windward) sides of the island. It contains 5,897 acres, hosted fisheries (including fish ponds), kula (dry land) agricultural field systems, forest resources, and numerous fresh water sources with springs and intermittent streams. In the near shore sections of Palawai, potable water sources were developed, and villages established all along the coast. On the leeward side, Palawai is bounded by Kealia Aupuni on the west, and by Kama'o on the east. At the mountain top, Palawai shares the highest peak, Lana'i Hale (site of a traditional spring), as a boundary point, and adjoins Kaunolu and Pawili, from the mountain to the windward coast. The basin region of Palawai Ahupua'a was also the site of the first foreign settlement on Lana'i in 1854, in the form of the original Mormon colony in Hawai'i. During the Mahele, Palawai was awarded to Chiefess Kekauonohi, and later inherited by her husband, Ha'alelea. The kapu fish was anae (mullet) and the kapu wood was 'ahakea (Bobea). Seven awarded kuleana claims were noted in Palawai.

Paoma'i (literally, Sick Pao): Paoma'i, situated in the northern region of Lana'i, contains 9,078 acres, and is bounded by Mahana on the east, and Ka'a on the west. The ahupua'a extends from the reef-lined fisheries, across the kula lands, and into the forest region. Major villages occurred along the coast, where access to fisheries, and near shore water sources sustained the people. On the kula lands a significant portion of the Lana'i dry forest occurred, and gulches hosted potable water that could be collected seasonally. In the uplands, the forest cover supplied people with access to necessary resources for daily life, and sheltered cultivated of crops. Several places in the uplands of Paoma'i were noted as gathering places for chiefly and community events. At the outset of the Mahele, Paoma'i was identified as belonging to the King, though Charles Kana'ina made a claim for the ahupua'a on behalf of his son, William C. Lunalilo. The kapu fish was he'e (octopus), and the kapu wood was 'aiea (Nothocestrum). At the close of the Mahele, no specific title was listed for Paoma'i, but it later appeared in the Government land inventory, and was sold as a Royal Patent Grant.

Pawili (literally, Strike and twist, as of the wind): The ahupua'a of Pawili (also written Paawili), is on the eastern (windward) side of Lana'i, and contains 1,930 acres. Pawili extends from the ocean to the mountain, where it meets Ha'alele Pa'akai, the second highest peak on Lana'i. Pawili is bounded on the south by Ka'ohai, and on the north by Palawai Ahupua'a. It also contains the only formal "Lele" (a detached land division, taking up a portion of another ahupua'a) recorded on the island of Lana'i. The lele of Pawili is situated in the ahupua'a of Kealia Aupuni, and afforded the people of Pawili with fertile lands in the Palawai Basin for the cultivation of crops like sweet potatoes. Along the coast of Pawili, which included an important reef-sheltered fishery, there occurred several villages, one of the major heiau on the island, and other ceremonial sites. Springs and wells were developed in the coastal region, and the deep valleys at the back of Pawili provided seasonal water sources as well. During the Mahele, William C. Lunalilo claimed Pawili, but relinquished it to the Government land inventory. No record of a kapu fish or wood was found in the historical documents. One awarded kuleana claim is noted in Pawili.

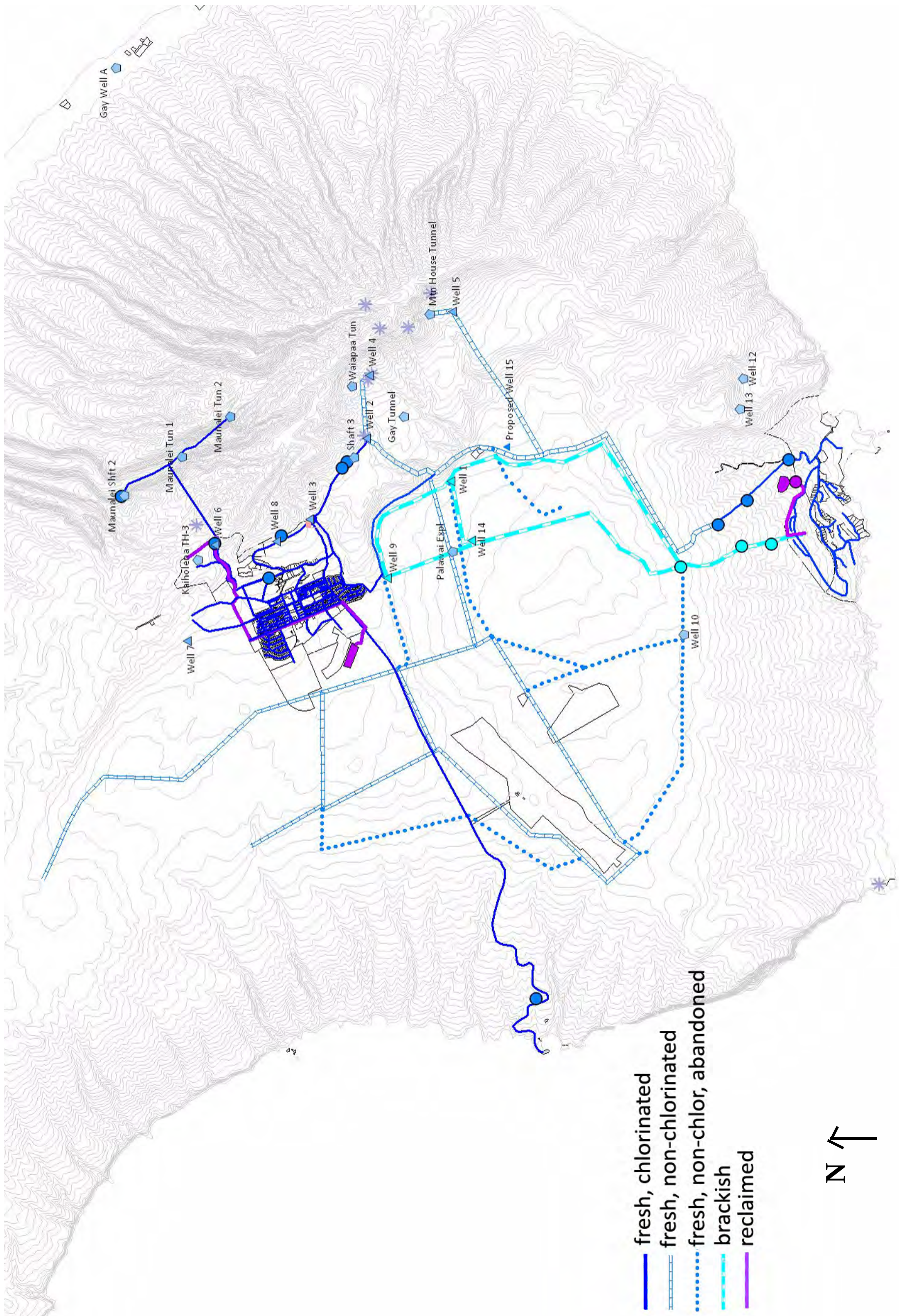
The total land area of these thirteen ahupuaa is 88,853.38 acres.

Water Systems

Lanaʻi has five water systems. Two potable water systems, Lanaʻi City to Kaumalapau (PWS 237) and Manele, Hulopoʻe and the Palawai Irrigation Grid (PWS 238), are regulated both by the State Department of Health under the Safe Drinking Water Act, and by the Public Utilities Commission (PUC). Potable water rates for these systems have not been updated since June of 1996. Shortly before finalization of this draft, in July of 2009, the Lanaʻi Water Company received an Amendment to its Certificate of Public Convenience and Necessity, pursuant to §269-7.5 HRS, to provide non-potable water service in Manele-Hulopoʻe, as well as to set rates, rules and regulations. There are also two reclaimed water systems. One, Manele Water Resources, LLC, obtained a Certificate of Public Necessity and Convenience from the PUC to deliver reclaimed water for irrigation in the Manele-Hulopoʻe area, and was able to set rates in March of 2007. The other remains non-regulated and serves only the Koele Golf course. In addition to these five systems, "Lanaʻi Holdings, Inc." (LHI) is a private, non-regulated water company which consists of the potable and brackish sources serving these utilities, as well as Castle & Cooke designated uses on any of the above systems. The potable and brackish systems are wholly owned subsidiaries of LHI.

The following schematic, Figure 3-24, shows the approximate alignment of pipes, tanks and wells of the Lanaʻi water systems.

FIGURE 3-24. Schematic Layout of Lana'i Water Systems. Blue is Potable, Aqua is Brackish, Purple is Reclaimed



Notes: This figure is also provided as an 11x17 exhibit in the large exhibits file. Since completion of the review draft in October, 2009, the chlorination point for Manele & the Palawai Irrigation Grid has been moved from Breaker #1 up to the Hi'i Tank site.

The five water systems on Lana'i collectively serve about 1,573 meters. Water rates for the potable systems are $1.10 for the first 25,000 gallons, and $1.62 thereafter. Water rates for the brackish system are $3.57 for the first 1,000 gallons per day, $4.64 for 1,000 to 2,500 gallons per day, and $5.72 above 2,500 gallons per day. Sewer rates are charged by unit, at a rate of $56.74 per single family, $42.21 per multi-family, and $92.12 per hotel unit. Non-food commercial customers are charged $9.98 per 1,000 gallons, while those that serve food are charged $10.07. The Harbor is charged $10.05 per thousand gallons.

Key system facilities issues include: the need for backup sources to meet reliability criteria and distribute withdrawals; the age and condition of the system; leaks and high pressures in certain areas - especially the irrigation grid; frequent loss of service in the MECO/Miki Basin area; the need for improved monitoring and maintenance; and the small customer base to support the necessary improvements and replacements.

Source capacity of each system is listed in Figure 3-25 below, and in more detail in Figure 3-26. System Standards require that sources be able to meet maximum day demand with an operating time of 16 hours simultaneously with maximum fire flow required independent of the reservoir, assuming the largest pump is down. The standby unit may be used to determine the total flow required. The system should also be able to provide for maximum day demand while simultaneously providing water for a two hour fire for the highest zoning density served, with credit given for 3/4 of reservoir storage.

Maximum day demand is defined as 1.5 times average day demand. The standard means that there should be sufficient source capacity to meet one and a half times average demand plus fire, essentially with 2/3 installed capacity. So, in order to meet system standards, about 2.25 times average day demand in source must be installed. Stated another way, about 44% of the full installed capacity, less the largest unit, should meet or exceed average day demand. With Well 3 down, Lana'i City fell short of pump capacity standards by 256,113 GPD in 2008. However, with the 2 MG tank, there was adequate fire protection.

FIGURE 3-25. System Capacities

System Area	Installed Capacity	2/3 Installed Capacity	Avg Day Metered Demand 2008	Max Day Demand 2008
Koele, City , K'pau Potable	2,016,000	1,344,000	522,742	784,113
Less Largest Pump	792,000	**528,000**	522,742	**784,113**
Manele Potable w/Well 2/Shaft 3	3,024,000	2,016,000	375,146	562,719
Less Largest Pump	1,296,000	**864,000**	375,146	**562,719**
Manele Brackish golf course & landscape	1,353,600	902,400	760,357	1,140,536
Less Largest Pump**	864,000	576,000	760,357	1,140,536** (N/A)

** The system standard which requires meeting maximum day demand in 16 hours pumping with the largest pump out only applies to potable systems, or systems serving livestock, and so would not apply to Manele brackish irrigation. The information is included here only to indicate the potential irrigation shortfall if a pump went out.

FIGURE 3-26. Source Capacities By District and Island-wide

Installed and Standard Source Capacities By District

Lana`i City, Koele & Kaumalapau		**Manele, Hulopo`e, Palawai, Irrigation Grid**		**Brackish - Manele, Irrigation Grid, Others**	
Source	**GPM**	**Source**	**GPM**	**Source**	**GPM**
Well 6	550	Well 2/ Shaft 3*	1,200	Well 1	340
Well 7	NIU	Well 3**	"550/OOS	Well 9	300
Well 8	850	Well 4	900	Well 12	NIU
Maunalei - Shaft 2	NIU	Well 5	NIU	Well 14	300
Tunnels	NIU	** Well 2/ Shaft 3 pump to be replaced with smaller pump*			
Well 3 (could serve either way)	550/OOS	*** Well 3 could serve either direction, Lana`I City or Manele & IGGP. However, it is out of service & will be replaced.*			
Total GPM	1,400	Total GPM	2,100	Total GPM	940
Total GPD Wells		**Total GPD Wells**		**Total GPD Wells**	
Total Lana`i City, Koele & Kaumalapau	2,016,000	Total Manele and IGGP	3,024,000	Total Brackish	1,353,600
Largest Pump Out	792,000	Largest Pump Out	1,296,000	Largest Pump Out	864,000
Max Day Capacity*		**Max Day Capacity ***		**Max Day Capacity ***	
2/3 Installed Less Largest Pump	528,000	2/3 Installed Less Largest Pump	864,000	2/3 Installed Less Largest Pump	576,000
Average Day Capacity **		**Average Day Capacity ****		**Average Day Capacity *****	
2/3 of 2/3 Installed Capacity less largest pump	**352,000**	2/3 of 2/3 Installed Capacity less largest pump	**576,000**	2/3 of 2/3 Installed Capacity less largest pump	**384,000**
Effluent				**Effluent**	
Lana`i City WWTF - R-3	500,000			Manele WWTF	140,000
Lana`i City Auxilliary WWTF R-1	400,000				
Total Koele, City and Kaumalapau	2,416,000	Total Manele & IGGP	4,377,600	Total Manele & IGGP	4,377,600
Total City, Koele, Kaumalapau Potable	2,016,000	Total Manele Potable	3,024,000	Total Manele & IGGP Brackish	1,353,600
Total **Potable** - Standards	**352,000**	Total **Potable** - Standards	**576,000**	Total **Brackish** - Standards***	**384,000**
				Installed Capacity	
* Statewide System Standards indicate that a system should meet max day demand (=Avg Demand x 1.5)				Total All Island Potable	5,040,000
PLUS fire flow in 16 hours pumping, with the largest pump out. Referred to as Max Day Capacity above.				Total All Island Brackish	1,353,600
** This means that 2/3 of the above should be able to meet Average Day Demand				Total All Island Effluent	540,000
*** Standards only apply to brackish water if people or animals depend upon them.				Total All Island	6,933,600

Reservoirs and storage should be sized to meet maximum day demand plus the highest applicable fire flow for a presumed two hour fire. A table of storage is shown in Figure 3-28.

Overall system capacities are summarized in Figure 3-27, below.

Developed & Utilized Resources - System Infrastructure

FIGURE 3-27. Summary of System Capacities and Use

Lanaʻi City, Koele and Related Areas	**MGD 2008**
Total Installed Capacity	2.416
Installed Capacity of Potable Sources	2.016
Average Fresh Water Use	0.523 metered / 0.605 pumped
Average Reclaimed Use	0.209 to Koele Golf Course
Capacity of Brackish Sources in Use	0.000
Capacity of Reclaimed Water Facilities	0.400
Average Effluent Production	0.235
Potable Storage	2.786
Non Potable Storage	16.8 active / 22.8 total
Approximate Miles of Pipeline	35.59 miles

Manele, Hulopoʻe and Related Areas	**MGD 2008**
Total Installed Capacity	4.518
Installed Capacity of Potable Sources in Use	3.024
Average Potable Use	0.375 metered / 0.683 pumped
Average Brackish Use	0.760 metered / 0.944 pumped
Average Reclaimed Use	0.073 wtf production
Capacity of Brackish Sources in Use	1.354
Capacity of Reclaimed Water Facilities	0.140
Average Effluent Production	0.073
Potable Storage	2.000
Non Potable Storage	17.85 active / 19.35 total
Approximate Miles of Pipeline	43.04 miles*

(*Estimate does not include roughly 14.81 miles of abandoned or out-of-use pipeline in the Palawai Irrigation Grid)

FIGURE 3-28. Lana'i Tanks and Storage

TANK NAME	TANK CAPACITY IN MG	SPILLWAY ELEVATION	GROUND ELEVATION	YEAR BUILT	TANK MATERIAL	USE	Cl2 SITE	COMMENT
Lana`i City, Koele & Kaumalapau								
Maunalei Tank	0.030		1017	1992	Steel	Potable - PWS 237	N	*Not In Use*
Koele Tank	0.750	2057	2025	1995	Bolted Steel w Glass Fused Coating	Potable - PWS 237	N	SCADA
Lana`i City - Niniwai Tank		1878	1830	1951	Steel	Potable - PWS 237	N	*2 MG Not In Use*
New Lana`i City Tank	2.000	1980	1942	2008	Bolted Steel w Glass Fused Coating	Potable - PWS 237	N	Chlorinated at Well 6
Kaumalapau Tank	0.022		360	1992	Bolted Steel w Glass Fused Coating	Potable - PWS 237	Y	
Lana`i AWWTF R-1 Reservoir	10.000		1518.5			Non-Potable - Effluent		
Koele Clubhouse Lake 1	1.900		1761			Non-Potable - Effluent		Passive
Koele Clubhouse Lake 2	0.900		1741			Non-Potable - Effluent		Passive
Koele 8th Hole Lake/Reservoir	2.000		1739			Non-Potable - Effluent		
Koele 9th Hole Lake/Reservoir	1.100		1746			Non-Potable - Effluent		
Koele 13th Hole Lake/Reservoir	0.900		1991			Non-Potable - Effluent		
Koele 2nd Hole Lake/Reservoir	1.5					Non-Potable - Effluent		
Koele 3rd Hole Lake/Reservoir - Tee	0.900					Non-Potable - Effluent		
Koele 3rd Hole Lake/Reservoir - Green	0.400					Non-Potable - Effluent		
Koele 6th Hole Lake/Reservoir	1.300					Non-Potable - Effluent		
Koele 17th Hole Lake/Reservoir	0.400		1822			Non-Potable - Effluent		
Koele 18th Hole Lake/Reservoir	1.500		1746			Non-Potable - Effluent		
Potable Storage	**2.802**							
Non Potable Storage	22.800							Including Passive
Non Potable Active Storage	**16.800**							
Manele, Hulopo`e and Portions of Irrigation Grid								
Hi`i Reservoir	1.000	1823	1810.2		Concrete Lined		N	PE Cover
Hi`i Tank	0.500	1823.5	1791.5	1952	Welded Steel	Potable - PWS 238	N	
Manele Breaker Tank 1	0.100	1141	1127	1987	Bolted Steel w Glass Fused Coating	Potable - PWS 238	Y	Chlorination Site
Manele Breaker Tank 2	0.100	755.8	742	1987	Bolted Steel w Glass Fused Coating	Potable - PWS 238	N	
Manele Breaker Tank 3	0.300	341	326	1987	Bolted Steel w Glass Fused Coating	Potable - PWS 238	N	
Wells 9 & 1 Control Tank	0.050	1434.5	1420.5		Steel	Non-Potable - Brackish		Abandoned
Palawai Brackish Reservoir	15.000	1211	1239		Lined	Non-Potable - Brackish		
Effluent Reservoir	2.800		275		Lined	Non-Potable - Effluent		
Manele GC Pond	1.500		250			Non-Potable - Effluent		Passive
Potable Storage	**2.000**							
Non-Potable Storage	19.350							Passive
Non-Potable Active Storage	**17.850**							

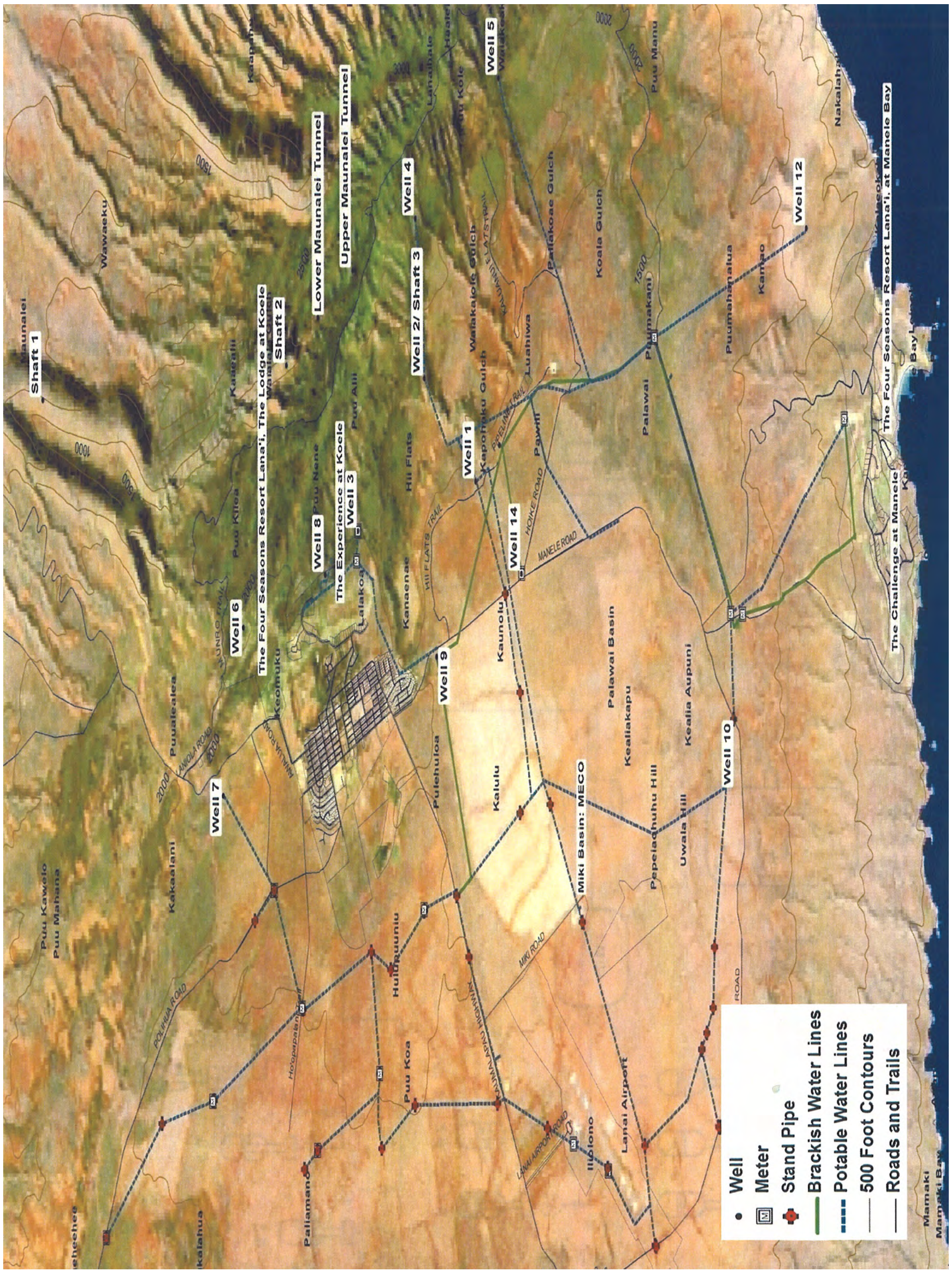
FIGURE 3-29. Lanaʻi Pump Inventory - Source

Well / Source	Pump & Motor Description	Pump Elevation	GPM	Calibrated GPM	24 Hrs	16 Hrs	44.44%	2008 Actual MAV in GPD	Character
6	Submersible Byron Jackson 23 Stage, 1800 RPM, 2500 V with 200 HP Type H 14" Motor installed 2006	863	550		792,000	528,000	352,000	327,912	Potable Drilled 1986
7								0	Proposed Potable Drilled 1987 **Not In Use**
8	Submersible Byron Jackson 11 MQH, 20 stage, 1800 RPM with 300 HP Type H, F1 Amp 74 Motor 2300 Volts	782	850	816	1,224,000	816,000	544,000	276,890	Potable Drilled 1990 pump lowered to 783' 09/09
2	Vertical Turbine Fairbanks Morse Pomona 3 Stages, 1780 RPM with 75 HP Ingersoll Rand Booster FL Amps 90 voltage 480 Frame-L365TP	1,335	1,200	1,152	1,728,000	1,152,000	768,000	2,418	Potable Drilled 1946 ***Rarely Used Confined Space Issues***
3	Submersible Byron Jackson #781-5-1808 22 Stage 1800 RPM 23 stage w/Byron Jackson Type H 300 HP 14" Motor	866						0	Potable Drilled 1950 **Out of Service**
4	Submersible Byron Jackson #841-S-0046, 13MQH, 15 stage, 1800 RPM with Byron Jackson Type H 300 HP 14" Motor Amp 74 2300 Volts	1,253	900	864	1,296,000	864,000	576,000	683,867	Potable Drilled 1950 Out of Service
5		1,293						0	Potable Drilled 1950 **Out of Service**
1	Submersible Crown 340 GPM 9 Stage, 3,470 RPM, with Hitachi 100 HP Motor Installed 2005	516	340	300	489,600	326,400	217,600	393,981	Brackish Drilled 1945
9	Submersible Byron Jackson 16 stage 600-4114-931-R-005 6 MQH 3600 RPM w Franklin Electric 100 HP Motor Installed 2005 F1-Amp-148 480 Volt	466	300		432,000	288,000	192,000	151,440	Brackish Drilled 1990
12		-5						0	Brackish Drilled 1990 **Not In Use**
14	Submersible Byron Jackson Hitachi 125 HP Motor Installed 2003	400	300		432,000	288,000	192,000	404,714	Brackish Drilled 1995
		----------	----------		----------	----------	----------	----------	
	Source Capacity		4,440		6,393,600	4,262,400	2,841,600	2,241,222	

FIGURE 3-30. Lana'i Pump Inventory - Boosters and Totals

Boosters									
Maunalei	Byron Jackson Can Type Vertical Booster 11LQ 3600 RPM 6 Stages with Vertical Solid Shaft 20 HP 3600 RPM 444 VP Frame WP-1 Enclosure 225 Amp F1	481						0	Potable Booster Quasi-Source **Out of Service**
Well 2 / Shaft 3 Booster	Ingersoll Rand Booster Pump 40 HP								Potable Source **Rarely Used**
Manele SPS A - 2 Pumps	Dual submersible pumps. 18 HP constant speed motor at 91' Total Dynamic Head (TDH). Located at Road E. Pumps to SPS B.		295	ea.	424,800	283,200	188,800		Effluent Booster
Manele SPS B - 2 Pumps	Dual submersible pumps. 120 HP at 240' TDH. Located at Manele Terrace Subdivision. Pumps to SPS #2.		490	ea.	705,600	470,400	313,600		Effluent Booster
Manele SPS # 1 - 2 Pumps	Dual dry pit pumps. 75 HP at 190' TDH. Located at Hulopo`e Park. Pumps to SPS # 2.		550	ea.	792,000	528,000	352,000		Effluent Booster
Manele SPS # 2 - 2 Pumps	Dual dry pit pumps. 75 HP at 180' TDH. Located near the entrance to Manele Resort. Pumps to SPS # 3.		550	ea.	792,000	528,000	352,000		Effluent Booster
Manele SPS #3 - 2 Pumps	Dual dry pit pumps. 75 HP at 180' TDH. Located just below the sewage treatment plant, along the access road. Pumps to the headworks of the sewage treatment plant.		550	ea.	792,000	528,000	352,000		Effluent Booster
Koele WW - Green 4	Sim Flo 40 HP	1,992	1100	280	403,200	268,800	179,200		Effluent Booster
Koele WW - Green 17	Sim Flo 40 HP	1,748	800	280	403,200	268,800	179,200		Effluent Booster
		----------	----------	----------	----------	----------	----------	----------	
			4,335		4,312,800	2,875,200	1,916,800	0	
			8,775		**10,706,400**	**7,137,600**	**4,758,400**	**2,241,222**	
	Subtotal Potable In Use		**3,500**		**5,040,000**	**3,360,000**	**2,240,000**	**1,291,087**	
	Subtotal Brackish in Use		**640**		**1,353,600**	**614,400**	**409,600**	**545,421**	
	Subtotal Wastewater In Use		**3,535**		**3,909,600**	**2,606,400**	**1,737,600**		

FIGURE 3-31. Photo Schematic of Lana‘i Water Systems, Courtesy of Lana‘i Water Company, Inc.



Lana‘i City Water System - Potable Uses

The Lana‘i City Water System serves Koele, Lana‘i City and Kaumalapau. The system has roughly 1,400 service connections, served by two wells, three tanks and roughly thirty-five miles of potable line. Source for this system is currently drawn from two active wells, Well 6 (aka Kaiholena Well 6 - USGS #5054-01) at 1,910’ and Well 8 (USGS # 4753-01) at 1,902’. Well 3 was once an important source for this system, but has since been taken out of service. A replacement for this well is in progress as of this draft, and scheduled to be on-line in 2010.

The system is untreated with the exception of the standard required chlorination, which takes place at the sources, and again at Kaumalapau Harbor tank. Koele, Lana‘i City and Kaumalapau represent three service zones on the system.

Koele is served by Wells 3 and 8, via the 750,000 gallon Koele Tank, with a spillway at 2057.5’. The low elevation limit of this pressure zone is about 1,740’. The Koele Tank primarily serves Koele Villas and lots and the Lodge at Koele, but water from this tank can drop to the City through a PRV.

Lana‘i City is served primarily by Well 6. Well 6 feeds directly to the New Lana‘i City Tank, with a spillway elevation of 1,980 feet. Water from Wells 3 (once replaced) and 8 can also contribute source to Lana‘i City via a PRV from the Koele service area. Well 6 feeds directly to the New Lana‘i City 2,000,000 gallon tank, with a spillway elevation of 1980’.

Kaumalapau is fed from Lana‘i City via a 2-1/4” pipe to the 22,400 gallon steel storage tank at Kaumalapau, with a spillway elevation of 375’. This tank services Kaumalapau Harbor and small surrounding developments.

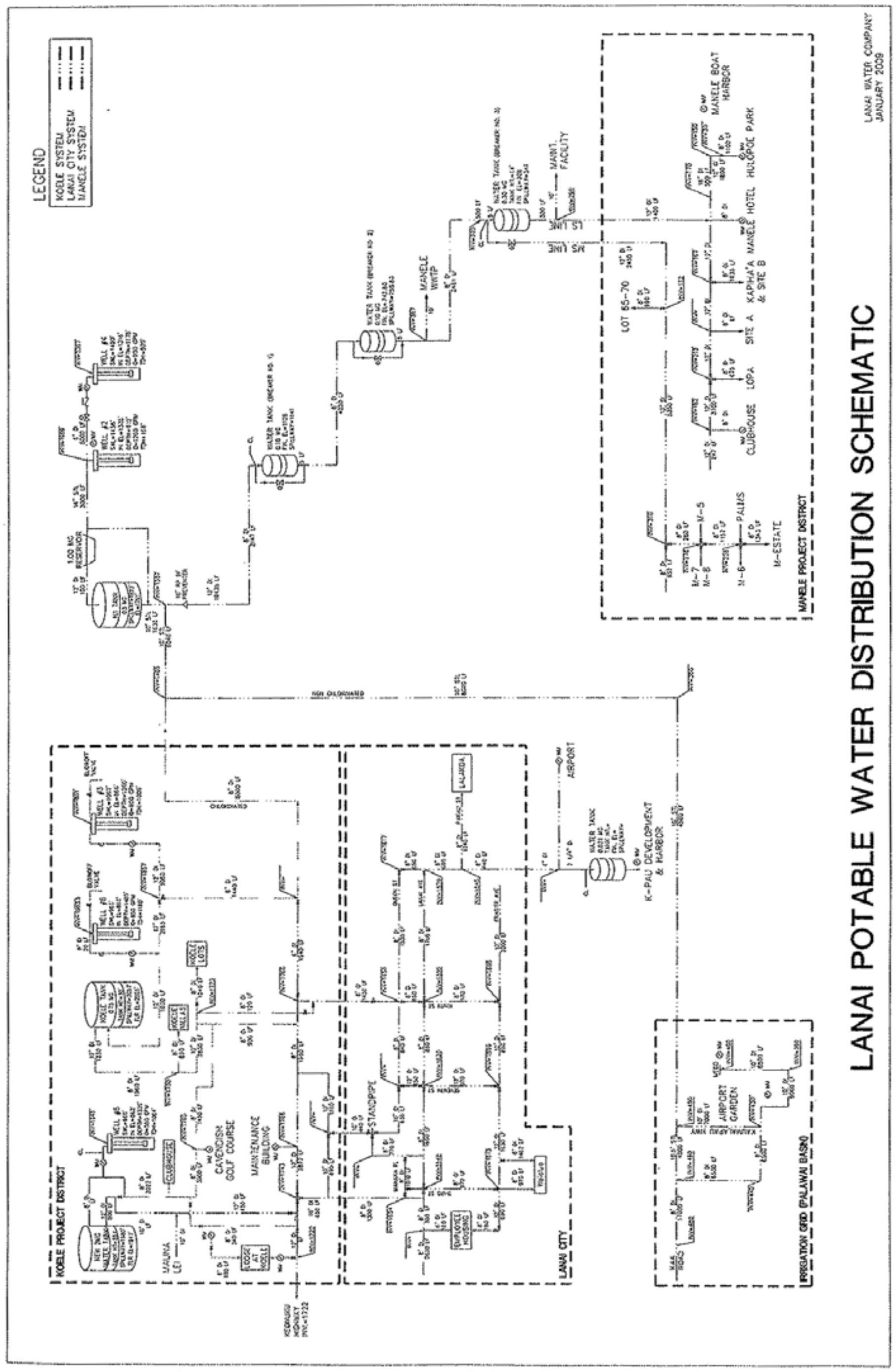
Lana‘i City - Non Potable - Uses - Reclaimed Water

Two wastewater treatment plants serve Lana‘i City. The County’s Lana‘i City Wastewater Treatment Facility has a capacity of about 500,000 gallons per day and treats water to R-3 quality. In calendar year 2008, the Lana‘i City Wastewater Treatment Facility had an influent of about 308,412 gallons per day, and produced about 245,456 GPD of effluent.

From the Lana‘i City Wastewater Treatment Facility, effluent proceeds to the CCR-owned Lana‘i City Auxilliary Treatment Facility where it is further treated to R-1 quality water. The Auxilliary Treatment Facility has a capacity of about 400,000 GPD. In 2008, with an influent of 245,456 GPD, the Auxilliary Treatment Facility produced about 234,093 GPD of R-2 water.

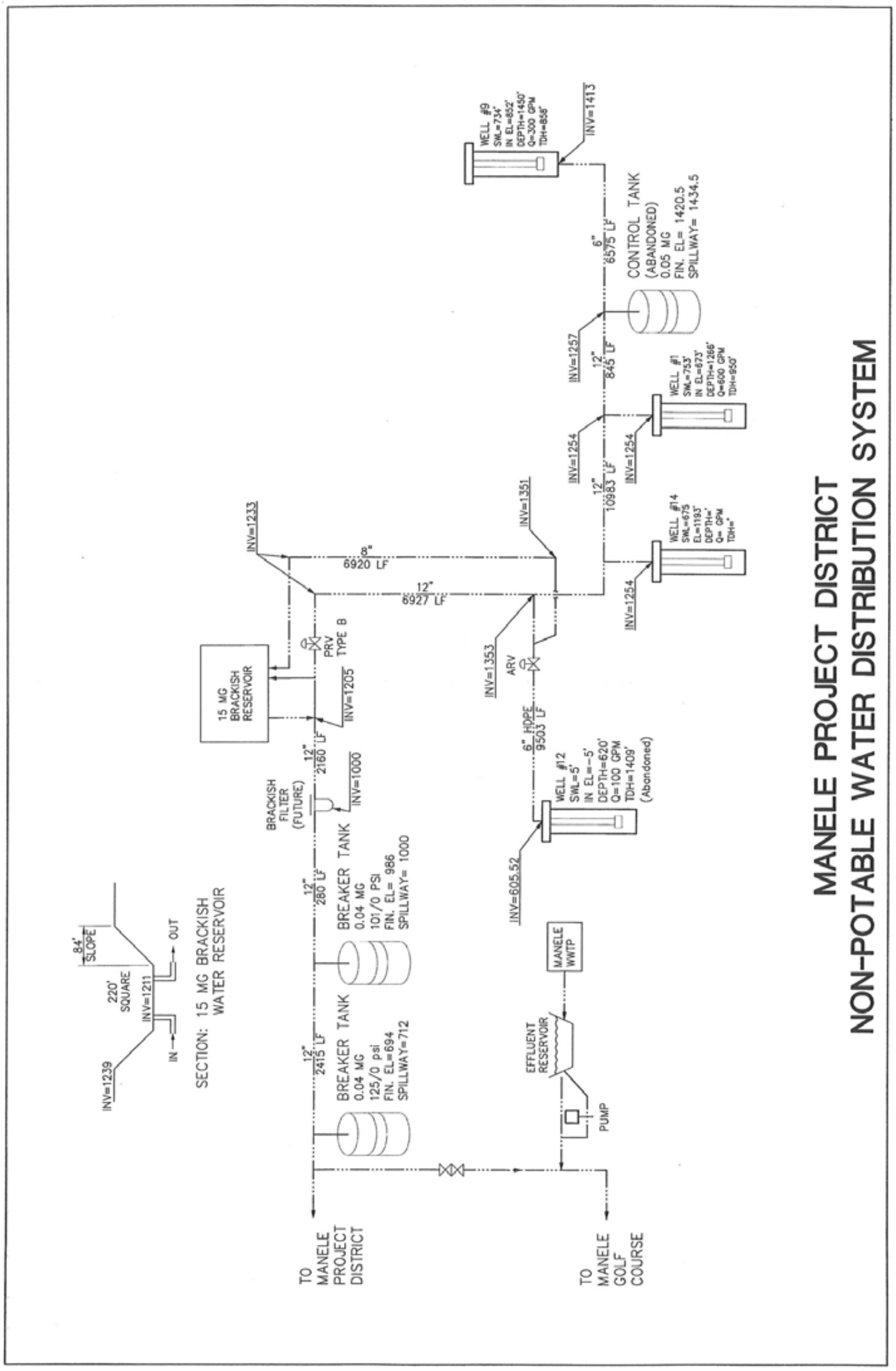
The Auxilliary Treatment Facility has a storage capacity of about 10 MG, with additional storage in water features at the “Experience At Koele” Golf Course of about 13.1 MG. The non-potable system has roughly three miles of waterline. About 209,721 gallons per day were pumped to the “Experience At Koele” Golf Course from the Auxilliary Water Treatment Facility during 2008.

FIGURE 3-32. Lana'i Potable Water System Schematic



Note: An 11x17 version of this figure is provided in the large exhibits file.

FIGURE 3-33. Manele Non-Potable System Schematic



Manele Water System - Potable Uses

The Manele Water System serves Manele Resort, Hulopo‘e Beach Park, and the Manele Small Boat Harbor, as well as the Palawai Irrigation Grid. It has roughly 200 service connections and is served by two wells, five tanks and roughly thirty-five miles of potable or non-chlorinated waterlines. Water for the Manele system is drawn primarily from Well 4 (aka Soule’s Bench Well, USGS #4952-02), with very occasional withdrawals from Well 2/Shaft 3 (USGS # 4953-01). From Well 4, at an elevation of about 2,327’, it proceeds to the 1 MG concrete Hi‘i Reservoir and 0.5 MG Hi‘i Tank at 1,823’. From Hi‘i, water is carried to Manele via three steel breaker tanks in series at spillway elevations of 1,141’, 755.8’ and 341’ respectively. Breaker Tanks 1 and 2 have capacities of 100,000 gallons each. Breaker Tank 3 has a capacity of 300,000 gallons. Water for the Palms and multi-family estates at the west end of Manele is channeled into a line just above Breaker Tank 3. From Breaker Tank 3, water continues to the Harbor, the Beach Park and the Hotel.

Manele Water System - Non Potable Uses

Brackish

Brackish water for landscaping at Manele comes from Wells 1 (USGS # 4853-02), 9 (USGS # 4854-01) and 14 (USGS # 4854-02) at 1,265’, 1,411’ and 1,193’ respectively. A 0.5 MG control tank exists after Well 9 at 1,420.5’ with a spillway elevation of 1,434.5’, but this control tank is currently by-passed to minimize unnecessary pumping costs. From Wells 1, 9 and 14, water proceeds to the 15 MG Reservoir with a spillway elevation of 1,211’. Water is then piped via two 40,000 gallon breaker tanks with spillway elevations of 1,000’ and 712’ toward Manele. Just above Manele, brackish water is blended with reclaimed effluent for golf course irrigation. There are roughly seven miles of brackish waterline.

Reclaimed Water

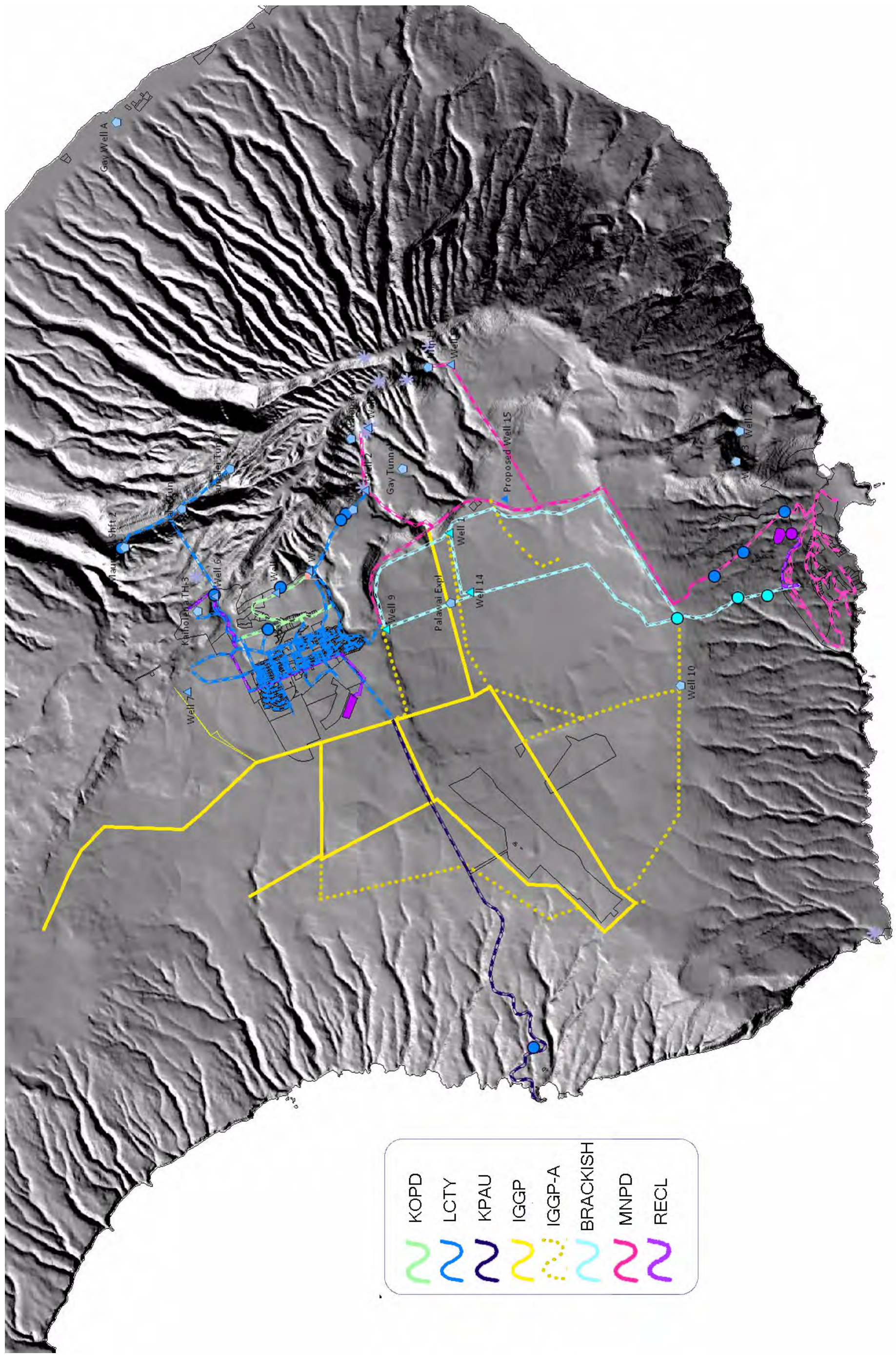
The Manele Wastewater Treatment Facility has a capacity of 140,000 GPD. During calendar year 2008, with an influent of 77,281 GPD, it produced 72,940 GPD of effluent. From the effluent reservoir, this water is pumped directly to the Manele Golf Course via roughly one mile of wastewater line.

FIGURE 3-34. Wastewater Facility Capacity, Influent and Effluent on Lana‘i - 2008

Name		Capacity	Average Influent	Average Production
Lana‘i City WWTF	R-3	500,000	308,412	
Lana‘i City Auxilliary WWTF	R-1	400,000	245,456	234,093
Manele WWTF	R-1	140,000	77,281	72,940

Water Systems

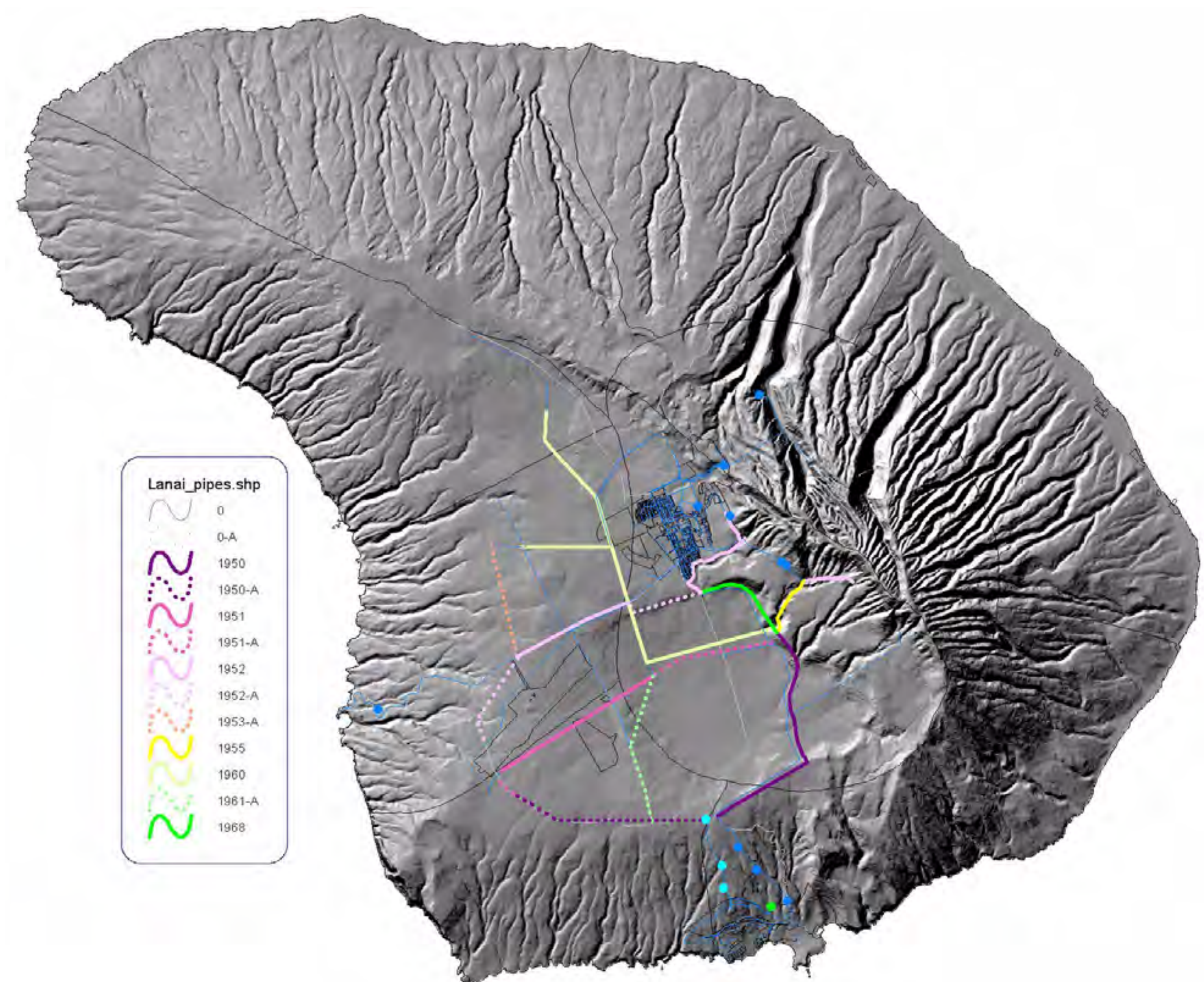
FIGURE 3-35. Lanaʻi Water Systems By District



Pipelines

In all, Lana'i has roughly 93.44 miles of pipeline, as measured from GIS plots. Of this, about 78.63 miles are active, and 14.81 miles are abandoned or out of use. The age and condition of some of these lines, combined with the lack of customer base to generate adequate revenues for necessary replacements, is a matter of serious concern to both Lana'i Water Company, Inc. and the community it serves. Long segments of pipe in the irrigation grid, and to the west, south and east of Lana'i City, are in need of repair, replacement or in some cases possibly abandonment. A portion of the line from Hi'i tank down to the Palawai Basin is unburied and in a fire-prone area. In addition, some lines are either too small in diameter to satisfy system standards or constructed of problematic materials, such as asbestos-concrete or galvanized iron. These situations will be a challenge for the utility in the coming decade.

FIGURE 3-36. Palawai Grid Pipe Age Data Dotted lines in this image are abandoned**.**



Developed and Utilized Resources - Wells & Pumps

Lanaʻi has 23 well holes, of which six or seven are currently in use for its two public water systems. Estimated 24 hour pumping capacity for utilized wells totals 6.934 MGD. At present, Wells 6 and 8 are used for domestic and municipal use in the Lanaʻi City and Koele Project District areas, as well as for the Airport, Kaumalapau Harbor, north end game management and Miki lumber yard areas. This is PWS 237. Well 4, and occasionally Well 2/Shaft 3, are used for domestic and municipal use in the Palawai Irrigation Grid and the Manele Project District areas. This is PWS 238. Wells 1, 9 and 14 are used for irrigation of the Manele Golf Course and landscaped areas at Manele. Total reported pumpage for calendar year 2008 was 2,241,222 GPD.

Lanaʻi City, Koele, Kaumalapau and Related Uses

Maunalei Sources

The combined Maunalei sources were once the primary source of drinking water for Lanaʻi City. Gravity flow from the Upper Maunalei tunnel was conducted via a 2” line to the Lower Maunalei Tunnel, where the flows of the two tunnels combined. At one time, these combined tunnel flows were about 274,000 GPD. However, the average over the period of record entered in this report was closer to 150,000 GPD. From the Lower Maunalei Tunnel this combined tunnel water gravity flowed to the Maunalei Shaft 2 and booster station via a 4” line. The Maunalei shaft ran at a 30 degree slope into the dike complex from an elevation of 851’, where it met a concrete floor at 740’. From that point a deep well continued 259’ straight down. The well at one time had a submersible 170 GPM Anderson pump. Later reports indicated a 500 or 600 GPM pump to boost the shaft water to the booster. Reported historical flows were about 500,000 GPD. A 750 GPM booster pump lifted water from the Maunalei tank, via another series of 4” lines, 1,100’ up and over the ridge and back downward by an 8” line to the Koele 2 MG tank. The Shaft 2 pump was activated only when the Maunalei Tunnel flows were not adequate to keep the Maunalei Tank levels up. Chlorination facilities were located at the 21,000 gallon Maunalei tank. Although zero flows have been reported from Maunalei sources on the periodic pumping reports since 1995, the sources were used most heavily from 1948 to 1994. The 1998 sanitary survey report indicated that the sources were still utilized to serve a bee keeping operation and a boy scout facility. The tank can be chlorinated to accommodate such events. It is not clear from any of the available data whether the lower tunnel still flows at all. It may be possible to further develop pumping capacity in shaft two or the tunnels. It is not clear whether these sources could be utilized for additional development without modifications for two reasons: first the numeric groundwater model indicates that they will cease to run under most pumping scenarios; and second, they may be subject to becoming GWUDI (“*Groundwater Under the Direct Influence*” of surface water).

Well 6

Well 6 is currently the major source serving Lanaʻi City, Koele Project District and related areas. From a pump elevation of 868’ (intake elevation 863’) , a 550 GPM pump with a 200 HP motor pumps water up to ground level at 1,910 feet and proceeds to the Lanaʻi City 2 MG tank via a 10” ductile iron pipe. From the 2 MG tank it serves the Koele Lodge and Villas, and Lanaʻi City. If necessary, water can also be pumped from the 2 MG tank to the higher elevation 0.73 MG Koele Tank, from where it can serve Koele, the City and the Palawai Irrigation Grid. Pipe connections also exist which could send this water toward Manele in an emergency. In calendar year 2008, Well 6 provided an average of 327,912 GPD to the Lanaʻi City area. Chlorides in the well appear to be stable, though water levels are declining.

Well 7

Well 7 has never been in regular use. It is considered a future Lana'i City / Koele source, but could be used to serve areas makai of the city, Kaumalapau area, or even to offset pumpage from elsewhere, freeing water for Lana'i City or even Manele. It has a direct feed to the irrigation system at the north end of the old plantation.

Well 8

Well 8 is located above the City and *Experience at Koele* Golf Course at about 1,902' elevation. From a pump depth of 863' (intake 862'), the pump was recently lowered to 783' (September, 2009). Water from this well can be sent via 8" ductile iron lines either to the 0.75 MG Koele Tank, or directly to the Koele Lodge, the Koele Villas or the 2 MG City tank. Although it has an 850 GPM pump, with a 300 HP motor, Well 8 is currently pumped less than Well 6. During calendar year 2008, Well 8 provided about 276,890 GPD to the Koele Project District area and the surrounding area. Chlorides are marginally higher than those at Well 6, but both wells are fresh. Water levels show a slight declining pattern.

Manele, Hulopo'e, Palawai Irrigation and Related Uses

Well 2 / Shaft 3

Well 2 / Shaft 3 is a potable source, but was once a major source of the plantation's irrigation water. In a 1989 memo from R.C. Oda to J.H. Parker of Dole Foods, Mr. Oda wrote, "This complex above Kapohaku Gulch has been the plantation's major source of irrigation water, but deliveries have declined due to the continuing drought." In 2001, Tom Nance noted that the water levels had recovered about half way to the well's pre-use level with the facility's minimal use. (Tom Nance, *Current Status of Lana'i's High Level Aquifer as Portrayed by Datea From Its Wells*, September, 2001). The ground elevation at Well 2 is 1,510' and the pump elevation is at 1,335'. Water travels via a 16" ductile iron line to the Hi'i Reservoir or Hi'i Tank, or it can bypass these and continue directly in 8" and 12" lines to the Manele Project District or Palawai Irrigation Grid. The portal to Shaft 3 is located at 1,810'. Shaft 3 is drilled at a 30 degree slope with a slope length of about 620' - intersecting with Well 2 at an elevation of 1,510'. The complex has a 1,200 GPM vertical turbine pump, and a 75 HP Ingersoll Rand booster pump. Various reports have described proper operation of this complex and how to work with it. One is left with the impression that this complex was not the most convenient to use, even aside from safety issues. Nevertheless, this was a major source of water for the Plantation and one of the least expensive. As shown in Figure 3-9, Well 2/ Shaft 3 has one of the shortest lifts from the pump intake to the tank outlet, which explains why this complex was so economical. Historical estimates of safe yield for this source have ranged between about half a million gallons per day and 1.2 million gallons per day. Annual MAV pumpage has varied over the years from as little as 70,000 gallons to 700,000 gallons. Well 2 / Shaft 3 has been used only sparingly since 1996, in part due to safety issues in the shaft. In calendar year 2008, average pumpage was only 2,418 gallons per day. Water levels are stable, though rarely reported in recent years. Surprisingly for such high level water, there is a slight rising trend in historical chlorides. Replacement of Well 2 / Shaft 3 is planned.

Well 3

Well 3 is no longer in use and will be replaced. It has been out of service since period 5 of 2006. Well 3 was located such that it has the most flexibility of any source in the system, but it was most recently used primarily as backup for the Manele system, serving as a secondary backup for the City, Koele and related areas. From a pump elevation of 866’, a 900 GPM pump drove water up to an 8” ductile iron line with an invert of 1,845’, and from there it could proceed either to the Palawai Basin via 10” ductile iron lines, or to the Manele Project District via 12” and 8” ductile iron lines. Water from Well 3 could also be pumped through 8” and 12” ductile iron lines to the Koele and Lana‘i City systems - either via the 0.75 MG Koele Tank or directly toward Koele Villas, Cavendish Golf Course, along West Loop Road and on into the city via Ninth Street. Various estimates of the well’s safe yield given from 1957 to 1977 ranged from 65 MGY to 130 MGY or 178,000 to 356,000 GPD. Another estimate was 32 GPM per foot of drawdown. In past years Well 3 was pumped at a rate of about half a million gallons per day, but toward the end of its pumping years, pumpage was closer to 100,000 GPD. Water levels and chlorides are both stable.

Well 3 Replacement

As this document is drafted, a replacement for Well 3 is in progress, with completion expected in 2010. The well permit application indicates that Lana‘i Holdings, Inc. intends to install the existing Well 3 pump into the new well hole. The well has been drilled, but testing is not yet complete and so a well completion report had not yet been submitted as of this draft. The information on the proposed permit indicates a ground elevation of 1,850’, (1,852’ at top of casing), and a total well depth of 1,400’. Anticipated water elevation was 1,010’. As with the previous Well 3, this well should be able to serve either the Koele / Lana‘i City system or the Manele / Hulopo‘e system. System connections are expected to be the same as for the original Well 3, described above.

Well 4

This is the island’s most productive well, and the primary source serving the Manele, Hulopo’e, Palawai irrigation grid and related areas. Well 4 has been used for both drinking water and plantation irrigation, but is presently the major potable source for Manele. It has a 900 GPM pump with 300 HP motor, which lifts water from the 1,316’ pump elevation to ground elevation at 2,327’. The water is transported through 6”, 12” and 16” lines to Well 2 and then onward to the 1 MG Hi‘i Reservoir or 0.5 MG Hi‘i tank. The water can also bypass this storage and feed directly to the Manele Project District or Palawai Irrigation Grid, or theoretically with some valve and system adjustments, it could be fed back to Lana‘i City if it were necessary. Keith Anderson, a hydrologist that consulted for Lana‘i Water Company during the 1960s and 1970s, estimated safe yields for this well between 200,000 and 300,000 GPD. However, a 1974 Company report considered it the most productive well, with good recharge and ability to deliver 600 GPM (864,000 GPD). Historical annual average use of the well has reached as high as nearly 1 MGD, but in recent years pumpage has been in the 600,000 gallon range. During calendar year 2008, Well 4 provided an average of about 683,867 GPD. Water levels and chlorides seem stable.

Well 5

Well 5 has not seen much use since 1994. It is considered a potential backup or future source for the Manele area. Located at 2,296’, there is currently no pump in the well. Safe yield estimates for this well have run from about 150,000 GPD to about 220,000 GPD. Historical reports have noted that it needs to be used with caution, and time is needed to allow water to recharge. Despite such caveats, it had a 900 GPM pump and fed into the system around the Palawai Basin. Although data on water levels and chlorides are limited, they seem to be stable.

Brackish Sources

Well 1

Well 1 is located at the 1,265’ elevation. The elevation of the pump intake is 516’. Water from this well feeds via 8”, 10” and 12” waterlines to the brackish 15 MG reservoir and then onward to Manele via 12” lines. Safe yield estimates for this source have ranged from 110,000 to 140,000 GPD or so. The well is fitted with a 340 GPM pump with a 100 horsepower Hitachi motor. Well 1 has been pumping around 400,000 GPD in recent years. Pumpage in calendar year 2008 was 393,981GPD. Water levels in Well 1 show a declining pattern.

Well 9

Well 9 is located at 1,411’ and the pump had been located at 950’ until October of 2003, when the pump was lowered 42’ to about 908’. The pump has since been lowered again, to 466’. The well has a 300 GPM pump and 100 HP motor. Water from Well 9 goes to Manele PD via the 15 MG brackish reservoir. Average pumpage in 2008 was 151,440. Chloride levels look stable. Water levels show a declining trend.

Well 10

Well 10 was an experimental well only, drilled to test the extent of the utilizable aquifer at the edges of the Palawai Basin. Although there are discrepancies in reported chlorides, the results were high enough that the well was not considered promising, though it was at one time outfitted with a 300 GPM pump. No pump is currently reported. Ground elevation is 1,228’.

Well 12

Wells 12 and 13 were drilled in the southeast rift zone to the east of Manele Resort. Well 12 tested at less than 100,000 GPD, but was thought potentially useful for small amounts of local irrigation use. Well 12 is located at 605’ elevation, with the pump 5’ below sea level in a thin basal layer. Tests in 2003 revealed low production and high chlorides. (Initial chlorides were 708 mg/L, similar to those found in Well 14.) The well was outfitted with a 100 GPM submersible Plueger Worthington pump and 60 HP motor. There is one full MAV period of data for Well 12. Average pumpage for 1995 was about 14,000 GPD. Well 12 was not utilized during 2008.

Well 13

Well 13 was drilled at 695’ in 1990, in the hope that it could be used for irrigation of Manele Project District. Pump tests indicated that production capacity would be too low to make it worth outfitting the well. It is not currently in use.

Well 14

Well 14 was drilled in the Palawai Basin in 1995. Tests in October 2003 revealed salinity in the 700+ parts per million (ppm) range (i.e. 700+ mg/L). At that time it was thought that the well was not likely to be appropriate for use. However, in April of 2004, pumpage started sporadically and at present the well is pumped regularly and mixed with water from Wells 1 & 9. Average daily pumpage for calendar year 2008 was 404,714 GPD. Chlorides run from 700 to 800 mg/L. Water levels show a declining trend, though the period of record is still rather short.

Well 15

As of this drafting, a permit has been approved for drilling of a "Well 15", (USGS # 4753-01). The proposed site for this well is in the leeward aquifer system, south of Well 1, at an elevation of 1,310'. Total anticipated well depth is 1,200' with an anticipated water level of 700'. The proposal anticipates a pumping rate of 350 GPM and a withdrawal of 250,000 GPD. The proposed use of the well is listed as municipal, though given the location, it seems more likely to be a brackish irrigation well. (This application was originally submitted as Well 11. It was later decided to change the name to Well 15, since there had once been a wellhole drilled under the name Well 11, though not in use.)

FIGURE 3-37. Location of Proposed Well 15 Relative to Other Well Sites

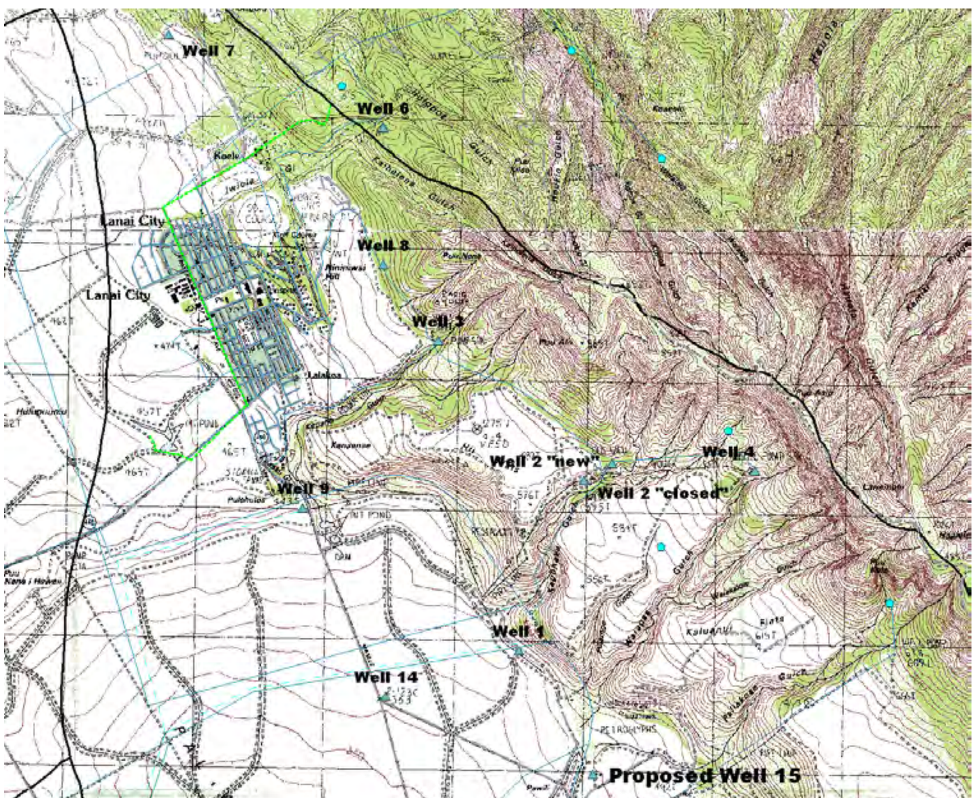


FIGURE 3-38. Well Holes on Lana'i . CWRM Data Base.

WELL NO	WELL NAME	YEAR DRILLED	WELL TYPE	GROUND ELEV	WELL DEPTH	BOT HOLE	CASING DIAM	INIT HEAD	INIT CHLOR	TEST GPM	TEST DDOWN	PUMP GPM	RECENT PUMP GPM	PUMP ELEV	PUMP DEPTH
5149-01	Gay Well A	1900	PER	16	60	-44	6	2	821	400		0			
5053-01	Maunalei Tun 1	1911	TUN	1103				1103				0			
5053-02	Maunalei Tun 2	1911	TUN	1500				1500				0			
4852-01	Mtn House Tunnel	1918	TUN	2700				0				0			
4853-01	Gay Tunnel	1920	TUN	1920				0				0			
4952-01	Waiapaa Tun	1924	TUN	2220				0				0			
5154-01	Maunalei Shft 2	1936	TUN	851	372	479		735	31	20	2	0			
5253-01	Maunalei Shft 1	1936	TUN	294	293	1		2.4	374			0			
4853-02	Well 1	1945		1265	1274	-9	12	818		300	45	700	300	677	588
4953-01	Well 2	1946		1510	609	901	18	0				1400	1200	1330	180
4852-02	Well 5	1950		2296	1122	1174	18	1570				900	900	1293	1,003
4952-02	Well 4	1950		2327	1178	1149	18	1589		660	16	900	840		
4954-01	Well 3	1950		1850	1199	651	18	1078				300	900	812	1,038
5054-01	Kaiholena TH-3	1950						1064				0			
4953-02	SHAFT 3	1954	SHF					0				0			
5054-02	Well 6	1986	PER	1910	1310	600	16	1005	23	30	50	550	640	868	1,042
5055-01	Well 7	1987	PER	2100	1650	450	8	650	67			500	500	840	1,260
4555-01	Well 10	1989	ROT	1228	1020	208		208	330			300			
4552-01	Well 12	1990	PER	605	630	-25	12	5	708	160	8.2	100	100	-13	618
4553-01	Well 13	1990	PER	695	750	-55	12	20		12	12	0			
4854-01	Well 9	1990	ROT	1411	1451	-40	14	808		336	105.1	300	300	461	951
4954-02	Well 8	1990	ROT	1902	1490	412	14	1014	40	1110	37.9	800	640	863	1,039
4854-02	Palawai Expl	1995	ROT	1193	950	243	14	95	551.1	700	170			0	
4854-02	Well 14	1995	ROT	1193	950	244	14	551	700	300	32.7	300	300	361	833

Note: Initial Head as reported here is not always the same as Initial Water Level. The differences are:
Maunalei Shaft 2 Initial Water Level is 739' vs. 735',
Well 1 Initial Water Level is 876' vs. 818',
Well 4 Initial Water Level is 1,576' vs. 1,589',
Well 5 Initial Water Level is 1,548' vs. 1,570',
Well 9 Initial Water Level is 803' vs. 808'.
Palawai Exploratory Well tested at 710 ppm. chlorides.

PER - Percussion Drilled
TUN - Tunnel
SHF - Shaft
ROT - Rotary Drilled

Water Systems

FIGURE 3-39. Well Pumpage 1948-2008

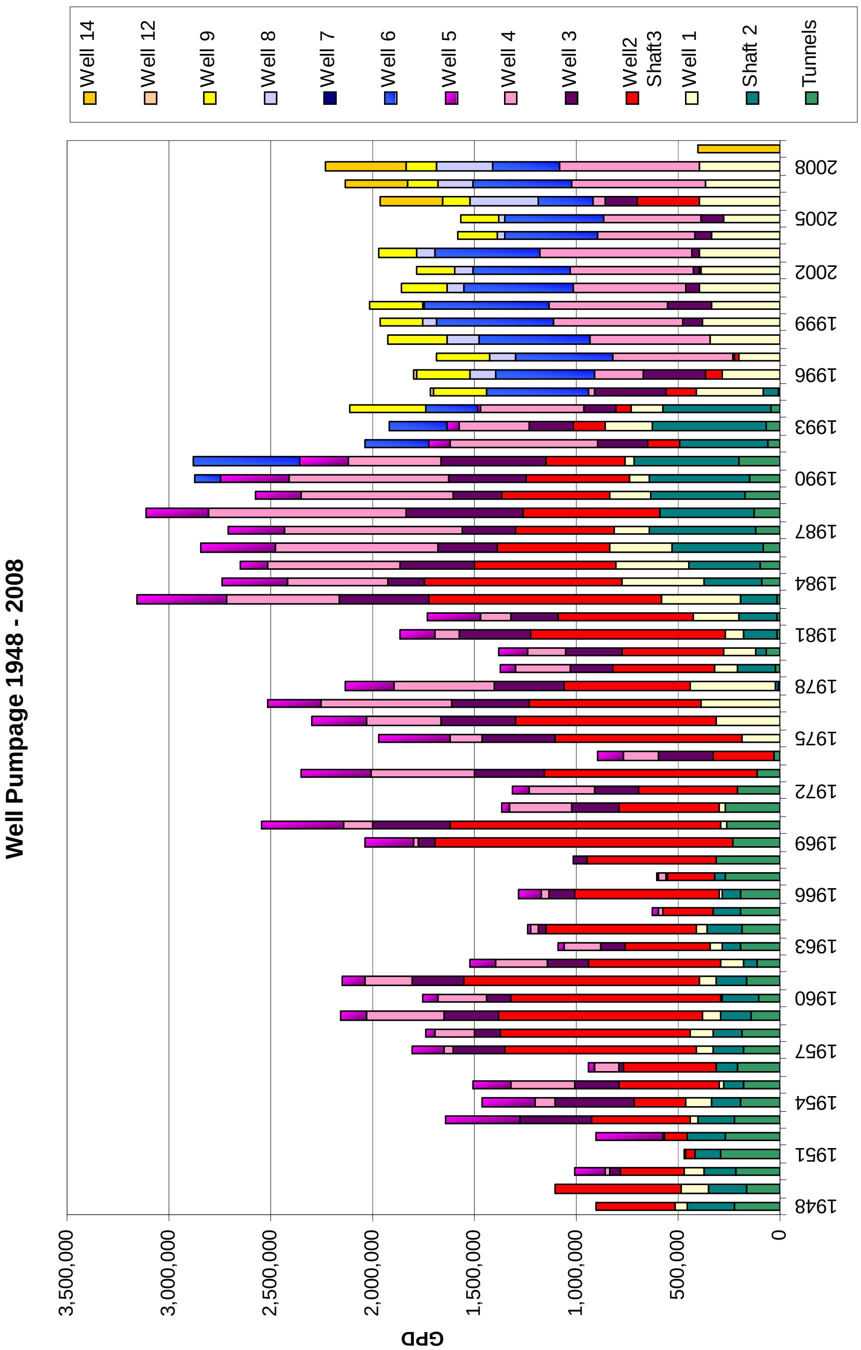
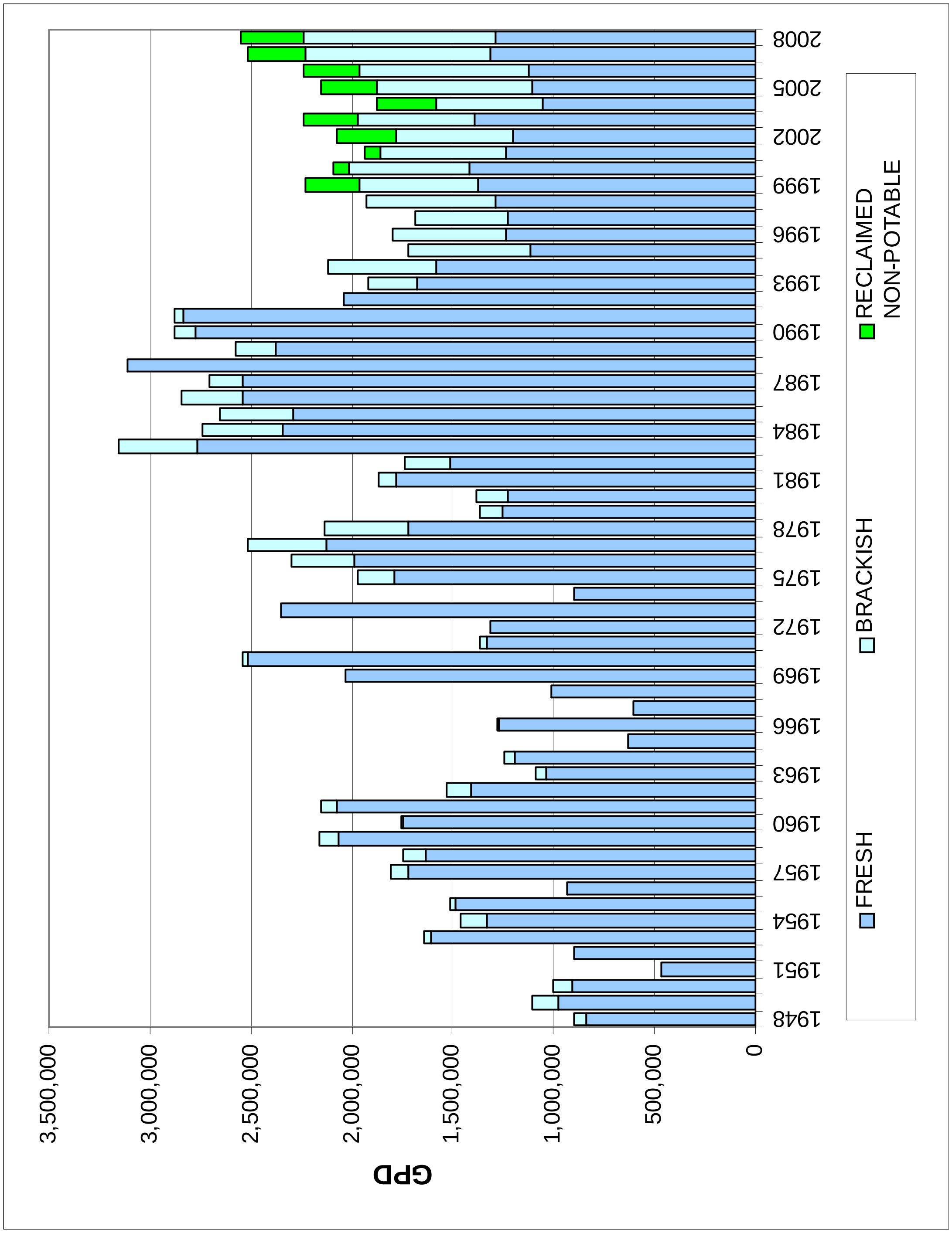


FIGURE 3-40. Potable, Brackish and Reclaimed Use 1948-2008



Water Systems

FIGURE 3-41. Potable, Brackish and Reclaimed Water Use on Lana'i

YEAR	FRESH	BRACKISH	RECLAIMED NON-POTABLE	TOTAL
1948	841,493	58,827		900,320
1949	978,123	128,986		1,107,110
1950	911,721	94,945		1,006,666
1951	467,827	19		467,847
1952	901,408	112		901,521
1953	1,605,085	36,000		1,641,085
1954	1,327,285	131,962		1,459,247
1955	1,488,233	21,874		1,510,107
1956	936,721	0		936,721
1957	1,717,501	85,427		1,802,929
1958	1,635,022	106,858		1,741,879
1959	2,067,436	89,792		2,157,227
1960	1,743,534	7,877		1,751,411
1961	2,073,326	77,282		2,150,608
1962	1,412,959	112,962		1,525,921
1963	1,035,603	54,003		1,089,605
1964	1,190,411	51,633		1,242,044
1965	628,425	0		628,425
1966	1,267,929	12,008		1,279,937
1967	605,729	22		605,751
1968	1,015,126	0		1,015,126
1969	2,035,000	0		2,035,000
1970	2,518,299	25,652		2,543,951
1971	1,334,156	29,855		1,364,011
1972	1,312,301	1,041		1,313,342
1973	2,353,307	85		2,353,392
1974	896,784	0		896,784
1975	1,787,159	186,526		1,973,685
1976	1,985,079	316,554		2,301,633
1977	2,121,939	390,689		2,512,628
1978	1,717,594	413,843		2,131,437
1979	1,252,835	116,786		1,369,621
1980	1,227,239	156,429		1,383,667
1981	1,778,975	87,988		1,866,963
1982	1,513,863	220,233		1,734,096
1983	2,769,565	385,881		3,155,446
1984	2,341,790	400,424		2,742,214
1985	2,291,841	357,154		2,648,995
1986	2,541,694	303,792		2,845,486
1987	2,539,017	169,038		2,708,055
1988	3,112,702	0		3,112,702
1989	2,377,393	198,468		2,575,860
1990	2,778,336	96,839		2,875,175
1991	2,830,921	48,201		2,879,121
1992	2,040,515	0		2,040,515
1993	1,679,570	235,279		1,914,849
1994	1,581,981	532,165		2,114,146
1995	1,115,975	602,097		1,718,071
1996	1,237,689	557,909		1,795,598
1997	1,223,283	460,157		1,683,440
1998	1,287,443	638,409		1,925,852
1999	1,377,387	586,321	265,313	2,229,021
2000	1,418,701	598,253	73,432	2,090,386
2001	1,236,517	623,173	73,468	1,933,158
2002	1,202,529	577,552	292,639	2,072,721
2003	1,388,046	583,051	268,252	2,239,350
2004	1,052,044	531,956	294,140	1,878,140
2005	1,103,347	773,182	275,094	2,151,624
2006	1,124,246	838,219	279,980	2,242,446
2007	1,309,528	916,507	286,479	2,512,514
2008	1,291,087	950,135	307,033	2,548,255

Well Performance and Status

The pumpage and behavior of each well in terms of chlorides and water levels are provided on pages 61-77 of this chapter, in Figures 3-43 to 3-59. In water levels graphs for all wells, the green line is the initial water level, the yellow line is the action level set in the Lana'i Water Company, Inc.'s (LWCI's) operating guidelines, the red line is the lowest allowable level set in the same guidelines, the pink is the CWRM trigger for designation proceedings, and the dotted black line is the pump level as of the drafting of this document. The red and pink lines are normally so close as to be indistinguishable at the scale presented.

Water levels for the brackish Wells 1, 9 & 14 show a declining trend. Water levels at Well 3 are stable, though the well has not been pumped in some time. Water levels in Wells 6 and 8 show more gradual declining trends, although the pump in Well 8 was recently lowered by 80' (September, 2009). Water levels for Wells 2 and 4 appear relatively stable.

FIGURE 3-42. Low Water Levels vs. Pump Levels and High Water Levels vs. Action Levels

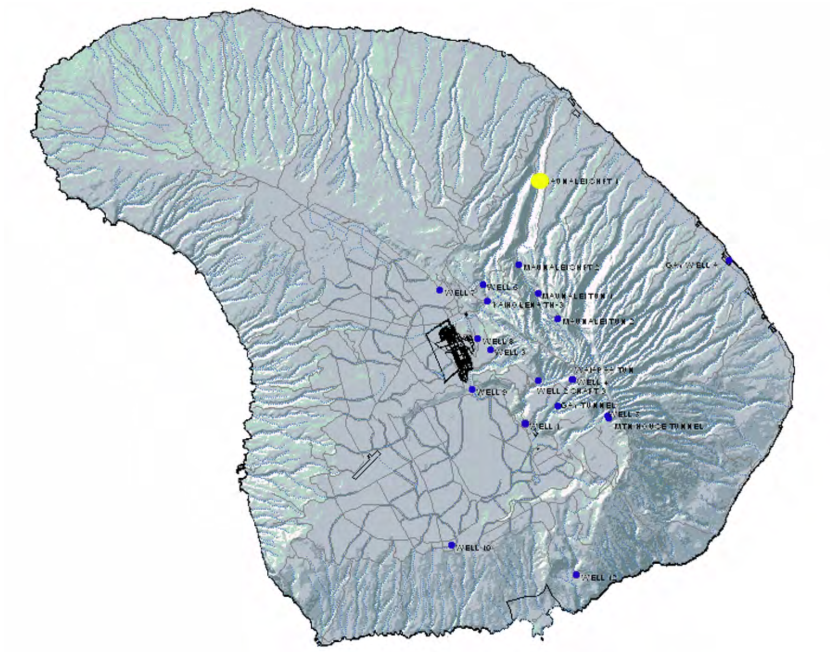
Well	Pump Intake Level	Low Water Level	Data * Date	Action Level	High Water Level	Data * Date
Maunalei Shaft 2	no data	668	P2, 1995	none	681	P2, 1995
Well 1	677**	555		550	575	
Well 2	1330	1,398	P10, 2006	1,050	1,441	
Well 3	812	874	P6, 2006	750	992	
Well 4	1316	1,457		1,100	1,495	
Well 5	1293	1,397	P10, 1993	1,100	1,491	
Well 6	868	913		750	924	
Well 7	840				973	P2, 2004
Well 8	863***	904		750	944	
Well 9	461	598		550	650	
Well 12						
Well 14	361	478		400	497	

* All water level data from Period 7, 2009 unless otherwise noted.

** Well 1 pump intake level is 677 per CWRM data. Water levels are lower than that. Follow up in progress as of this draft.

** Well 8 pump level as of Period 7 was 863.17'. Pump was lowered 80' to 783.17' in September, 2009.

FIGURE 3-43. Maunalei Shaft 1



Maunalei Shaft 1

Well No.	5253-01
Drilled	1936
Ground Elevation	294'
Depth	293'
Bottom of Hole	1
Initial Water Level	2.4'
Initial Chlorides	374 mg/L
Pump	Horizontal skimming shaft
Last Replaced	- - - - - -
Use	1937- ?

Notes:

Could never deliver more than 100,000 GPD without appreciable increase in chlorides.

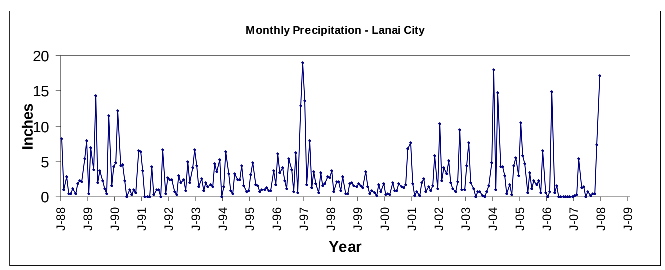
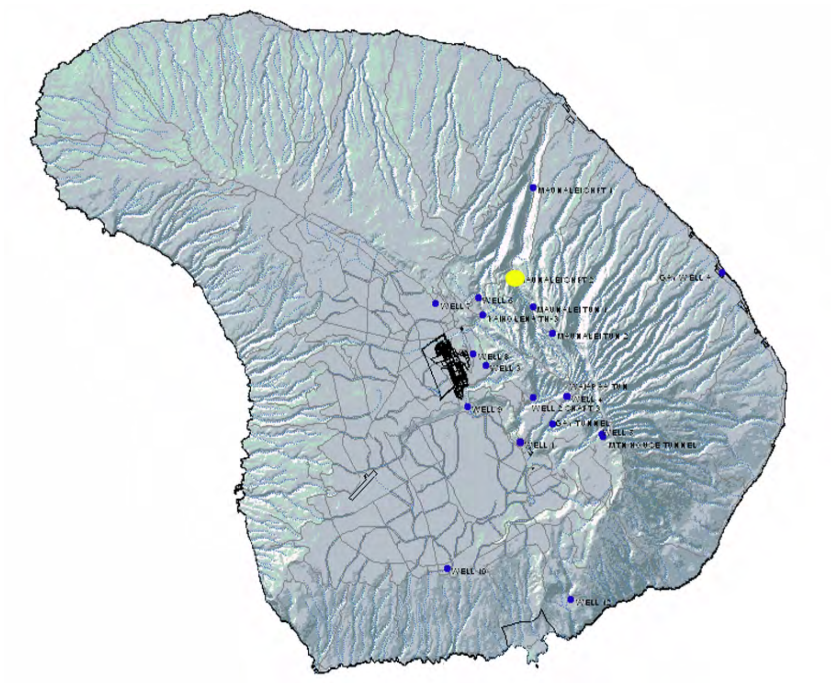
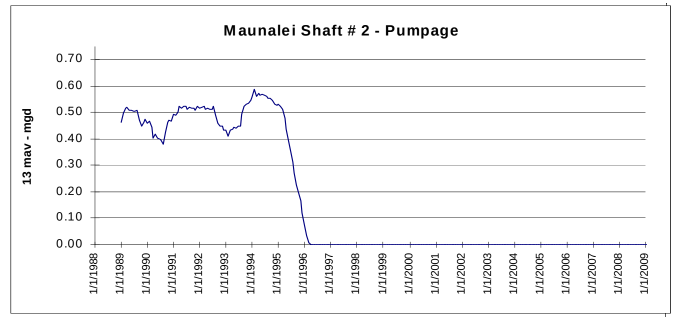
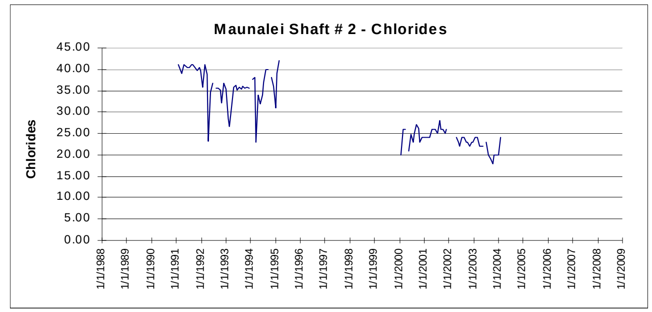
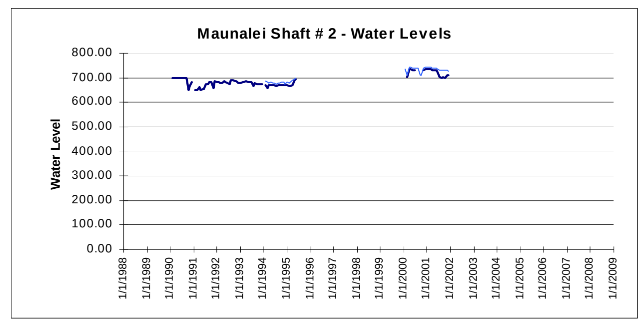


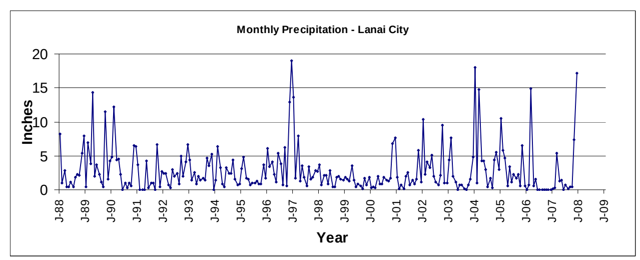
FIGURE 3-44. Maunalei Shaft 2











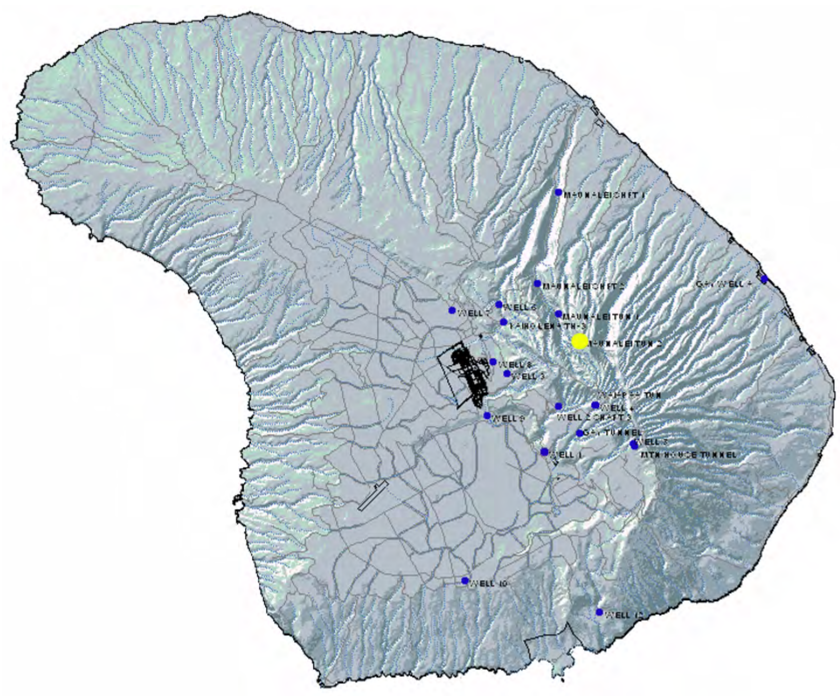
Maunalei Shaft 2

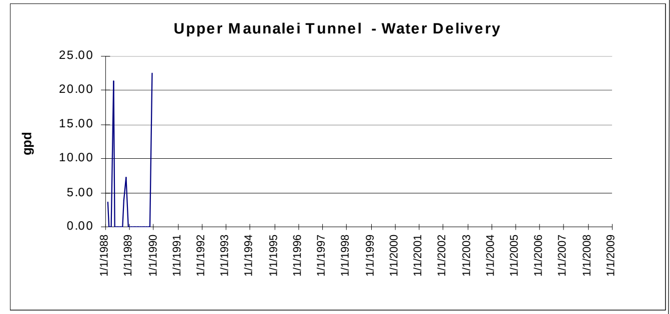
Well No.	5154-01
Drilled	1936
Ground Elevation	851' (875' at portal)
Depth	372'
Bottom of Hole	479'
Initial Water Level	739'
Initial Chlorides	31 mg/L
Pump	500 gpm electric line shaft
Last Replaced	1987 reconditioned
Use	1937- 1995 potable off line since 07/95

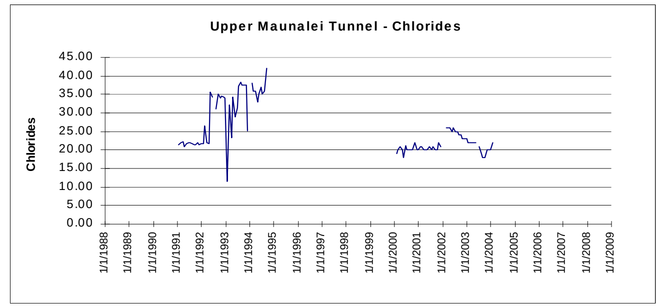
Notes:

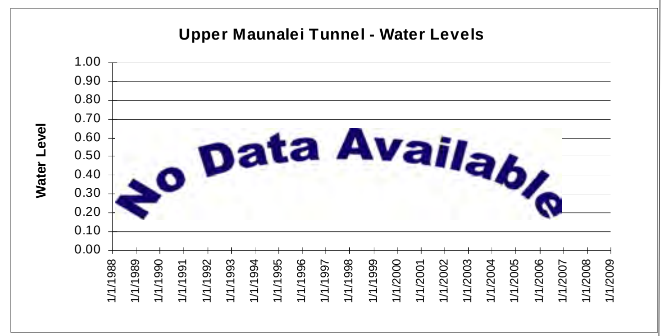
Shaft 2 was once the major source for Lana`i City. It had a 600 GPM submersible pump per 1991 sanitary survey, 900 GPM per 1998 sanitary survey. Not mentioned in 2005 sanitary survey. Booster Byron Jackson VLT vertical booster - variable 0 to 600 GPM 200 HP, 3600 RPM, 444 VP Frame, 225 Amp F1 Electric Motor. One hundred thirty five feet down from the entrance to shaft 2 is a vertical well. Water was pumped to a booster station. A 1989 report noted water levels dropping in both Maunalei Tunnels & Maunalei Shaft due to drought conditions. Periodic Water Reports indicate zero use starting in 1995.

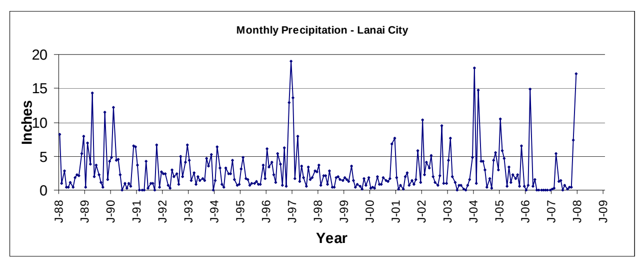
FIGURE 3-45. Maunalei Tunnel - Upper











Maunalei Tunnel 2 ("Upper")

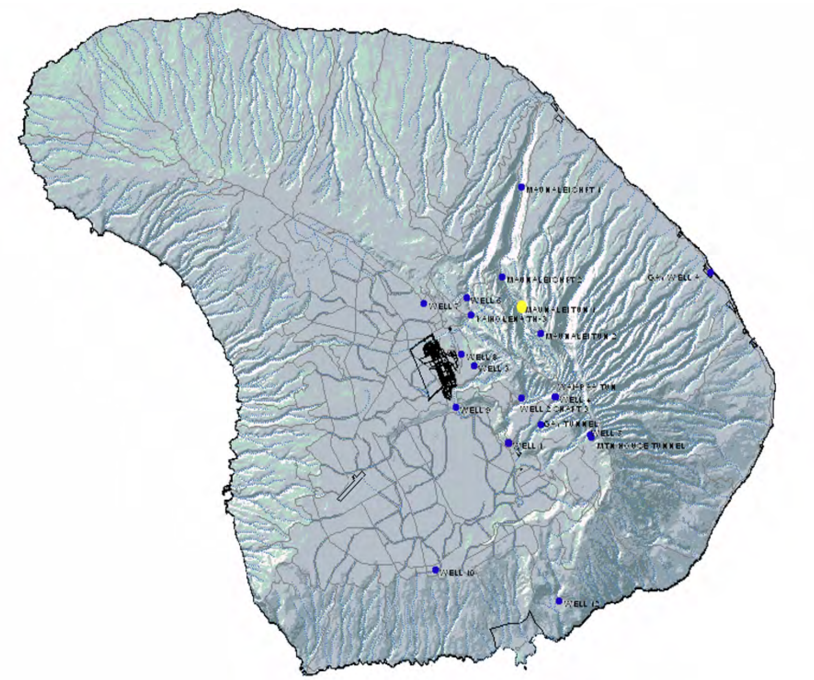
Well No.	5053-02
Drilled	1911
Ground Elevation	1,500'
Depth	------
Bottom of Hole	------
Initial Water Level	1,500
Initial Chlorides	------
Pump	------
Last Replaced	------
Use	1926-1991 potable

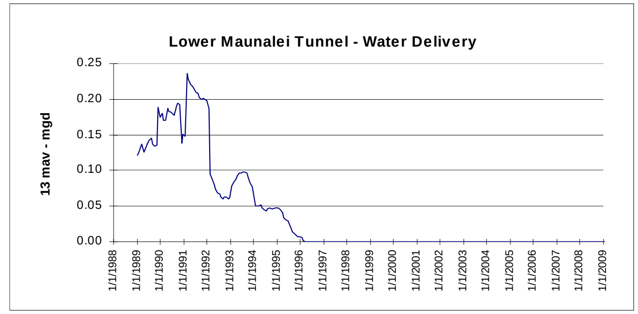
Notes:

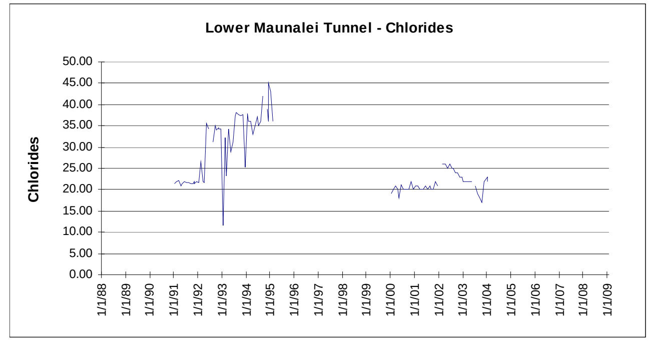
Was once major source for city. Combined yield of Upper & Lower tunnels was once about 275,000 GPD, with another 220,000 GPD from the shaft, or nearly half a million GPD from the combined Maunalei sources. A 1989 company report notes water levels dropping in both Maunalei Tunnels & Maunalei Shaft due to drought conditions. Periodic Water Reports indicate no flows as of 1995. However, 1998 Sanitary Survey indicates that the Lower Tunnel still provides water to a boy scout camp & a bee keeping facility. 30,000 gallon steel tank is chlorinated manually to accommodate events. Costs of using Maunalei to serve city considered too high. Tunnels could be GWUDI.

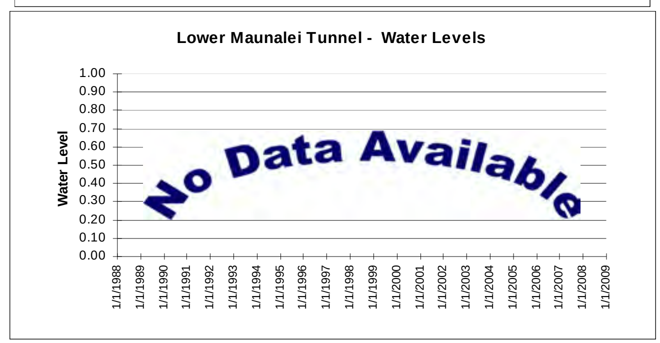
.

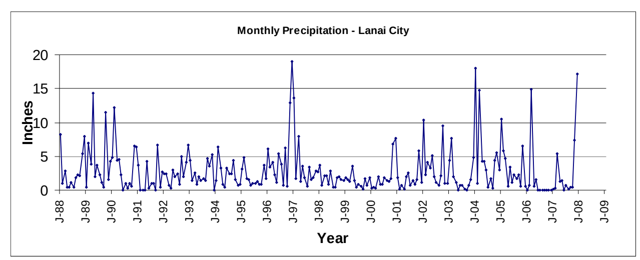
FIGURE 3-46. Maunalei Tunnel - Lower











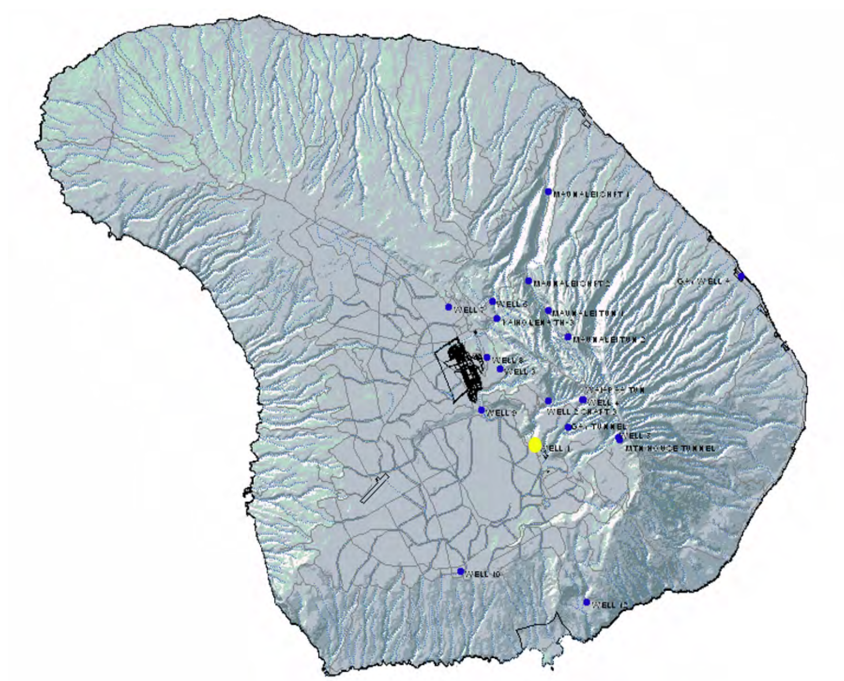
Maunalei Tunnel 1 ("Lower")

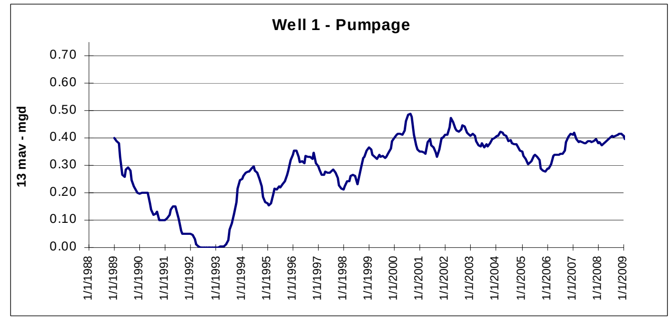
Well No.	5053-01
Drilled	1911
Ground Elevation	1,103'
Depth	- - - - - -
Bottom of Hole	- - - - - -
Initial Water Level	1,103
Initial Chlorides	- - - - - -
Pump	- - - - - -
Last Replaced	- - - - - -
Use	1926-1995 potable

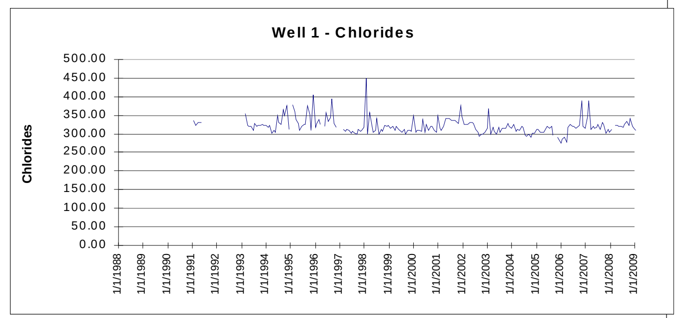
Notes:

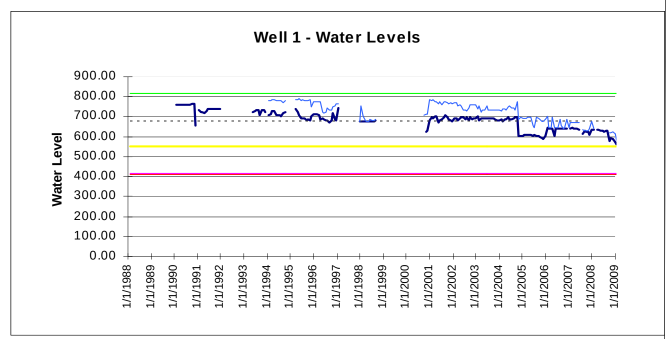
Was once major source for city. Combined yield of Upper & Lower tunnels was once about 275,000 GPD, with another 220,000 GPD from the shaft, or nearly half a million GPD from the combined Maunalei sources. A 1989 company report notes water levels dropping in both Maunalei Tunnels & Maunalei Shaft due to drought conditions. Periodic Water Reports indicate no flows as of 1995. However, 1998 Sanitary Survey indicates that the Lower Tunnel still provides water to a boy scout camp & a bee keeping facility. 30,000 gallon steel tank is chlorinated manually to accommodate events. Costs of using Maunalei to serve city considered too high. Tunnels could be GWUDI.

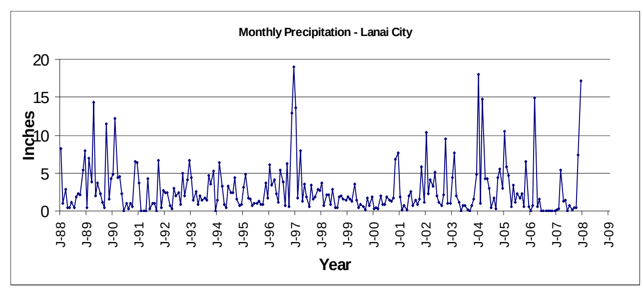
FIGURE 3-47. Well 1











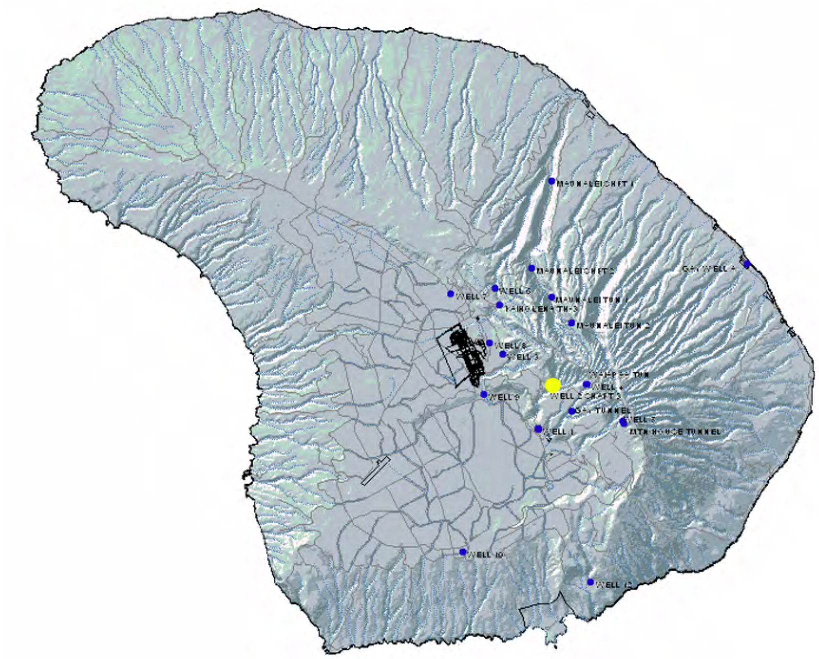
Well 1

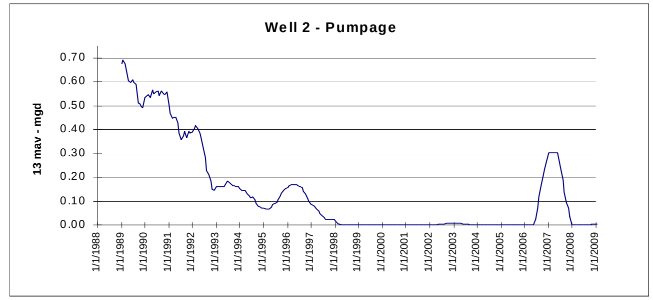
Well No.	4853-02
Drilled	1945
Ground Elevation	1,265
Depth	1,274
Bottom of Hole	-9
Initial Water Level	876
Initial Chlorides	- - - - - mg/L
Pump	340 GPM submersible Crown 3,470 RPM, 9 Stages Hitachi 100 HP Motor Installed 2005
Rebuilt and Drive Line	
Shaft Replaced	1987
Motor Replaced	2005
Used	1937-Present Irrigation - Manele

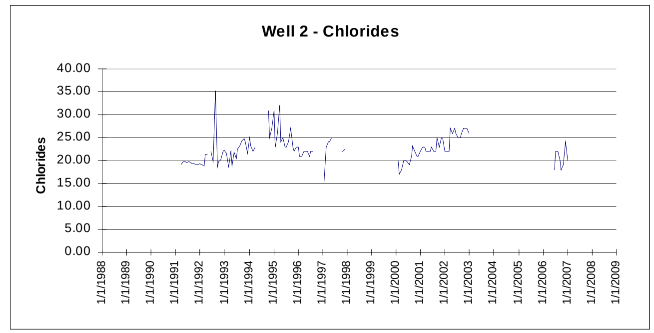
Notes:

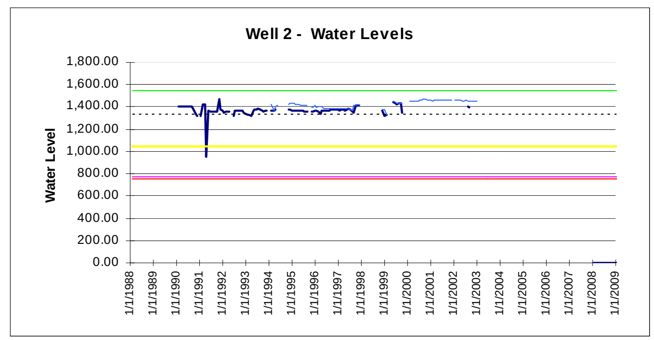
"Due for major overhaul" *JH Parker, 1989*
600 GPM pump 2002
Throttled back to 300 in October 2003
Replaced with 340 GPM pump in 2005

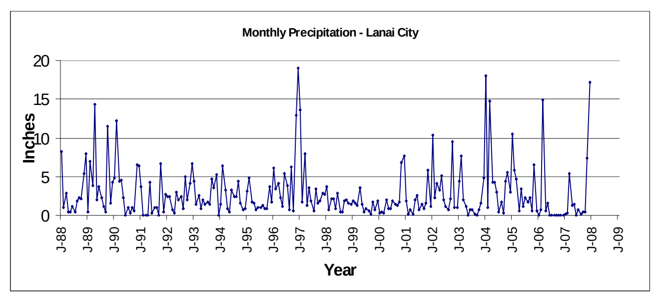
FIGURE 3-48. **Well 2 / Shaft 3**









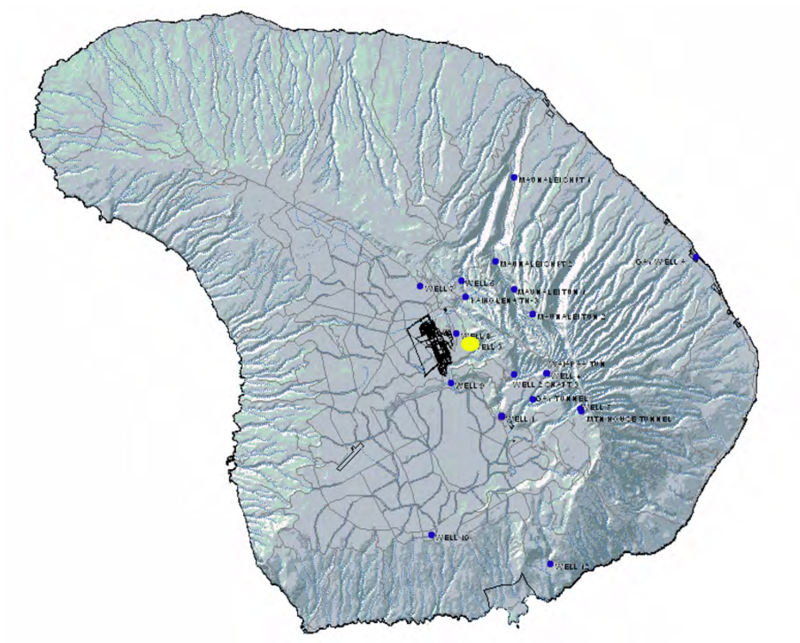


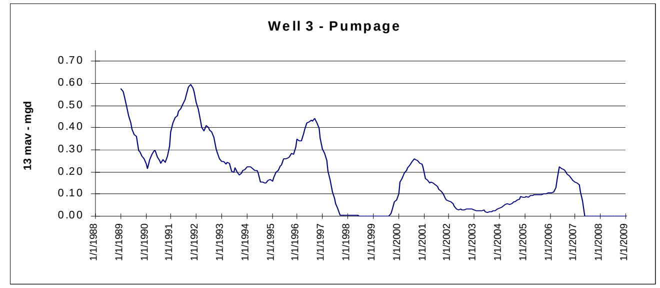
Well 2 / Shaft 3

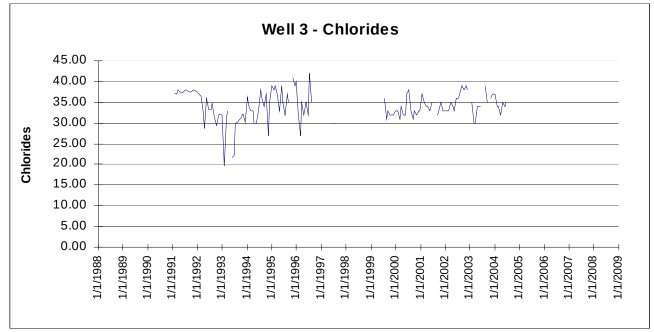
Well No.	4953-01
Drilled	1946
Ground Elevation	1,510’
Depth	609
Bottom of Hole	901’
Initial Water Level	- - - - - - -
Initial Chlorides	- - - - - - - mg/L
Pump	1200 GPM vertical turbine Fairbanks Morse Pomona Ingersoll Rand Booster 75 HP Electric motor FL Amp 90 480 Volt
Last Replaced	- - - - - -
Use	1946 - present Potable. Used for irrigation in past.

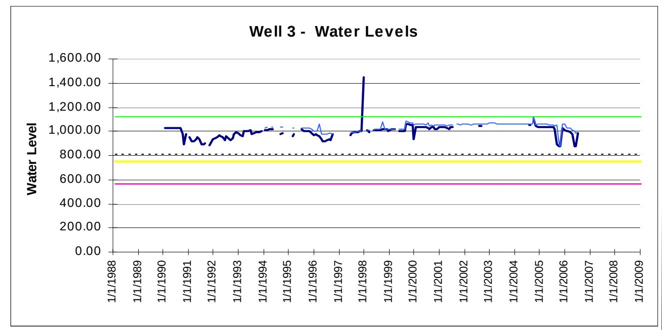
Notes: Well 2 / Shaft 3 was once the major source for the plantation Water deliveries declined during the 1980s “due to drought”. By 1989, the pump was nearing need of replacement. A 1989 report listed the pump as an electric powered line shaft.

FIGURE 3-49. Well 3 - Old









Well 3 – "Old" (No Well Completion Report for New Well 3 Yet)

Well No.	4954-01
Drilled	1950
Ground Elevation	1,850'
Depth	1,199
Bottom of Hole	651'
Initial Water Level	1,078'
Initial Chlorides	- - - - - - - mg/L
Pump	900 GPM Byron Jackson submersible 300 HP electric motor FL Amp 74
Last Replaced	1978
Use	1950 - present Potable. Used for irrigation in past. Could serve City or Manele.

Notes:

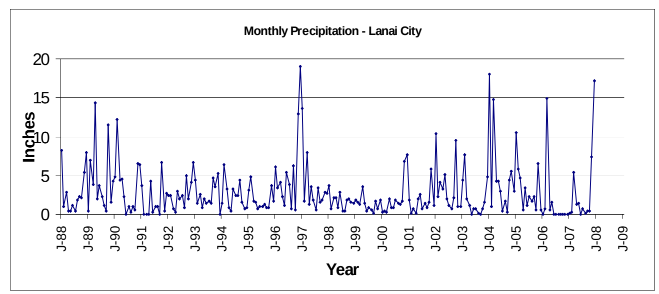
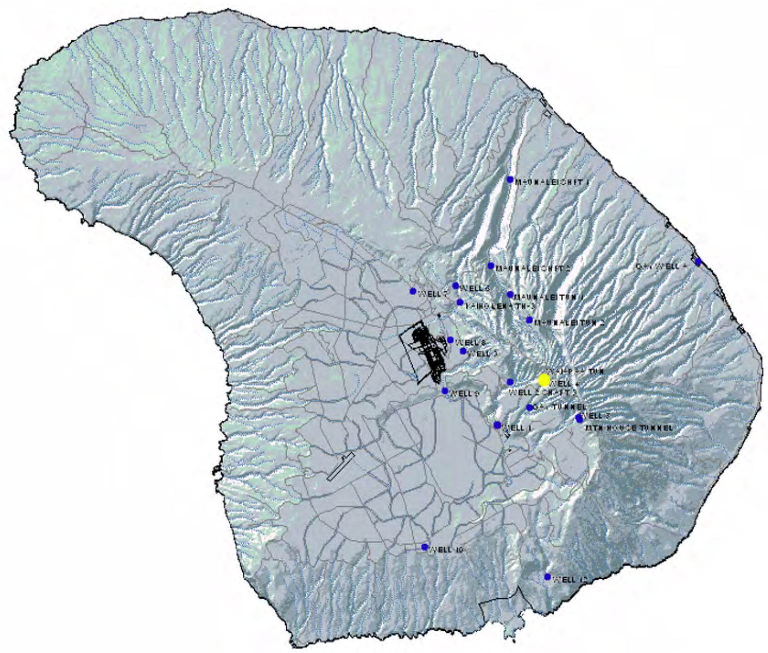
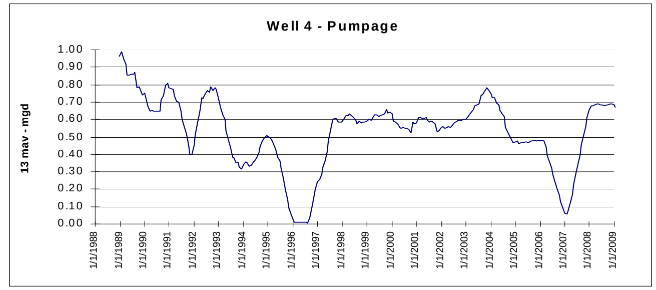
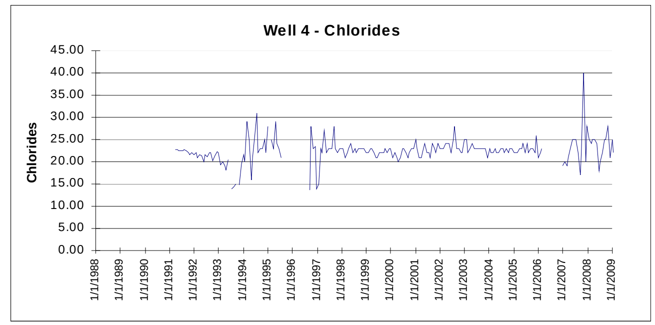
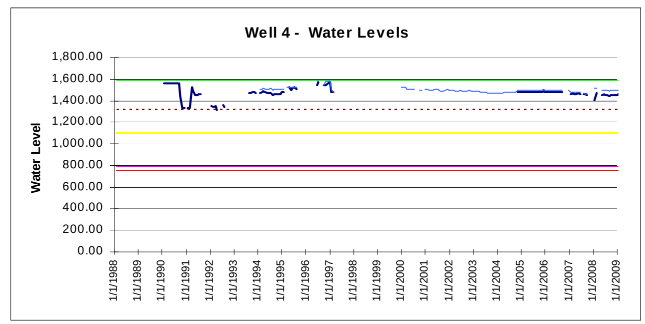


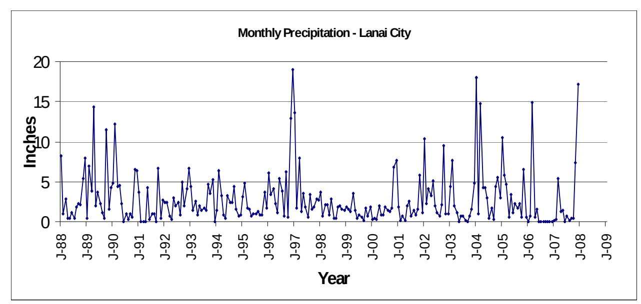
FIGURE 3-50. Well 4









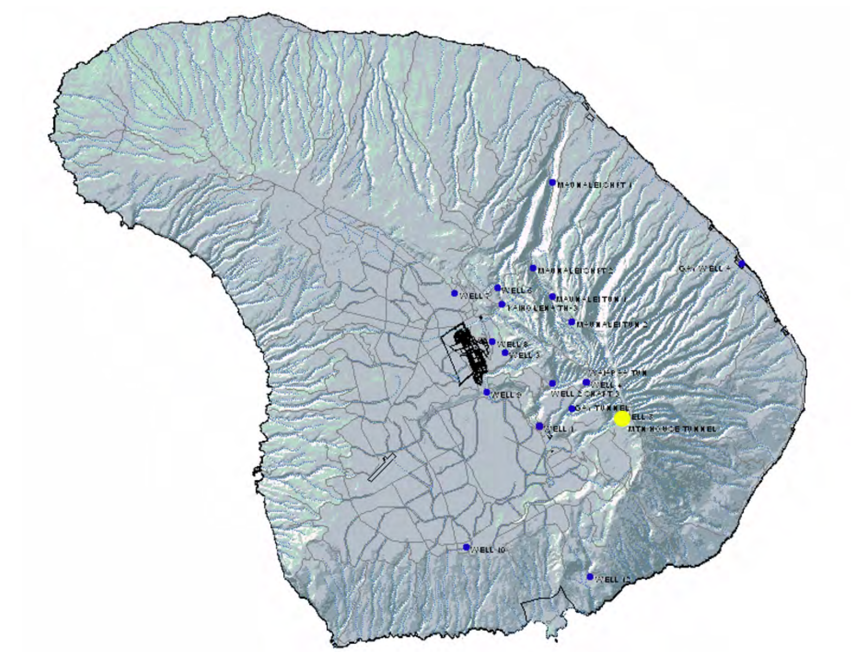


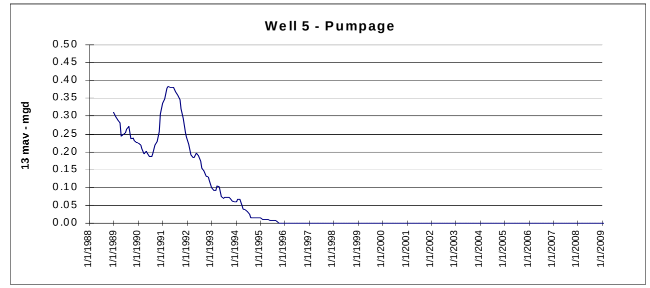
Well 4

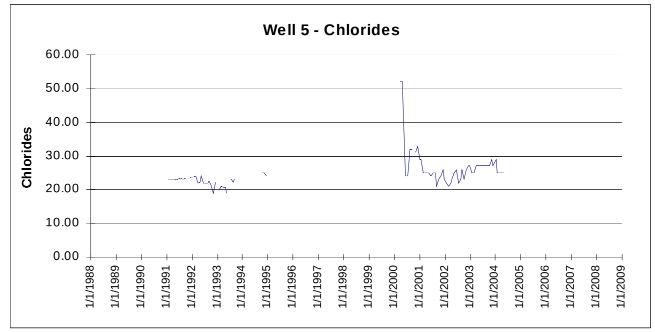
Well No.	4952-02
Drilled	1950
Ground Elevation	2,327’
Depth	1,178’
Bottom of Hole	1,149’
Initial Water Level	1,576’
Initial Chlorides	- - - - - - - mg/L
Pump	900 GPM submersible Byron Jackson 300 HP electric motor 2300 volts
Last Replaced	Motor Replaced 2006, 1984
Use	1950 - present Potable. Can be used for irrigation too.

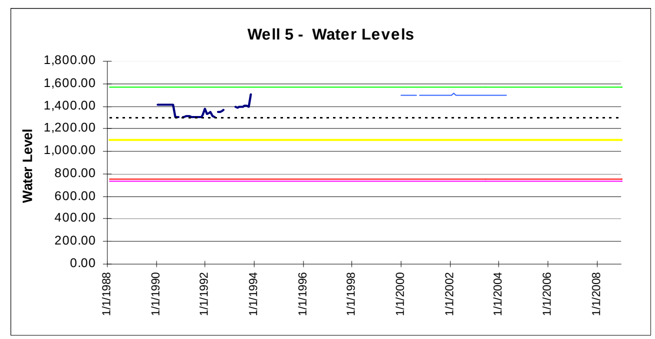
Notes: As of the 1989 report, this was the “best” well on the island, carried 20% of the withdrawal load. Per 1999 sanitary survey, average flow was 1,000 GPM.

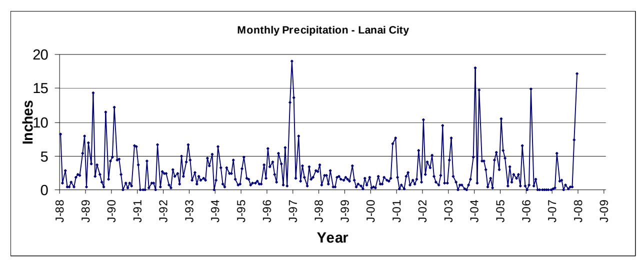
FIGURE 3-51. Well 5









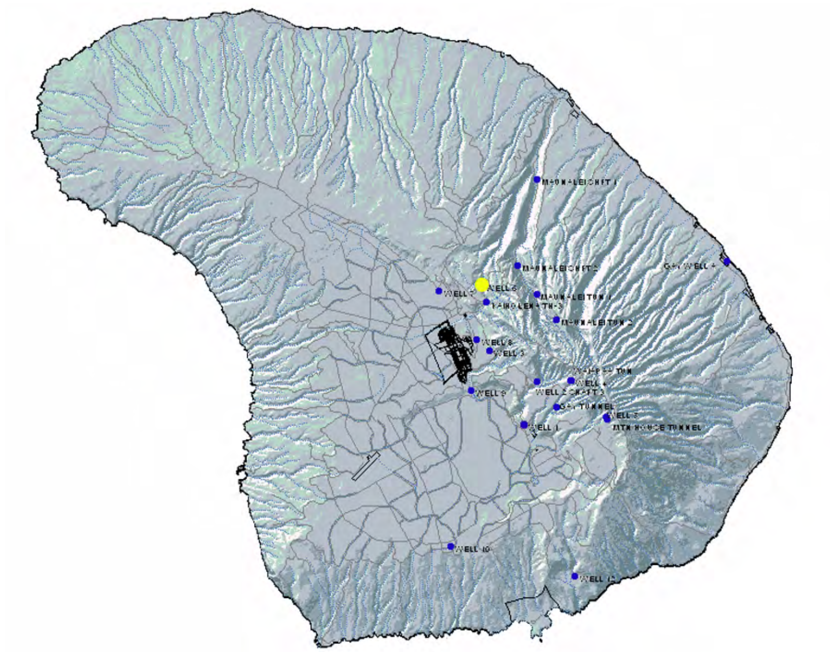


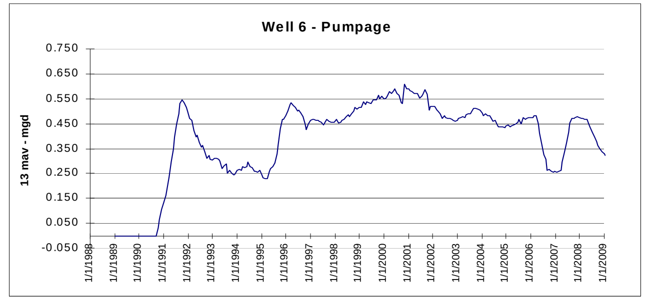
Well 5

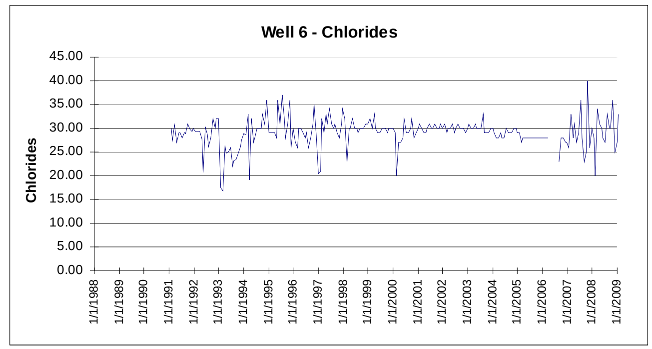
Well No.	4852-02
Drilled	1950
Ground Elevation	2,296’
Depth	1,122’
Bottom of Hole	1,174’
Initial Water Level	1,548’
Initial Chlorides	- - - - - - - mg/L
Pump	900 GPM submersible Byron Jackson
Last Replaced	1984
Use	Not in use since 1994. Potable or Irrigation. Was used for irrigation - especially as back-up for south slopes

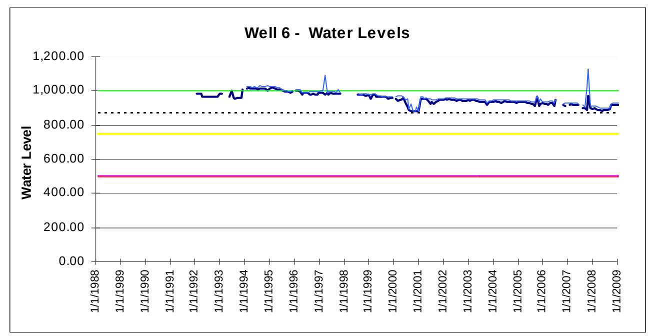
Notes: Water deliveries from this pump were declining by the late 1980s.

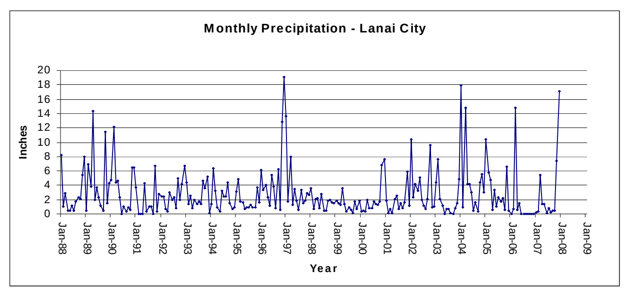
FIGURE 3-52. Well 6









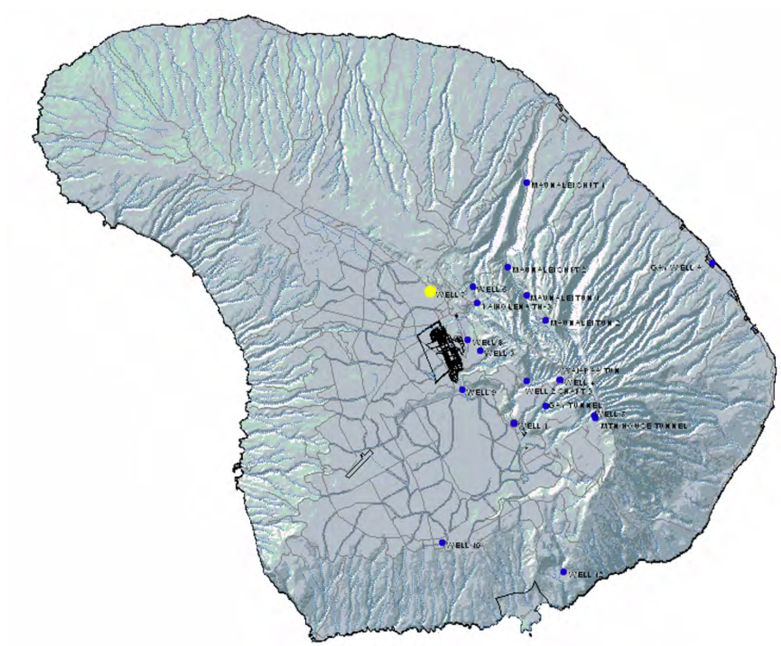


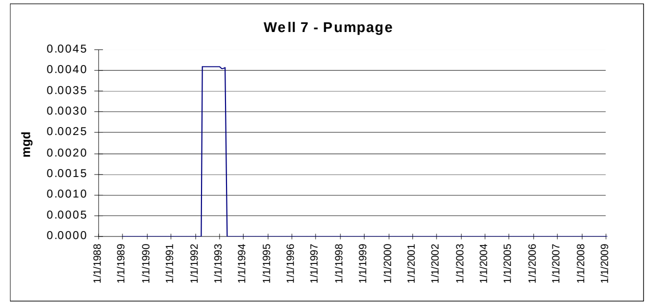
Well 6

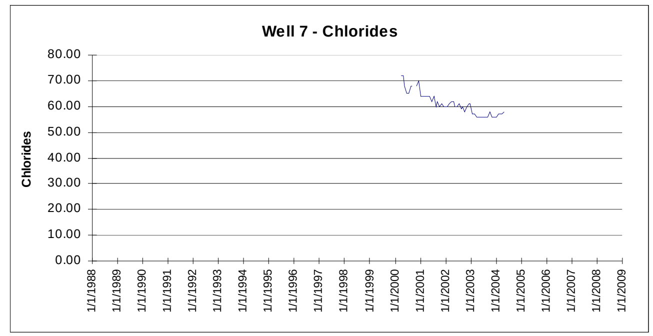
Well No.	5054-02
Drilled	1986
Ground Elevation	1,910’
Depth	1,310’
Bottom of Hole	600’
Initial Water Level	1,005’
Initial Chlorides	23 mg/L
Pump	550 GPM submersible Byron Jackson 1800 RPM
Motor	200 HP Type H 14” Volt
Last Replaced	2006
Use	1990-present Potable Municipal

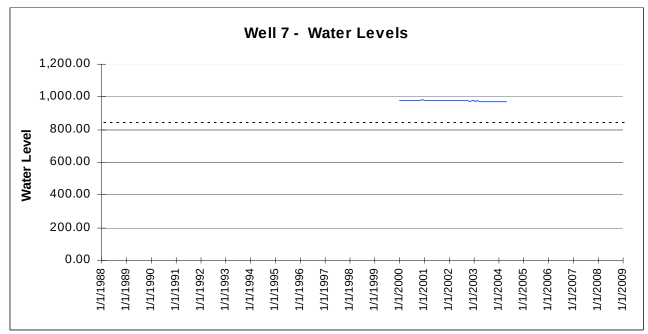
Notes: Currently serves Lana`i City & related areas.
1998 & 2005 sanitary survey noted 900 GPM submersible pump.

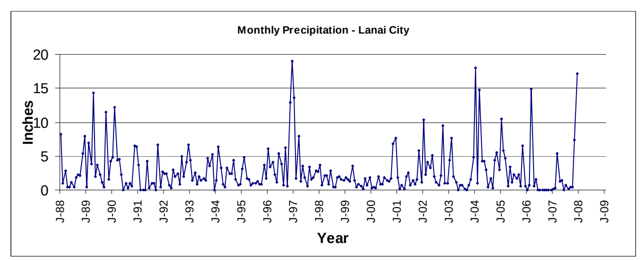
FIGURE 3-53. Well 7









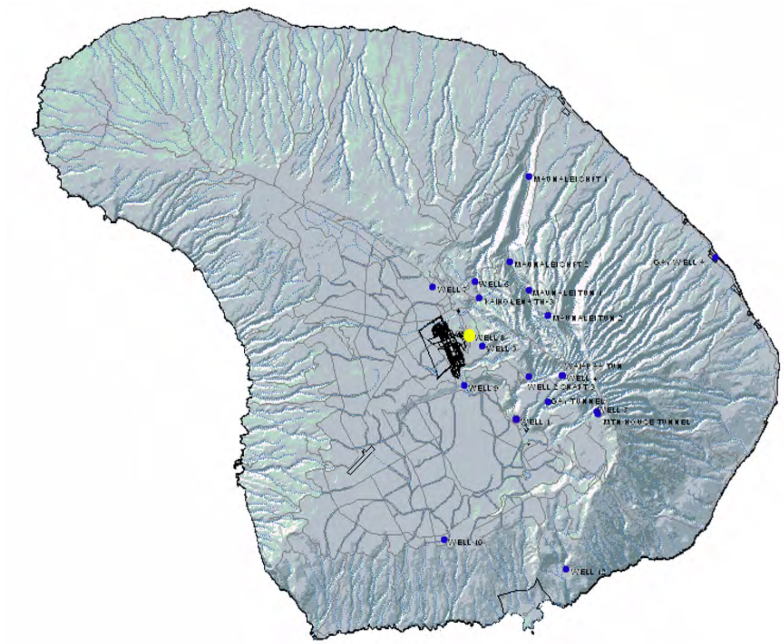


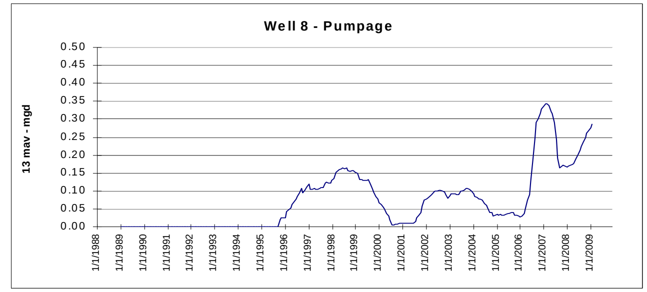
Well 7

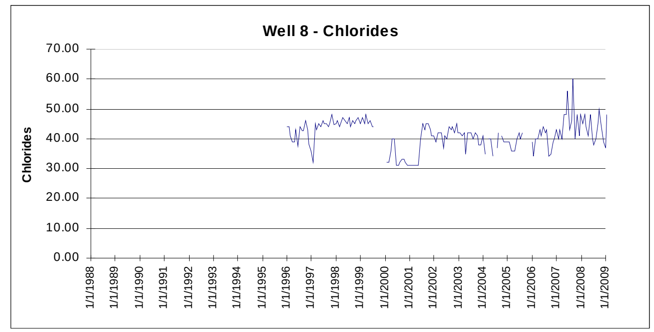
Well No.	5055-01
Drilled	1987
Ground Elevation	2,100'
Depth	1,650'
Bottom of Hole	450'
Initial Water Level	650'
Initial Chlorides	67 mg/L
Pump	Was 500 GPM Layne Bowler Vertical turbine oil lubricated Cumming NTA 8559 Prime Mover Engine 230 Net BHP, 1800 RPM
Last Replaced	1987
Use	Not in use Potable Irrigation or Municipal

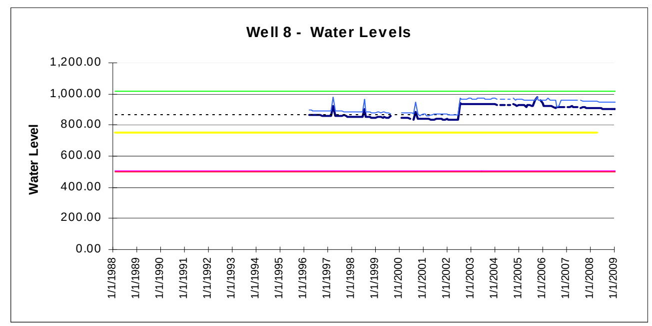
Notes: Had direct feed to the irrigation system at the north end of the plantation.

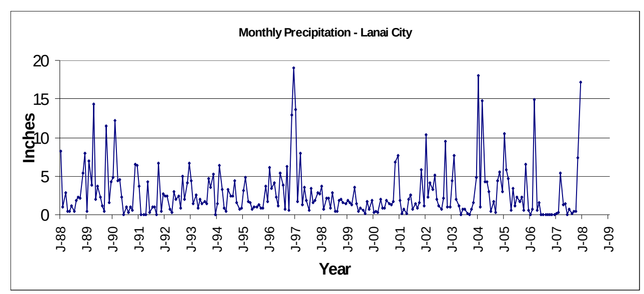
FIGURE 3-54. Well 8











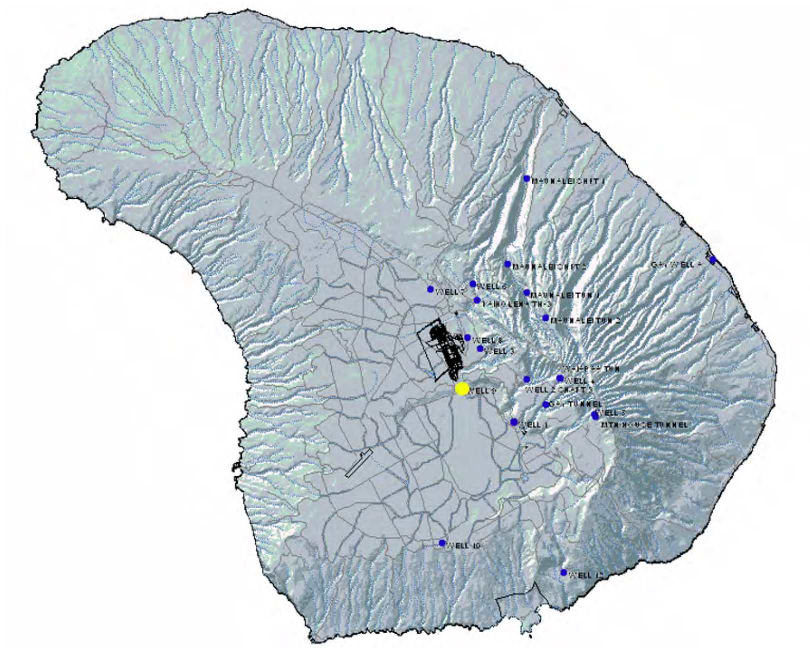
Well 8

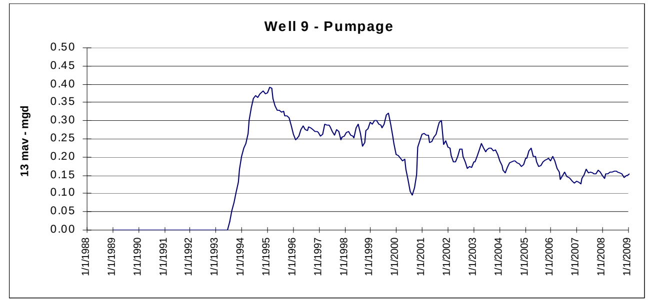
Well No.	4954-02
Drilled	1990
Ground Elevation	1,902
Depth	1,490'
Bottom of Hole	412'
Initial Water Level	1,014'
Initial Chlorides	40 mg/L
Pump	850 GPM submersible Byron Jackson 300 HP Type H 14" Byron Jackson Motor F1 Amp 74 2300 Volt
Last Replaced	1991
Use	1995-present Potable. Municipal.

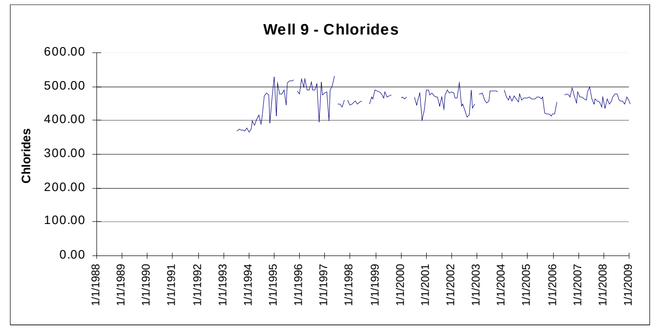
Notes

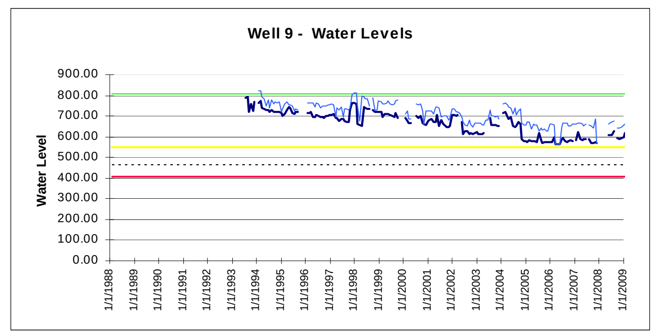
1998 sanitary survey noted avg flow of 705 GPM.
Rise in water levels reported in 2002 appears to have been due to a change in measurement method.

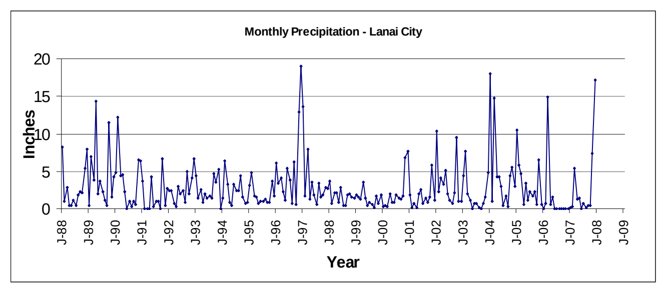
FIGURE 3-55. Well 9







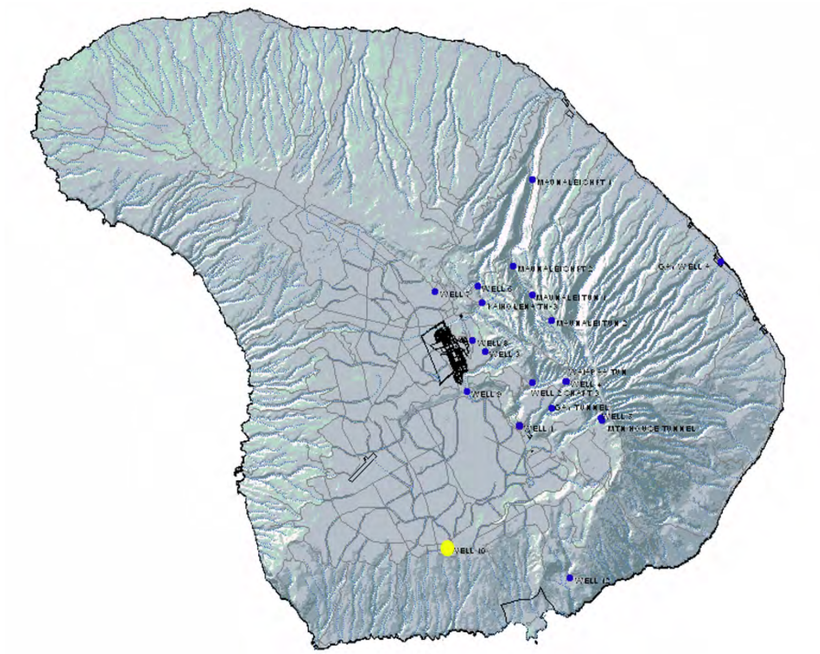




Well 9

Well No.	4854-01
Drilled	1990
Ground Elevation	1,411
Depth	1,451’
Bottom of Hole	-40’
Initial Water Level	808
Initial Chlorides	- - - - - - mg/L
Pump	300 GPM submersible Byron Jackson Franklin Electric 100 HP F1 Amp 148 480 Volt
Last Replaced	Motor, 2005, Pump, 1993
Use	1994-present Manele GC & Landscape Irrigation Pump lowered 42’ in 10/2003

FIGURE 3-56. Well 10



This experimental well was drilled in part to try to test the extent of the utilizable aquifer at the edges of the Palawai Basin.

Well 10

Well No.	4555-01
Drilled	1989
Ground Elevation	1,228'
Depth	1,020'
Bottom of Hole	208'
Initial Water Level	208'
Initial Chlorides	1,300 or 330 mg/L *
Pump	300 GPM
Last Replaced	1993
Use	
Notes:	*Discrepancy between CWRM database and Lana`i Water Resources Report. Lana`I WR report est of 1,300 mg/L makes more sense at that elevation.

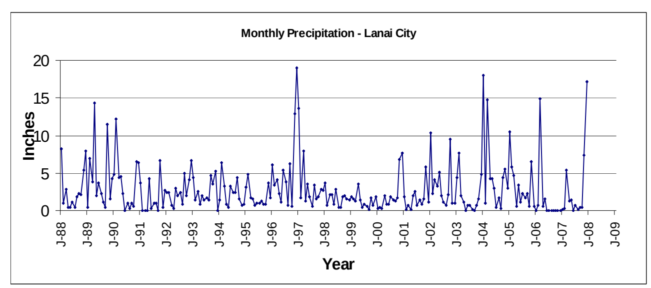
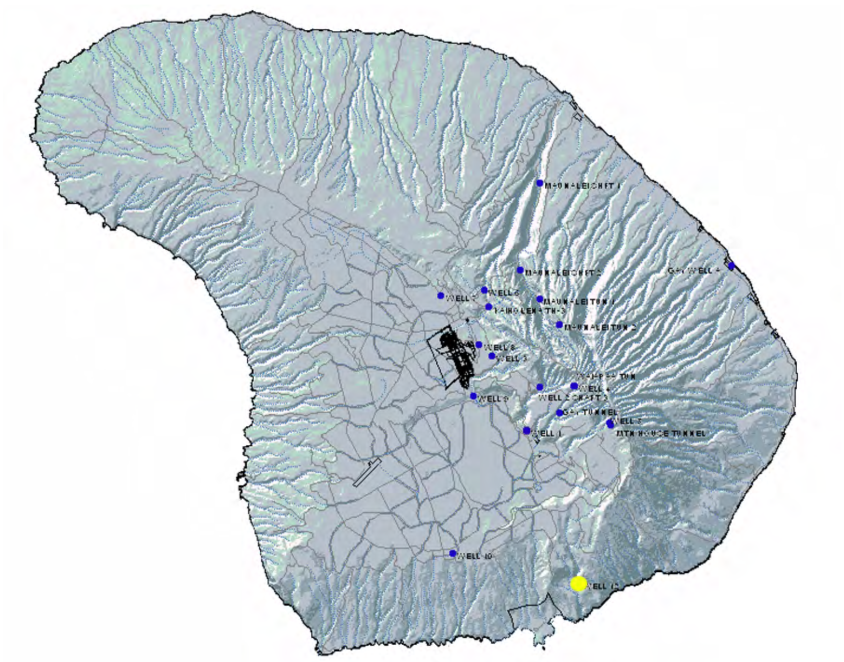
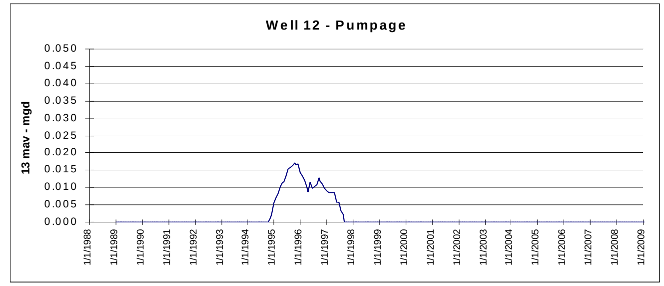
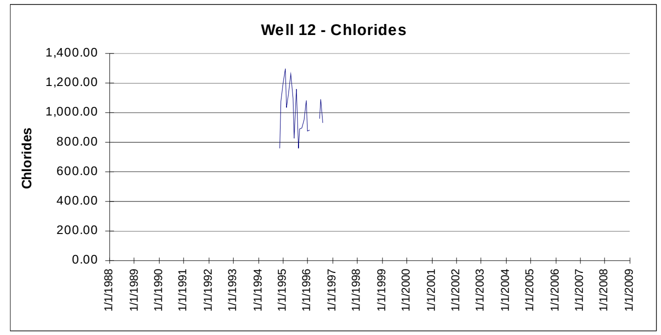
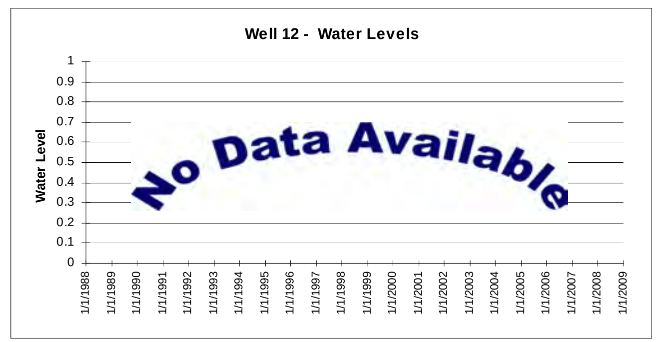


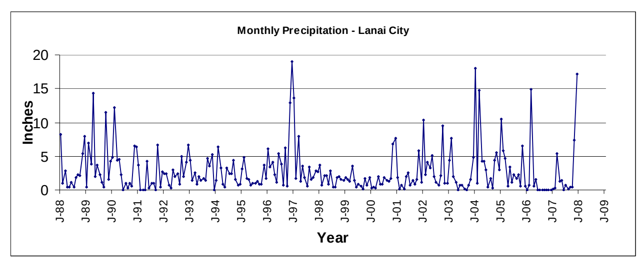
FIGURE 3-57. Well 12







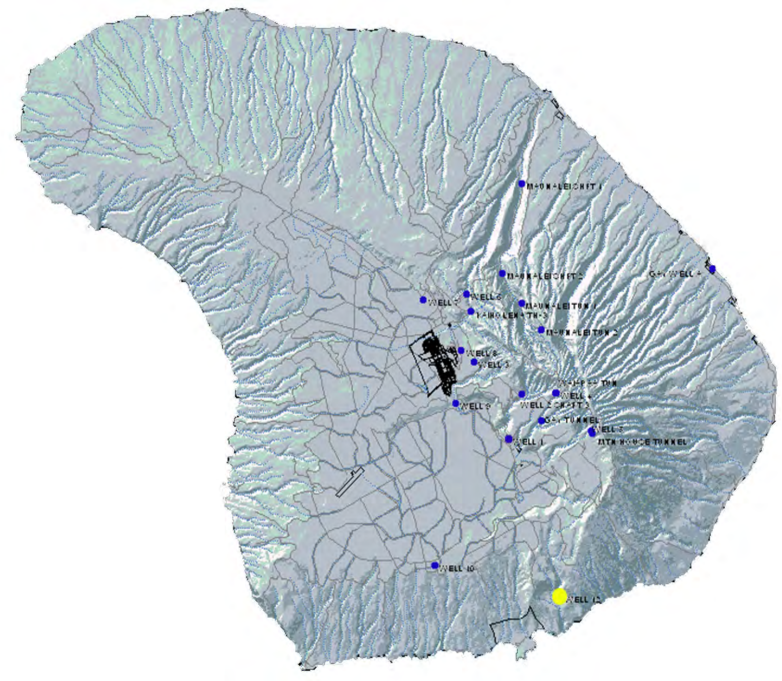




Well 12

Well No.	4552-01
Drilled	1990
Ground Elevation	605'
Depth	630'
Bottom of Hole	-20'
Initial Water Level	55'
Initial Chlorides	708 mg/L
Pump	Was 100 GPM submersible Pflueger/Worthington 3600 RPM Pfleuger 60 HP water-filled hi temp Winding F1 Amp 90 480 volt
Last Replaced	1993
Use	Not in use
Notes:	Intended for Manele GC & landscape irrigation.

FIGURE 3-58. Well 13



Well 13

Well No.	4553-01
Drilled	1990
Ground Elevation	695'
Depth	750'
Bottom of Hole	- 5'
Initial Water Level	20'
Initial Chlorides	- - - - - - mg/L
Pump	- - - - - -
Last Replaced	
Use	Not in use
Notes:	Was Intended for Manele GC & landscape irrigation. Pump tests showed production capacity too low.

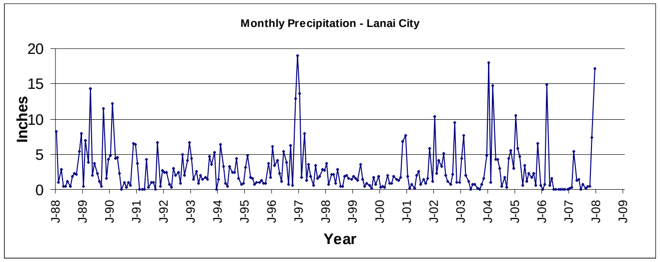
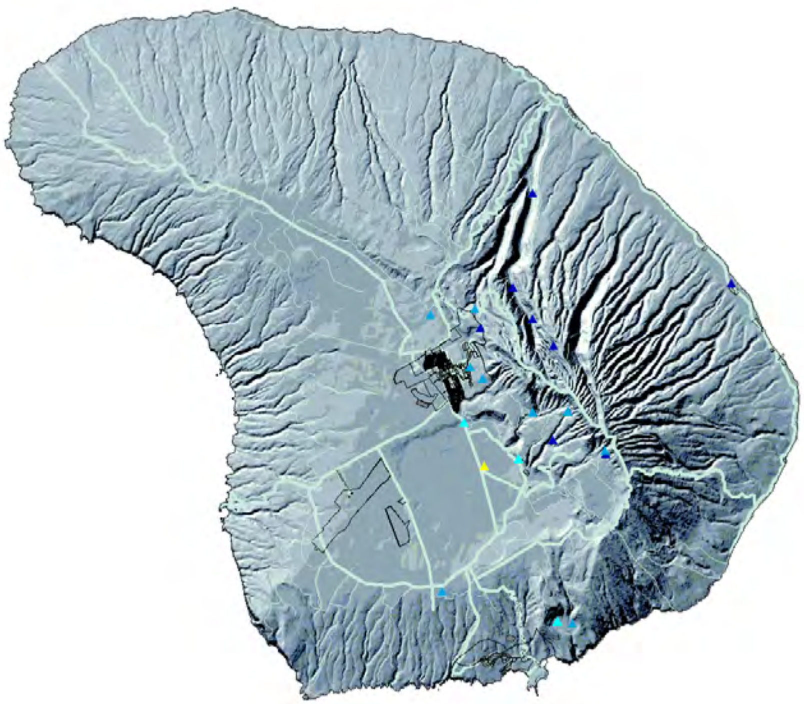
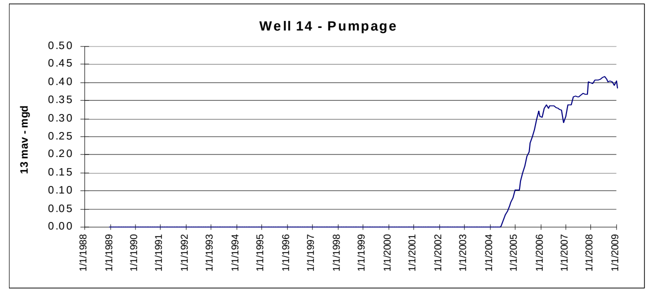
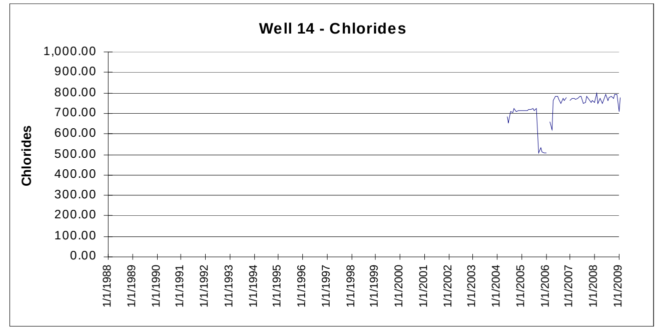
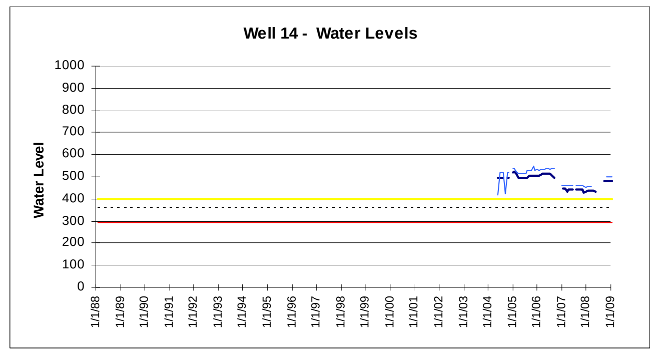


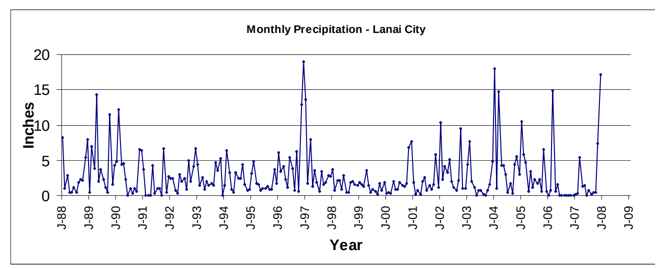
FIGURE 3-59. Well 14











Well 14

Well No.	4854-02
Drilled	1995
Ground Elevation	1,193'
Depth	950'
Bottom of Hole	244'
Initial Water Level	551.1'
Initial Chlorides	710 mg/L
Pump	Submersible Byron Jackson 300 GPM, 125 HP Hitachi Motor 480 Volts
Last Replaced	2003
Use	Manele Irrigation

Notes:

System Finance And Economics

A cursory analysis of the financial situation of the Lana‘i Water Company reveals that existing rates and fees are not adequate to fully recover current operating and maintenance costs. Nor would they provide enough revenue to cover necessary plant replacements.

Rates and fees for potable water from the Lana‘i Water Company, Inc., Brackish Water System, and for wastewater from Manele Water Resources, LLC are provided in Figures 3-61 to 3-63. Income and Balance Statements are provided in Figures 3-64 through 3-68. Annual water revenues for LWCI have recently been estimated at roughly $660,000. This represents only 46% of operating costs. Over half of the required revenues are borne by the parent company. These costs do not include most of the capital requirements for major asset replacements and additions delineated in this plan.

Both the Lana‘i Water Company, Inc. (LWCI), and Manele Water Resources, LLC are wholly owned subsidiaries of Lana‘i Holdings, Inc. (LHI). Source water production is metered and purchased by LWCI from LHI. A major cost component for LWCI operations, as shown in Figure 3-43 below, is purchase of source delivery. This was reflected in the 1995 PUC filing for potable water rates, as well as the 2008 PUC filing for brackish water rates. LWCI purchases water delivery from LHI at the following rates:

Potable water for Lana‘i City / Koele System 237	$2.12 / 1,000 gallons
Potable water for Manele / Hulopo‘e System 238	$2.12 / 1,000 gallons
Brackish water for Manele / Hulopo‘e System	$2.93 / 1,000 gallons

The last rate case for the potable systems was in 1995. Costs reported for that rate case are shown in Figure 3-60. Revenues for plant replacement were not reflected in this breakdown. Existing rates do not provide recovery of all existing and anticipated system costs. The rates were not structured for full cost recovery, but with the intention that the water utility would be subsidized by the parent company. Recent filings for Non-Potable Water Service by LWCI, as well as for rates for Manele Water Resources, LLC, were also structured with intention that these systems would be subsidized by the parent company, rather than achieve full cost recovery. In addition, current rates do not reflect the need to replace broad areas of the system that are fully depreciated. Long stretches of pipe between the City and Kaumalapau and within the Palawai Irrigation Grid are not only fully depreciated, but also in poor repair. Revenues going forward will need to accommodate replacement of plant facilities. Some system replacement may be provided for in the process of accommodating new or intensified development.

In order to evaluate the magnitude of system replacement needs, Department of Water Supply staff obtained maps of Lana’i water systems and facilities and, with consultation from Lana‘i Water Company staff, entered this information into a GIS system with known data on age, material and condition. Based upon information provided, over thirty million dollars worth of replacement and expansion needs were identified over the next 30 years. These are described and discussed further in Chapter 5 of this document. These estimates are consistent in general magnitude with other estimates that have been discussed. Brown & Caldwell identified over $15 million in asset replacement alone (not including expansion) needed over the next twenty years (*DRAFT Lanai System Acquisition Appraisal*, Brown & Caldwell, May 29, 2009) , and an older plan by R.M. Towill Corporation identified $10.45 million in a five year plan (*Castle and Cooke Resorts LLC's Proposed Water Supply and Demand Plan for the Island of Lana'i,* December 2004, RM Towill Corporation).

For the purpose of examining specific capital options and /or demand side management options, an effort was made to estimate the marginal costs of serving water from the various existing sources of the island. The marginal costs of production are the increase in total costs as a result of producing one extra unit. The weighted district marginal costs of production per thousand gallons, based on the calculations in the table in Figure 3-69, were about $2.17 for Lana'i City and Koele districts, $1.77 for Manele potable district, and about $1.71 for the brackish Manele system. The estimated costs are lower than the costs charged, because they do not include all the costs of serving water from these wells, but only the marginal costs of production of the wells, primarily electrical power costs of pumping. Large capital replacements, administrative costs, "purchase of water" agreements and other costs are not reflected. What is reflected is the relative marginal cost of serving water based on elevation, water levels and system parameters. These relative costs are informative for resource planning and considering long term capital and operating investments discussed in Chapter 5.

Costs of operating these wells are affected by energy costs, which have been volatile in recent years. In addition, the status of the aquifer itself can affect pumping costs. As water levels in an aquifer decline, water must be lifted greater distances to the surface. This results in increased pumping expenses. A comparison of Figure 3-9 (page 3-12) and Figure 3-69 (page 3-89) helps to illustrate this point. The blue columns on page 3-12 illustrate the pumping lift of each well. In general, the shorter the column, the more economical the well. As water levels decline, pumps are asked to produce a greater lift, (a longer column), so declining water levels render wells more expensive to pump. Figure 3-9 (page 3-12) is a snapshot of aquifer status at each well, showing high and low water levels as of Period 7, 2009. In contrast, the table in Figure 3-69, uses the the lowest water level reported in recent years. Since lower water levels increase pumping lift, the lowest water levels result in the most expensive actual pumpage on a given well, yielding a conservative estimate of marginal costs. Even with these differences, Figure 3-9 illustrates the crux of the information in Figure 3-89. Both figures indicate that Well 2 could be the most economical well to operate, if safety and other logistical issues were resolved.

Although water levels have been declining in several wells, in most cases they remain hundreds of feet from the levels which would trigger designation proceedings. Pumps at several wells are likely to be lowered again during the planning period. Costs of pumping will rise with increasing pump-depth as well as with increasing costs of electricity. If water levels were to reach designation triggers with the same pumping distribution and energy costs as 2008, cost of production would be $2.95, rather than $2.17 for Lana'i City, $3.07, rather than $1.77 for Manele and the Palawai Irrigation Grid, and $2.02, rather than $1.71 for brackish water.

With a small customer base, many miles of fully depreciated or nearly depreciated pipe needing replacement, and rising costs to provide source, it appears that LWCI will either need substantial financial subsidy from its affiliates or increased rates and fees, or both, in order to maintain a reasonable level of service over coming decades.

FIGURE 3-60. Lana'i Company Operating Costs from PUC Rate Case 1995

Legend reads left to right, and refers to slices clockwise from right, starting with Purchased Water at 40.44%, Depreciation at 5.38%, Salaries, Wages and Benefits at 29.21%, Contract Services at 5.16%, etc.

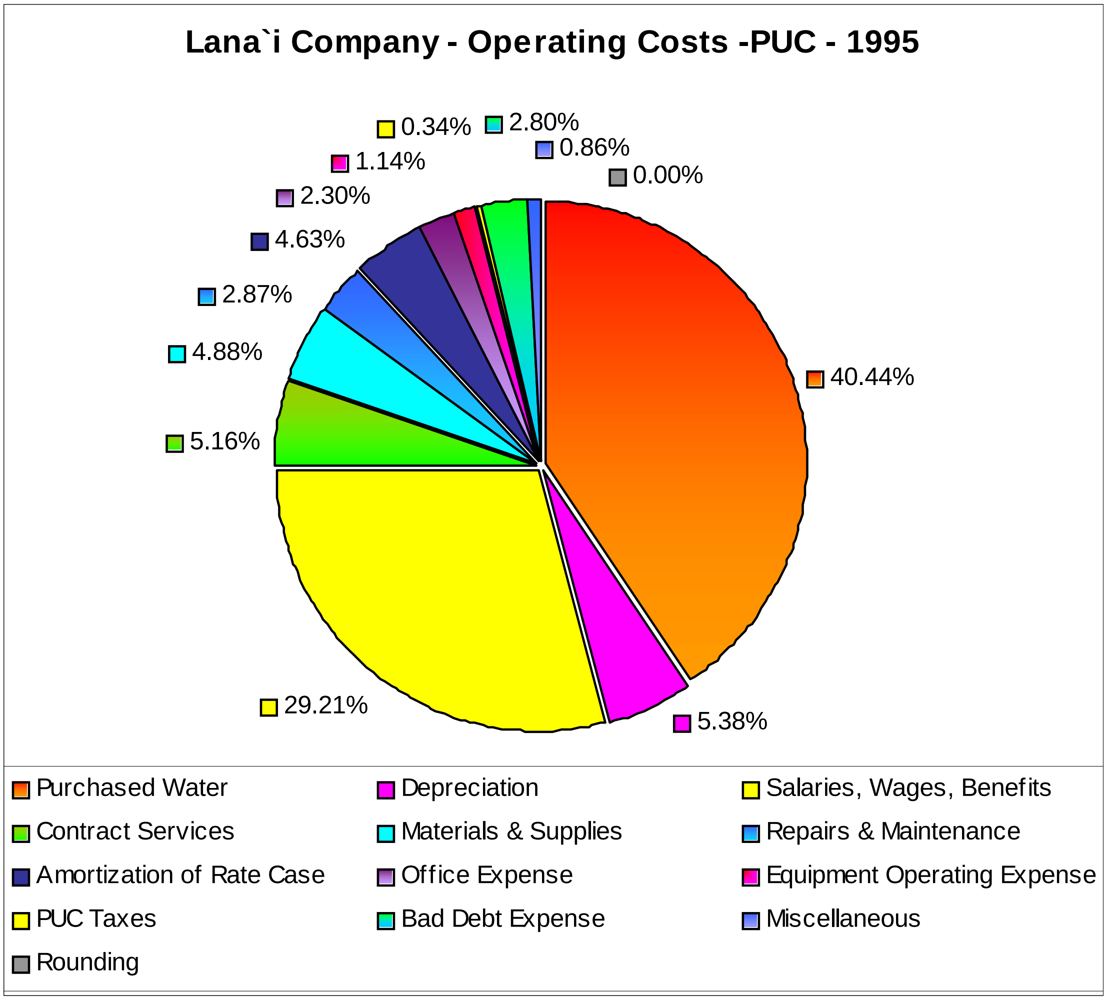


FIGURE 3-61. Current Rates & Charges - Potable Water

Use Charge (2 Month Billing Cycle)	Rate (per kgal)
First 25,000	$1.10
Over 25,000	$1.62

Tap-in-Charge per Connection	
Single Family Unit	$600.00
Multi Family Unit	$475.00
Commercial	$600.00
5/8" meter	$475.00
3/4" meter	$5,400.00
1-1/2" meter	$8,900.00
2" meter	$17,800.00
3" meter	$57,000.00
4" meter	$89,100.00
6" meter	$178,200.00
8" meter	$285,100.00
Agriculture	
5/8" meter	$700.00
3/4" meter	$1,000.00
1 inch meter	$1,700.00
1-1/2 inch meter	$3,500.00
2 inch meter	$5,700.00
Fee for inspection $30	
Fee for meter reinstallation dependent upon costs to company.	

Service Charge per 2 Month Billing Cycle	Rate
5/8"	$5.00
3/4"	$5.00
1"	$10.00
1-1/2"	$10.00
2"	$25.00
3"	$50.00
4"	$75.00
6"	$150.00
8"	$250.00
10"	$250.00
Hydrant	$80.00

FIGURE 3-62. Charges for Brackish Water - Manele-Hulopo'e As of July 31, 2009. PUC Docket 2008-0322.

Single Family		
Tier 1	<1,000 GPD per lot	$3.57
Tier 2	>1,000 GPD, <2,500 GPD	$4.64
Tier 3	>2,500 GPD	$5.72
Multi Family		
Tier 1	<1,000 GPD per unit	$3.57
Tier 2	>1,000 GPD, <2,500 GPD	$4.64
Tier 3	>2,500 GPD	$5.72
Homeowner's Association		
Tier 1	<1,000 GPD per acre	$3.57
Tier 2	>1,000 GPD, <2,500 GPD	$4.64
Tier 3	>2,500 GPD	$5.72
All Other		
Tier 1	<1,000 GPD per acre	$3.57
Tier 2	>1,000 GPD, <2,500 GPD	$4.64
Tier 3	>2,500 GPD	$5.72

Service Charge (meter reading) charge per meter per two month billing cycle

Meter Size	Rate Every Two Months
0.625	$ 5.00
0.75	$ 5.00
1.00	$ 10.00
1.50	$ 10.00
2.00	$ 25.00
3.00	$ 50.00
4.00	$ 75.00
6.00	$150.00
8.00	$250.00
10.00	$250.00

Water Facilities Capacity Charge Per Connection

Single Family Lot	$14,500
Multi Family Unit	$ 7,000
All Other	$14,500

FIGURE 3-63. Manele Water Resources, LLC. Fees for Sewer and Reclaimed Water As Of April 13, 2007. PUC Docket Number 2006-0166.

Monthly Flat Rate for Sewer Service

Residential		
	Single-Family	$56.74/ Month Per Dwelling
	Multi-Family	$42.21/Month Per Dwelling
Hotel		$92.12/Month per Guest room

Monthly Useage Charges:

Commercial/Recreational*		
	Non-Food Service	$ 9.98 per 1,000 Gallons of Potable Water Used
	Food Service	$10.07 per 1,000 Gallons of Potable Water Used
	Boat Harbor	$10.05 per 1,000 Gallons of Wastwater Pumped from DLNR Station

* These customers will also be charged a fixed service charge of $12.00 per month.

R-1 Reclaimed Water Sales

User Charge	$0.25/1,000 Gallons

FIGURE 3-64. Balance Sheet and Income Statement for Lana'i Water Company Inc. As Submitted for PUC Docket 2008-032

Exhibit H

Applicant's Balance Sheet and Income Statement

Docket No. 2008-________

LANAI WATER COMPANY

	10/31/2008	12/31/2007
Balance Sheet (unaudited)		
ASSETS:		
Cash	300.00	300.00
Accounts Receivable, net	83,297.57	211,440.39
Total Current Assets	83,597.57	211,740.39
Property, Plant & Equip	5,781,185.89	4,907,569.89
Accumulated Depreciation	1,260,213.36	1,194,784.79
Net Property, Plant & Equip	4,520,972.53	3,712,785.10
TOTAL ASSETS	4,604,570.10	3,924,525.49
LIABILITES & EQUITY:		
Accounts Payable	12,176,318.77	10,791,983.25
Accrued Liabilties	29,772.42	41,553.25
Income Taxes Payable	(270,078.93)	(329,851.28)
Total Current Liabilities	11,936,012.26	10,503,685.22
Deferred Taxes	(2,869,874.75)	(2,540,023.47)
Total Noncurrent Liabilities	(2,869,874.75)	(2,540,023.47)
Capital Stock	1,000.00	1,000.00
Other Paid-in-Capital	2,594,531.23	2,594,531.23
Retained Earnings - Beginning	(8,513,490.49)	(7,997,569.29)
- current p&l	(422,431.15)	(515,921.20)
- other	1,878,823.00	1,878,823.00
Retained Earnings - Ending	(7,057,098.64)	(6,634,667.49)
Total Equity	(4,461,567.41)	(4,039,136.26)
TOTAL LIABILITIES & EQUITY	4,604,570.10	3,924,525.49
Income Statement (unaudited)		
Net Sales	478,790.98	660,932.22
Cost of Sales/Operations (excludes selling cost; include selling depr/amort)	1,171,301.06	1,506,704.70
Operating Profit	(692,510.08)	(845,772.48)
Income Tax Provision	(270,078.93)	(329,851.28)
Net Income (Loss)	(422,431.15)	(515,921.20)

FIGURE 3-65. ***Pro Forma*** **Statement of Income for Non-Potable Brackish Operations of Lana'i Water Company, Inc., As Submitted for PUC Docket 2008-03222.**

Exhibit I
Docket No. 2008-_______

Applicant's *Pro Forma* Statement of Income (Non-Potable Operations)

OPERATING REVENUES		
Non-potable Water Revenues	$	253,184
Service Charges		2,340
Total Operating Revenues		255,524
COST OF OPERATIONS		
Purchased Water		166,014
Depreciation		2,695
Contract Labor		23,549
Amortization of Rate Case		100,000
Bad Debt Expense		5,110
PUC Taxes		16,315
Community Education		18,000
Total Operating Expense		331,683
NET OPERATING INCOME (LOSS) BEFORE INCOME TAXES		(76,159)
Income Taxes		
NET OPERATING INCOME (LOSS)	$	(76,159)
AVERAGE RATE BASE		45,362
RATE OF RETURN		-59.56%

FIGURE 3-66. Pro-Forma Balance Sheet - Lana'i Water Company Inc. Non-Potable Operations, As Submitted for PUC Docket 2008-0322

Exhibit J
Docket No. 2008-______

Applicant's *Pro Forma* Balance Sheet (Non-Potable Operations)

ASSETS

UTILITY PLANT:		
In service	$	53,896
Less accumulated depreciation		(9,882)
Total utility plant		44,014
Regulatory asset - net		200,000
TOTAL	$	244,014

LIABILITIES AND MEMBER'S EQUITY

LIABILITIES - Payable to affilitiates	$	320,173
MEMBER'S EQUITY		(76,159)
TOTAL	$	244,014

FIGURE 3-67. ***Pro-Forma*** **Income Statement for Manele Water Resources, LLC. As Submitted for PUC Docket 2006-0166**

		Proposed Rates	Reference
OPERATING REVENUES:			
Sewer service revenues and applicable service charges	$	458,781	MWR-202
R-1 water revenues		6,951	MWR-202
Total Operating Revenues		465,732	
COST OF OPERATIONS:			
Aqua Engineers Contract		279,185	MWR-206
Utilities - Electric		155,420	MWR-205
Insurance - Property		79,760	MWR-207
Maintenance - Equipment		31,590	MWR-208
Maintenance - Sewer Line		19,306	MWR-209
Chemicals		14,277	MWR-210
PUC tax expense		29,737	MWR-211
Admin salary allocation		8,892	MWR-212
Taxes - RPT		7,362	MWR-213
Utilities - Water		7,957	MWR-215
Amortization of rate case		6,667	MWR-216
Depreciation expense		541,444	MWR-204
Contract labor		3,318	MWR-214
Total Operating Expenses		1,184,915	
NET OPERATING INCOME (LOSS) BEFORE INCOME TAXES		(719,182)	[1]
Income Tax Expense			
NET INCOME (LOSS)		(719,182)	[2]; (a)
AVERAGE RATE BASE		2,105,933	[3]
RATE OF RETURN: NET OPERATING INCOME (LOSS) BEFORE DEPRECIATION & INCOME TAXES		-34.15%	[1] / [3]
RATE OF RETURN: NET INCOME (LOSS)		-34.15%	[2] / [3]

(a) Since MWR is not requesting to earn a return on a rate base in this filing, the net loss represents the revenue requirement deficiency.

FIGURE 3-68. Pro Forma Balance Sheet for Manele Water Resources, LLC. As Submitted for PUC Docket 2006-0166

Manele Water Resources, LLC
Balance Sheet - Proforma
For the twelve months ending June 30, 2007

Docket No. 2006-0166
Exhibit H
Page 1 of 1

ASSETS

UTILITY PLANT:	
In service	$ 10,969,054
Less accumulated depreciation	(9,133,843)
Total utility plant	1,835,211
Regulatory asset - net	13,333
TOTAL	$ 1,848,544

LIABILITIES AND MEMBER'S EQUITY

LIABILITIES - Payable to affiliates	$ 2,566,727
MEMBER'S EQUITY	(718,182)
TOTAL	$ 1,848,544

FIGURE 3-69. Estimated Operational Costs By Well. (Well Production Only - Does Not Include All Costs).

Groundwater Wells

Rough Operational Cost Estimates

AREA OF USE -->	LANA`I CITY & RELATED AREAS, KOELE PROJECT DISTRICT: POTABLE USES				MANELE PROJECT DISTRICT AND IRRIGATION GRID (PALAWAI BASIN & AREA MAKAI OF LANA`I CITY AWWTF): POTABLE USES				MANELE PROJECT DISTRICT IRRIGATION			
WELL NO. -->	**6**	**3**	**8**	**7**	**4**	**2**	**3**	**5**	**1*****	**9**	**14**	**12**
2008 Annual Pumpage (gal/year)	119,360,000	0	100,788,000	Not Used	248,927,700	880,000	0	Not used	143,409,000	55,124,000	147,316,000	Not Used
2008 Daily Pumpage (gal/day)	327,912	0	276,890	Not Used	682,000	2,000	0	Not used	393,000	151,000	404,000	Not used
Design Pumping Rate (gpm)	550	900	850	500	900	1200	900	900	600/300	300	350	100
Production Capacity Based on 16-Hour Operation (gal/day)	528,000	864,000	816,000	480,000	864,000	1,152,000	864,000	864,000	865,000	288,000	336,000	96,000
Pump Setting (ft) (Pump Intake Elevation)	863	866	783		1253	1335	866	1293	516	466		-5
Depth of Well (ft)	1320	1200	1489	1492	1178	(1) 812 (2) 596	1200	1122	1266	1450		620
Low Water Level *	880	874	910	650	1441	1350	874	1496	555	591	433	5
Ground El (CWRM)	1910	1850	1902	1775	2327	1510	1850	2296	1265	1411	1194	605
Grnd. El. Dest. Tank	1942	2025	2025	1942	1810	1810	1791		1353	1353	1353	
Pumping Lift (ft.)	1062	1151	1115	1292	886	460	976	800	798	820	920	600
(Kwh / kgal / kft)	5.00	5.00	5.00		5.00	5.00	5.00		5.00	5.00	5.00	
$ per Kwh	$0.400	$0.400	$0.400		$0.400	$0.400	$0.400		$0.400	$0.400	$0.400	
$ per Kgal (electricity)	$2.12	$2.30	$2.23		$1.77	$0.92	$1.95		$1.60	$1.64	$1.84	
Weighted District Cost	$2.17				$1.77				$1.71			

CHAPTER 4

Demand Analysis

In This Chapter

Key Points

- Historical pumpage on Lana‘i peaked at around 3.5 million gallons per day (MGD) in 1989. With the end of the pineapple economy in 1992, pumpage dropped to just under 2 MGD, gradually rising to 2.24 MGD in 2008 (2,241,222 GPD).

- Pumpage is reported in 13 MAV periods. After reconciling reported pumpage periods to match consumption, the resulting 2008 pumpage was 2.23 MGD. (2,231,876 GPD).

- Metered consumption in 2008 was about 1.66 MGD. (1,658,244 GPD).

Accounting for water source and pressure zone, water service can be broken down into roughly five service areas, with metered consumption as follows:

FIGURE 4-1. Metered Consumption by Service District Area - 2008 GPD

Service District Area	Abbreviation	2008 GPD	Wells Serving Area
Koele Project District	KOPD	149,128	6 & 8
Lanaʻi City	LCTY	358,008	6 & 8
Kaumalapau	KPAU	15,604	6 & 8
Manele Project District	MNPD	1,082,999	2 & 4 fresh 1, 9 & 14 brackish
Palawai Irrigation Grid	IGGP	52,505	2 & 4

2008 pumped water, metered demand and unaccounted-for water (UAFW) by Well Service Areas are shown below. Island-wide, unaccounted-for water was roughly 28.36% in 2008.

FIGURE 4-2. Pumped, Metered & Unaccounted-For Water by Well Service Area - 2008

Wells	Areas Served	Pumped Water 2008 MGD	Metered Demand 2008 MGD	Unccounted -For Water 2008%
6 & 8	Koele, Lanaʻi City, Kaumalapau	0.605	0.523	13.52%
2 & 4	Manele-Hulopoʻe, Palawai Irrigation Grid	0.683	0.375	44.61%
1, 9 & 14	Manele-Hulopoʻe Irrigation	0.944	0.760	18.76%
		2.232	**1.658**	
Note: Percents are accurate, but are average of twelve individual monthly amounts, so may not match precisely here.				

Opportunities for conservation and efficiency improvement on Lanaʻi are sufficient in degree to defer some new source development:

- Unaccounted-for water rates are high, particularly in the service areas of Wells 2 & 4. Much of this represents water losses which can be addressed by various repairs. In particular, as much as 200,000 GPD is estimated to be lost through leaking pipes in the Palawai Irrigation Grid.
- Island-wide, it is estimated that over 68% of pumpage, 1,131,512 GPD or more, is used for irrigation. Only about 44,401 of this is for agriculture. This indicates the potential for substantial savings from landscape efficiency programs. Even a modest program designed to reduce irrigation by 10% could result in over 100,000 GPD savings.
- per unit consumption rates in some areas are considerably higher than standards, also indicating opportunities for conservation.
- Analysis of building permit vintage indicates a theoretical “technical potential” for indoor savings of 175,192 GPD. If 57%, of this could be realized, it would represent 100,000 GPD.

In This Chapter

- Other conservation opportunities identified through the demand analysis include regular leak detection, regular water auditing, hotel conservation programs and incentives, and evaporation reduction from the brackish reservoir. These are addressed further, along with a conservation rate structure, in Chapter 5.

Forecasted demands range from 2.43 to 5.84 MGD, while build-out analysis points to demands as high as 7.13 MGD. Island-wide projections of demand in 2030 are shown in Figure 4-3. Projections broken out by well service area are also provided within this chapter.

FIGURE 4-3. Island-wide Projections for 2030 - Various Methods - Millions of Gallons Per Day (MGD)

Method	**Low**	**High**	**Base Range**
Time Trend	2.43	3.23	2.43 - 3.23
Forecast - Pumpage	2.98	5.84	3.03 - 4.10
Forecast Metered - Plus 12% UAFW LCTY, 15% MNPD	2.50	5.03	2.61 -3.53
Build-out - CCR 2006 Estimate * includes 12% UAFW			6.08
Build-out - CCR 2009 Estimate *includes 12% UAFW			6.97
Build-out - Re-Analysis of 2006 CCR proposal using system standards or forecast coefficients, adjusting existing uses to billed records, adding other known projects etc.*			6.29
Build-out - Re-Analysis of 2006 CCR proposal as above, adding Existing Phase I Project District Elements not included in proposal, updated scopes for affordable housing and HHL.			7.13
Build-out of **Phase II Only Plus** Other Known Projects			5.66
Note: 2030 build-out numbers shown in this table do NOT include resource reserves, but DO include water demands which may be met by means other than pumpage, such as use of reclaimed water, unidentified sources, desalinization or conservation and efficiency measures.			

- Without conservation, reclaimed water and/or other alternative sources, build-out of project districts plus other known projects at 2008 per unit consumption rates would result in total demands exceeding Lana‘i’s total sustainable yield.

Build-out proposals include a sizeable component of demand to be met by unidentified “alternate” sources, but do not include a component to be met specifically by conservation.

- The 2006 proposal included a total demand of 6,079,523 GPD worth of projects, of which roughly 4.163 MGD was to be met by pumping potable and brackish water, (3.411 potable and 0.752 brackish), 0.616 MGD was to be met by reclaimed water, and 1.3 MGD was to be met by one or more unidentified “alternative” sources.

- The 2009 proposal included a total demand of 6,969,848 GPD, of which roughly 4.208 MGD was to be met through pumping potable and brackish water, (3.374 MGD potable and 0.834

MGD brackish), 1.209 MGD was to be met by reclaimed water, and 1.553 MGD was to be met by one or more unidentified "alternative sources".

- The need for this unidentified source could be even greater than shown, due to project district elements not included in proposals, known projects for which estimates came in since the proposals, and unaccounted-for water rates which are higher than shown. A revised analysis of the proposals, plus other known projects, plus portions of the project districts which had not been included in the proposals resulted in total demands as high as 7.13 MGD, requiring pumpage as high as 5.8 MGD or potentially over 6 MGD to meet all demands.

- Based on this total demand, an effort was made to estimate how much alternative source might be realistically available from reclaimed water and conservation.

- Four hundred thousand to seven hundred thousand gallons per day (400,000 to 700,000) GPD was deemed to be a reasonably prudent estimate of available reclaimed water for the planning period, depending upon the progress of build-out.

- Conservation opportunities identified between this chapter and the next are folded into the capital plan in Chapter 5, for an estimated savings of 485,000 GPD. A substantial portion of that potential came from the analyses on unaccounted-for water, use types and end uses performed in this chapter.

Although the Project Districts were approved in 1986, only a small fraction of approved units have actually been constructed.

- In Manele, 16 out of a total 282 single family units have been built, although one hundred sixty-one (161) have received Phase II approval. Sixty-nine (69) out of a total 184 multi-family units have been built, although ninety-one (91) have received Phase II approval. Two hundred fifty (250) out of 500 hotel units have been built. Manele also has acreage for an additional golf course. In Koele, 13 out of a total 535 single family units have been built, though 255 have Phase II approval. Thirty-five (35) out of a total 156 multi-family units have been built, though 100 have received Phase II approval. One hundred and four (104) out of 253 hotel units have been built.

- Despite such a low percent of build-out in terms of unit-counts, consumption at the Manele Project District already exceeds the total demand initially estimated.

Analysis of demand led to the following conclusions:

- Absent alternative means of meeting demand, such as conservation, use of reclaimed water or desalinization, build-out of existing and pending entitlements would result in pumpage exceeding sustainable yield.
- Projected demands based on escalation factors derived from community plan forecasts are lower than build-out demand estimates. However, build-out estimates to date have been lower than actual build-out would be if existing trends continue.
- A target unaccounted-for water for planning purposes was identified as 12% for the service areas of wells 6 & 8 (Lana‘i City, Koele and Kaumalapau), and 15% for the service areas of wells 1, 9

In This Chapter

& 14 (Manele brackish) and Wells 2 & 4 (fresh water to Manele and the Palawai Irrigation Grid).

- Unaccounted-for water analysis identified substantial opportunity for conservation, which could offset or “serve” about 485,000 GPD of projected demand. Specific measures are discussed in Chapter 5.
- Due to the high conservation opportunity, a forecast elasticity of 1 was selected for new source planning, although a forecast elasticity of 1.5 was utilized for estimation of possible demand in the allocation table in Chapter 7. The difference is assumed to be met by conservation and other measures.
- Reasonable estimates of total reclaimed water that may be available to serve as source by 2030 were between 400,000 and 700,000 GPD.
- One subordinate recommendation is made in terms of data maintenance and use. The *Periodic Water Reports* would be more useful if it were broken down differently, either by the 3 well service areas or the 5 districts listed above. Monthly reporting might also facilitate water auditing.

Historical Source Use and Demand

When examining water demand in a community, one of the first tasks is to consider the major drivers of water use and how they are changing. Lanaʻi is a good example of how economic changes drive changes in water use.

For most of its 0.81 to 1.46 million year existence, Lanaʻi was uninhabited. The only consumption of water was by natural systems. The first known established consumption by humans and domestic animals started when the Hawaiians arrived on Lanaʻi during the 15th Century (1400s). Water was then used for human and animal consumption, and for cultivation of taro, sweet potatoes, bananas and other crops, as well as use incidental to aquaculture and fishing. The peak population prior to European contact is estimated at 3,000 to 3,250 people.

The early 19th century saw the introduction of both Europeans and large feral ungulate mammals such as goats, sheep, cattle and European hogs. Ranching began in about 1865. This was the main economic activity until the first sugar plantation was established in 1898. Not long thereafter, in 1921, the first pineapple crop was planted. Pineapple was the main use of water on the island for the next half a century. Pineapple production peaked during the 1980s. During that same decade, the first Project District was established on Lanaʻi in 1986. By 1990, plans had been announced to shift from pineapple to tourism. Pineapple cultivation ended in the early 1990s, with the last harvest in 1992. For the past two decades, water consumption on Lanaʻi has been primarily driven by the resorts and by construction related to the resorts.

The longest available pumpage record for Lanaʻi goes back to 1926. Pumpage data from 1926 to 2001 were plotted in the report *Current Status of Lanaʻi's High Level Aquifer as Portrayed by Data From Its Wells*, (Tom Nance for Lanaʻi Water Company, September, 2001). This data is presented in Figure 4-6. The time period plotted in this figure coincides roughly with the period from the inception of the pineapple economy to its end, and this fact is clearly reflected in the demand curve shown.

A March, 1977 report from Anderson & Kelly to Lanaʻi Land Company characterized demands from 1948 through 1977. The plot of this data in Figure 4-7, shows consumption during the heyday of pineapple. Municipal demand was fairly flat. Irrigation demand represented the lion's share of total demand. Overall demand showed seasonal peaks and valleys typical of a demand curve primarily driven by irrigation. At the time, irrigation demand was about 1.94 MGD and city demand was about 0.364 MGD.

FIGURE 4-6. Lana'i Pumpage and Precipitation - 1926 to 2001. Source: *Current Status of Lana'i's High Level Aquifer as Portrayed by Data From*

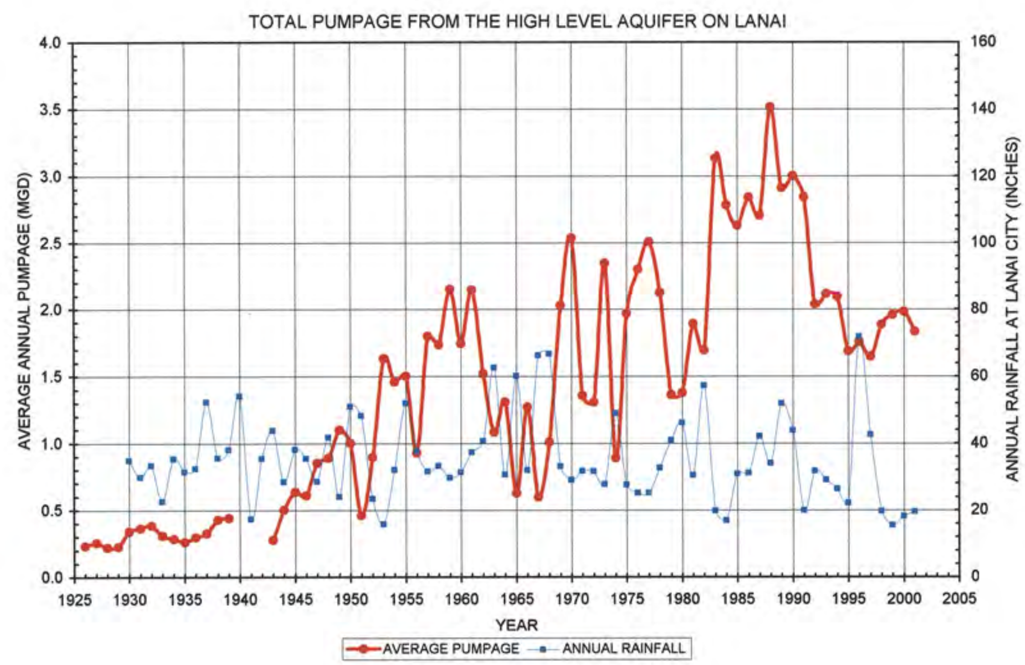
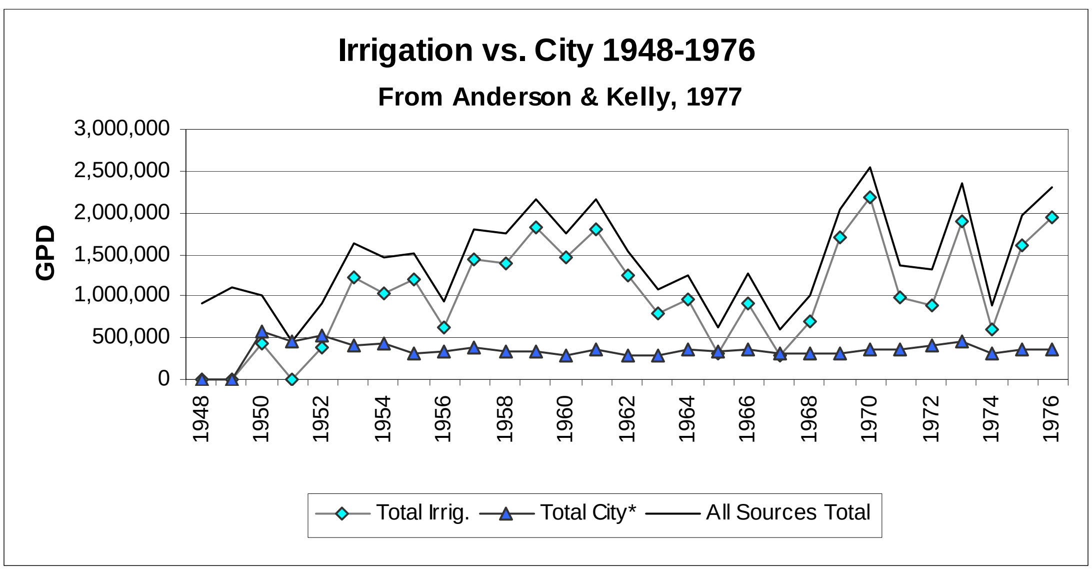


FIGURE 4-7. Lana'i Source Use 1948-1976; Source Anderson & Kelly Report to Lana'i Land Company, March 1977



Recent Production Records

Periodic Water Report

Pumpage data from 1985 to June of 2009 (Period 6, 2009), are shown in Figure 4-8 on the facing page. Annual average use on Lana‘i is calculated using a moving average of the thirteen periods (13 MAV) in the Lana‘i Water Company's *Periodic Water Report.* The upper graph in Figure 4-8 is a 13 period moving average. The lower graph shows the static of fluctuations between periods.

This report has historically referenced water deliveries in three areas, as shown in Figure 4-8:

- Lana‘i City
- Manele, Aoki Diversified Agriculture and Ag Activities Near the Airport (formerly titled "Irrigation")
- Kaumalapau

Historical pumpage on Lana‘i peaked at around 3.5 million gallons per day (MGD) in 1989, reflecting both pineapple use and the beginning of construction for the Project Districts. Pumpage dropped to just under 2 MGD with the end of the pineapple economy in about 1992. This decline was followed by a gradual rise to 2.24 MGD in calendar year 2008.

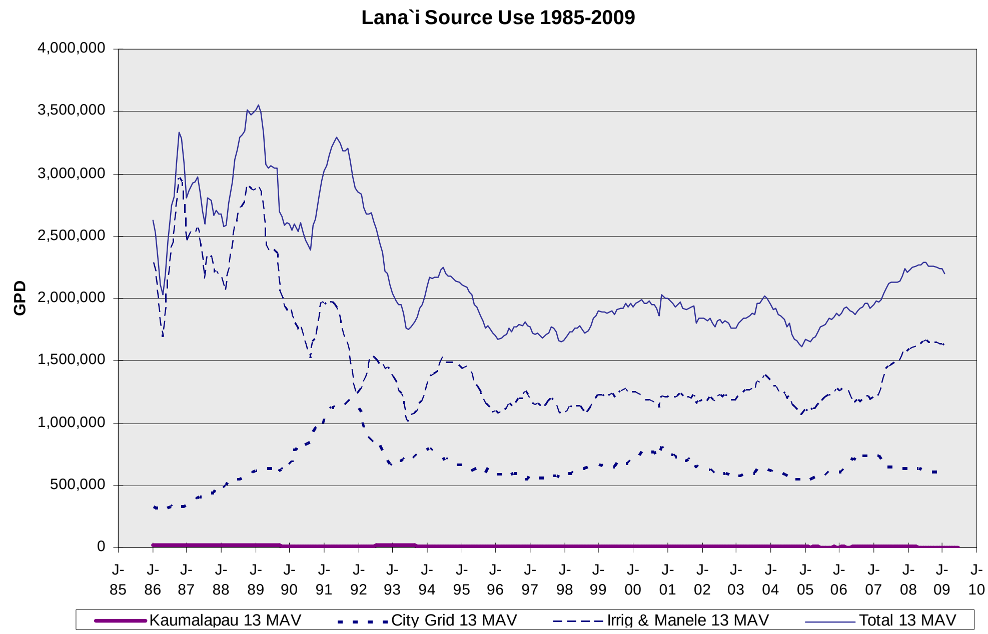
On a monthly basis historical withdrawals exceeded 4 MGD at times during the pineapple era, with one exceedence of 5 MGD in June of 1986. Irrigation use for the period entered peaked on a monthly basis in December of 1985. Irrigation use peaked on a moving annual average (13 MAV) basis in 1986, with additional peaks in 1988-1989. With the exception of two excursions between 2000 and 2005, monthly consumption has remained under 3 MGD since the end of the pineapple era.

The breakdown of water deliveries in the *Periodic Water Reports* is inherited from pineapple days. In the process of analyzing this data for the Water Use and Development Plan, it became clear that this structure is no longer the most direct portrayal of current service areas and districts. The *Periodic Water Report* would be more useful for analysis if it were revised to reflect either water served to the three well service areas, or the five service districts, defined by a combination of service area and major pressure zone, of Koele Project District (KOPD), Lana‘i City (LCTY), Kaumalapau (KPAU), Manele-Hulopo‘e (MNPD) and the Irrigation Grid in Palawai (IGGP). This is one of the recommendations of this document.

The *Periodic Water Report* provides pumpage in thirteen, twenty-eight day periods. This has not always been the case. For most of the period prior to 1982, pumpage was reported in 12 monthly periods. Billing is reported on a bi-monthly basis for Lana‘i Water Company, Inc. (LWCI) customers, and on a monthly basis for Lana‘i Holdings, Inc. (LHI) customers. For analytical purposes, it was necessary to account for the fact that pumpage and billing are reported in different time frames. In order to reconcile these periods and compare pumpage to consumption over consistent periods, the amount of water reported in each period was divided by the number of days in the period, and then apportioned based on the number of days actually in each month. For example, if a period were actually 30 days, and ran from January 30 to March 1, 1/30 would be assigned to January, 28/30 to February and 1/30 to March. Re-assignment of pumpage to actual month and year changed overall pumpage from 2,241,222 GPD to 2,231,876 GPD for calendar year 2008. Adjustments were also made to account for the fact that some billing is performed bi-monthly, while other billing is monthly, changing metered demand from 1,658,224 to 1,660,326. In all cases, adjustments resulted in changes of less than half a percent.

Recent Production Records

FIGURE 4-8. Source Use On Lana‘i 1985-2009 - 13 MAV and Monthly - in GPD



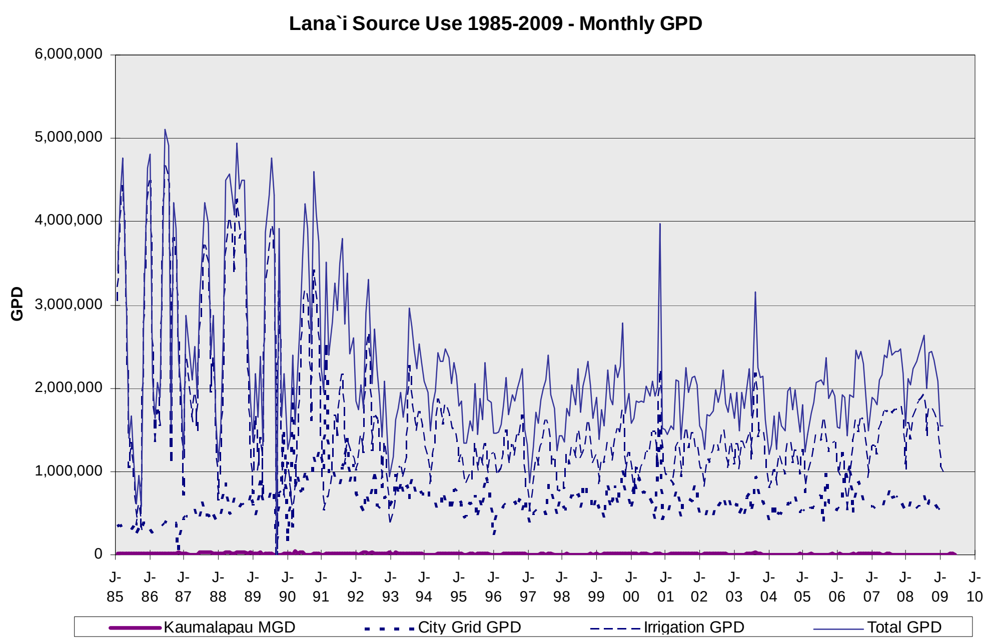
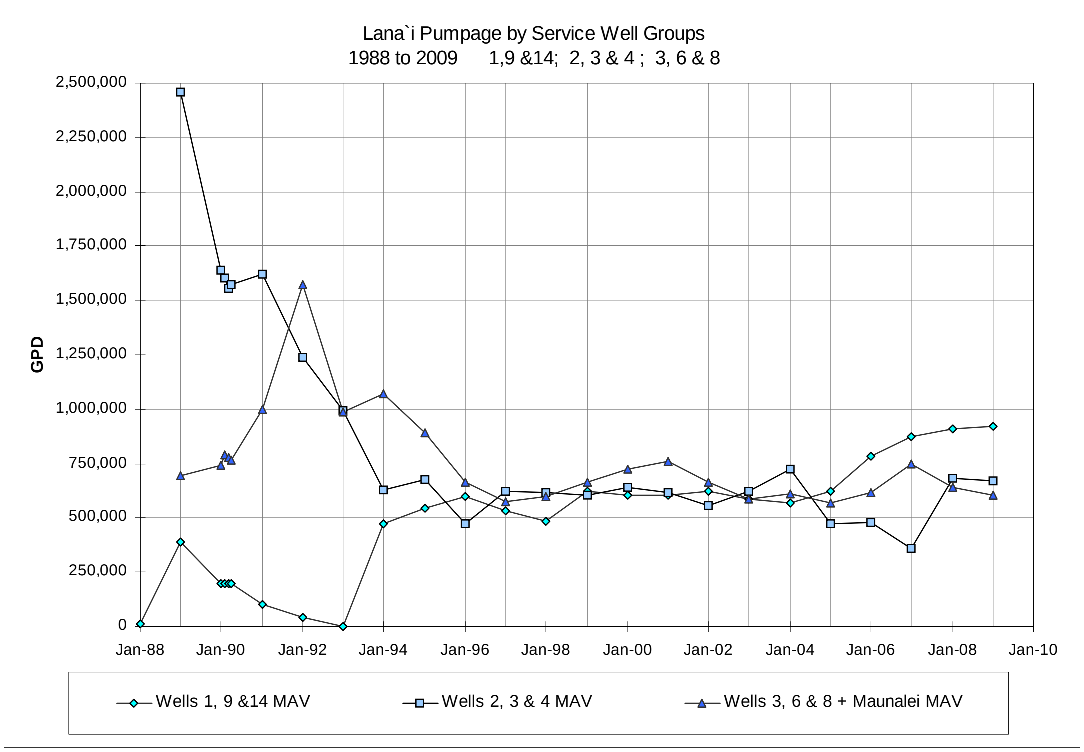


FIGURE 4-9. Annual Pumpage on Lana'i Broken Down By Well Service Areas



Production by Well Service Areas

Potable and brackish water service for the different regions on the island is divided into three main sets of sources. Figure 4-9 shows the relative pumpage by these groups of sources. Individual pumpage of each well was shown in Figures 3-60 to 3-77. The two potable water systems on Lana'i collectively use about 1.29 MGD. The brackish water system serving the Manele-Hulopo'e region uses about 0.94 MGD.

Lana'i City (LCTY), Koele (KOPD) and Kaumalapau (KPAU) receive potable water from Wells 6 and 8. Well 3 once served this area as well, but is currently out of service and will be replaced. Collective pumpage from Wells 6 and 8 was 605,046 GPD in 2008, with 54% coming from Well 6 and 46% from Well 8.

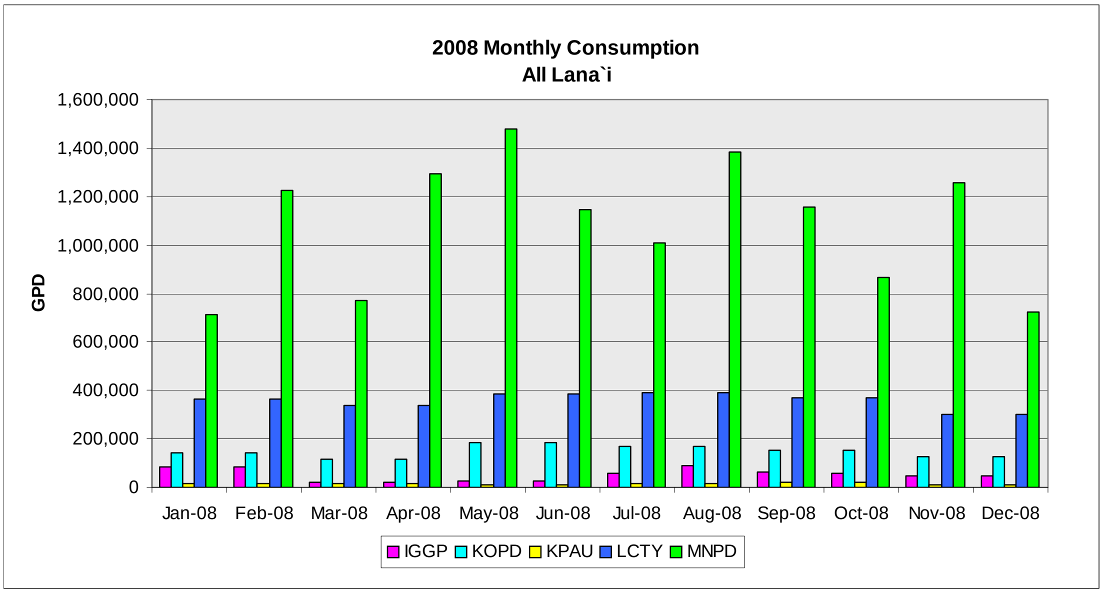
Manele-Hulopo'e (MNPD) and the Palawai Irrigation Grid (IGGP) receive potable water from Wells 2 and 4. Well 3 once provided water to this area as well. Well 2 is very rarely used due to safety issues. Collective pumpage from Wells 2 and 4 was 683,055 GPD in 2008, 99.7% of which came from Well 4.

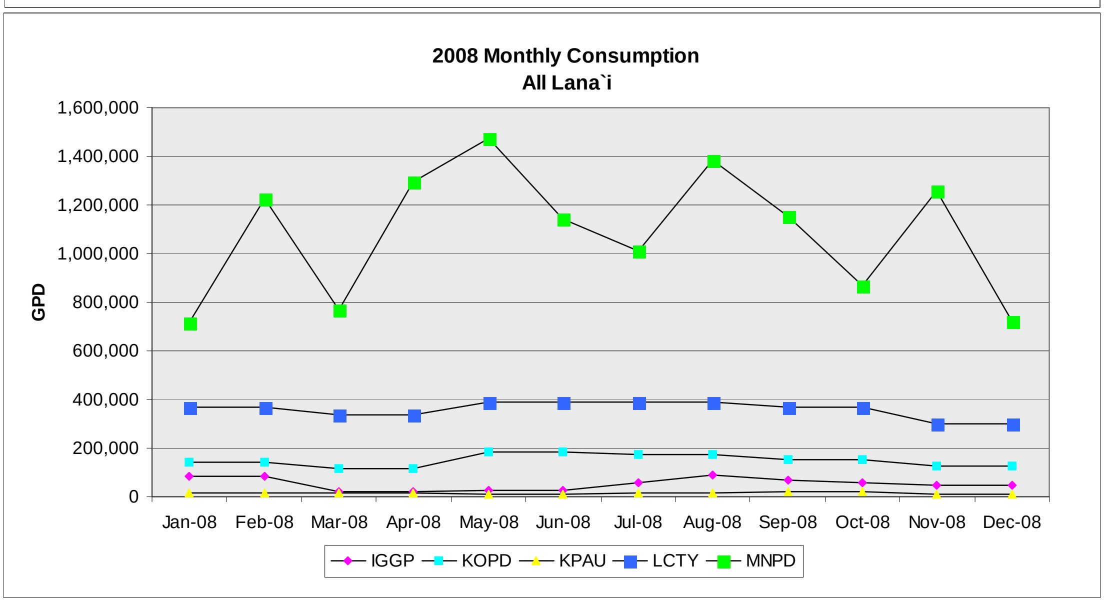
Wells 1, 9 and 14 serve brackish water for irrigation to the Manele area (MNPD). Collective pumpage from these wells in 2008 was 943,776 GPD, with 43% coming from Well 14, 41% from Well 1 and 16% from Well 9. The use of these wells has been the subject of heated community debate. The question at issues is whether maximum irrigation use from the high level aquifer for the Manele Project District should or should not exceed 650,000 GPD, based on County Ordinance 2133 and other past agreements and putative stipulations. Appeals are still in progress and the dispute is still unresolved as of this draft.

Recent Production Records

FIGURE 4-10. Seasonal Variation in Potable Water Consumption By District - 2008 Data

	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
IGGP	86,305	85,183	19,072	22,939	27,502	25,429	56,410	87,679	65,803	57,430	49,744	47,183
KOPD	143,578	143,677	116,983	116,983	183,690	183,690	171,442	171,442	153,672	153,672	124,901	124,901
KPAU	17,939	17,939	14,511	14,511	11,412	11,412	17,737	17,737	19,061	19,061	12,969	12,969
LCTY	366,590	366,590	336,940	336,940	387,218	387,218	389,009	389,009	367,659	367,659	300,271	300,271
MNPD	714,666	1,226,014	769,432	1,296,083	1,476,195	1,143,670	1,010,136	1,384,089	1,154,425	866,412	1,257,719	723,132
	---------	---------	---------	---------	---------	---------	---------	---------	---------	---------	---------	---------
	1,329,079	1,839,403	1,256,938	1,787,455	2,086,017	1,751,419	1,644,733	2,049,955	1,760,620	1,464,234	1,745,604	1,208,456





Seasonal Variation in Consumption

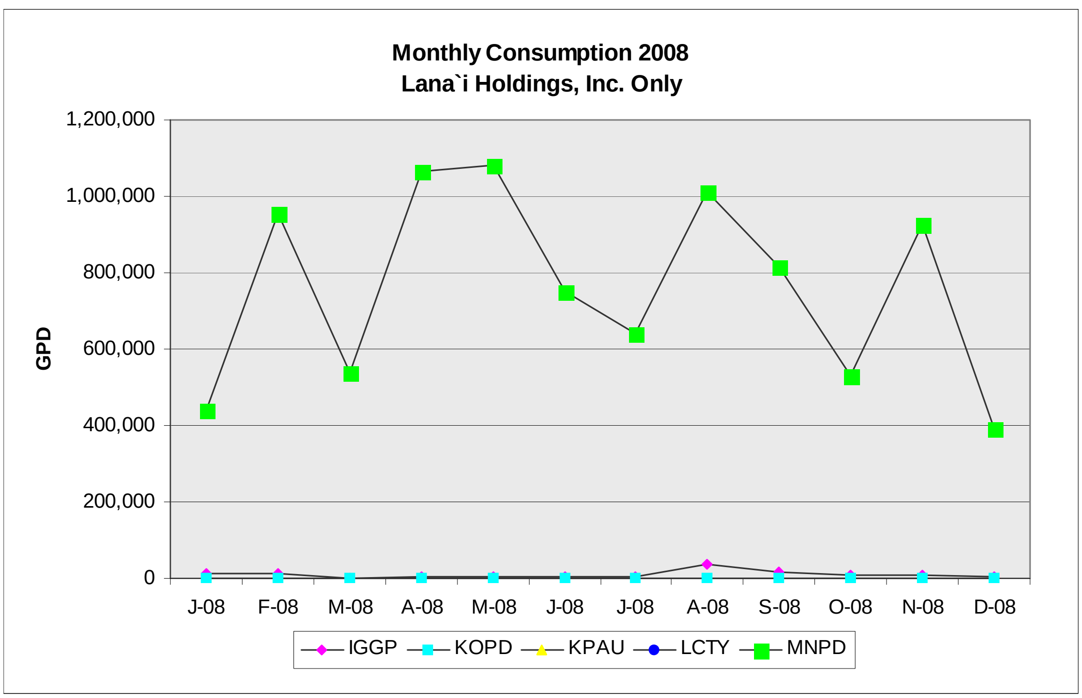
Average metered consumption on Lana‘i in 2008, according to the records provided, was 1,658,244 gallons per day (GPD). Meters are not read monthly, so some adjustments are necessary to break consumption into monthly increments, as described earlier. Small discrepancies are introduced between dividing by total number of days in a year, vs. applying pumpage to the days in each month of a period, dividing by those and then averaging, and in certain cases breaking these out further by class or district. As mentioned earlier, the differences are less than half of a percent. This analysis is valuable for considering seasonal trends.

As shown in Figure 4-10, water demand on Lana‘i shows a strong seasonal variation. Island-wide, metered consumption fluctuated 877,561 GPD from the lowest to the highest month, with the high minus the average at 425,691 GPD. This indicates that consumption is heavily influenced by irrigation demand.

The next question examined was whether any portion of this trend reflected irrigation use in meters which were not specifically dedicated to irrigation. In Figure 4-10, Lana‘i Water Company and Lana‘i Holdings demands for the Manele-Hulopo‘e areas are combined, which has the effect of flattening the areas with lower consumption. To examine seasonal trends in these user classes, as well as potential irrigation use by “non-irrigation” meters, these trends are further broken out in Figures 4-11 to 4-15.

Consumption of meters from Lana‘i Holdings, Inc. and Lana‘i Water Company Inc. are shown separately in Figures 4-11 and 4-12, below.

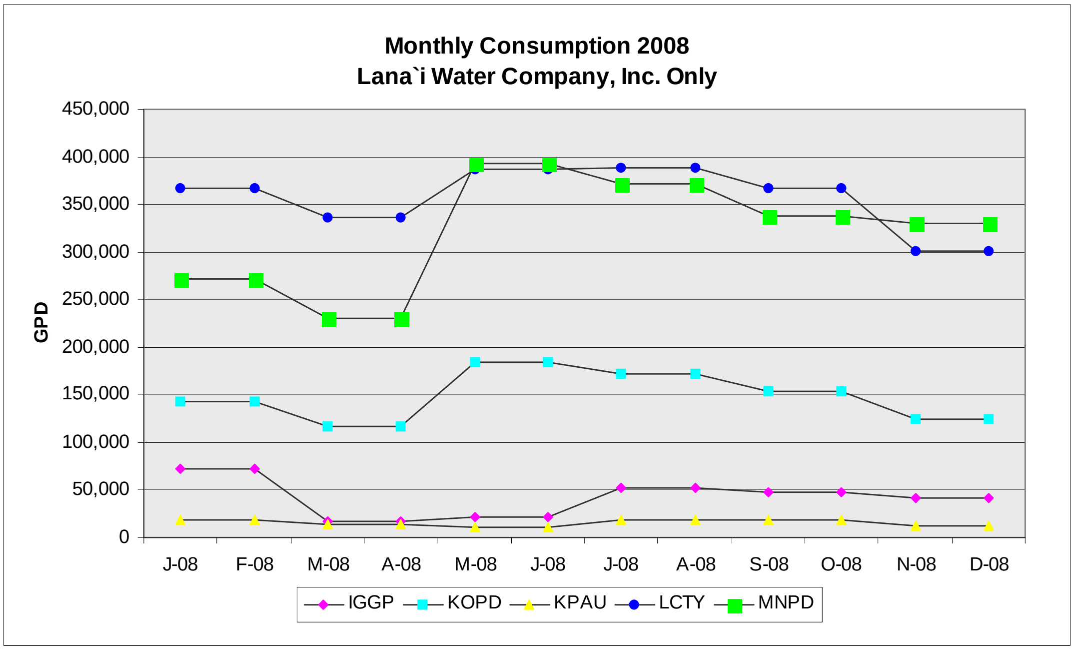
FIGURE 4-11. Seasonal Variation in Lana‘i Holdings, Inc. Consumption - 2008 Data



Note: This is a graph of Lana‘i Holdings meters only. Some communities are not visible in this graph because Lana‘i Holdings has few or no meters in those areas.

Recent Production Records

FIGURE 4-12. Seasonal Variation in Lana‘i Water Company, Inc. - 2008 Data



Lana‘i Holdings, which serves the majority of irrigation meters, has a distinct seasonal variation. The difference between the lowest and the peak months was 690,810, with peak minus average at 316,054 GPD.

Lana‘i Water Company meters also showed a marked seasonal response, with about 286,054 GPD between the lowest and highest months and 114,689 GPD between the peak and average months. These numbers indicate that irrigation is a substantial component of both potable consumption and non-potable use. As the graphs reveal, LHI meters are read monthly, while LWC meters are read bi-monthly.

Service District and Type of Use

With the help of Lana‘i Water Company staff, meters were assigned to use types. These are presented in the table in Figure 4-13, as printed from the billing database.

One small discrepancy is noted for data integrity purposes. One account registered a negative balance, in the amount of -1 GPD. This may be a data error or may simply reflect a meter replacement or billing adjustment. This was a construction meter in the Koele Project District area. To remain consistent with billing records and totals, and so as not to alter other totals previously run, the number was left as-is. One gallon per day was not deemed serious enough to invalidate either billing records or analyses. The discrepancy would not be worthy of note other than its appearance in Table 4-13.

FIGURE 4-13. Metered Consumption By Service District Area and Type of Use - 2008 GPD

IGGP	COMM		3,460	
	DEVEL		81	
	GOV		5,764	
	IRR-AG		28,044	
	IRR-DEV		6,225	
	IRR--GEN		8,932	
				52,505
KOPD	COMM		0	
	DEVEL		-1	
	HOT		30,961	
	IRR-AG		84	
	IRR-DEV		1,043	
	IRR-GEN		33	
	IRR-GOLF		14,286	
	IRR-HOT		51,880	
	IRR-MF		4,662	
	PQP		390	
	RES-MF		20,625	
	RES-SF		25,164	
				149,128
KPAU	COMM		14,058	
	IRR - SF		1,358	
	RES-SF		189	
				15,604
LCTY	COMM		43,311	
	DEVEL		296	
	GOV		10,180	
	HOT		3,125	
	IRR-AG		6,044	
	IRR-DEV		156	
	IRR-GEN		26,996	
	PQP		1,321	
	RES-MF		49,393	
	RES-SF		217,187	
				358,008
MNPD	COMM		21,179	
	DEVEL		34	
	HOT		238,016	
	IRR-AG		10,229	
	IRR-DEV		40,998	
	IRR-GEN		20,273	
	IRR-GOLF		596,009	
	IRR-HOT		1,280	
	IRR-MF		86,943	
	IRR-SF		36,388	
	PQP		6,507	
	RES-MF		9,847	
	RES-SF		15,295	
				1,082,999
			1,658,244	1,658,244

Recent Production Records

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FIGURE 4-14. Metered Consumption by Month and Type of Use

	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
	31	29	31	30	31	30	31	31	30	31	30	31
AG	41,841	43,047	20,539	21,883	38,034	37,223	60,299	61,653	52,185	52,174	51,681	51,698
IRR	601,266	1,110,364	628,963	1,158,098	1,235,152	901,395	780,447	1,184,293	974,602	678,250	1,041,608	504,504
COMM	65,378	65,378	51,299	51,299	70,151	70,151	111,347	111,347	107,639	107,639	85,478	85,478
DEVEL	654	654	387	387	380	380	467	467	286	286	293	293
GOV	12,804	12,804	13,626	13,626	11,133	11,133	21,355	21,355	21,079	21,079	15,528	15,528
HOT	268,905	268,905	210,435	210,435	361,453	361,453	281,341	281,341	255,193	255,193	255,082	255,082
PQP	5,002	5,002	5,965	5,965	12,042	12,042	9,710	9,710	7,650	7,650	8,860	8,860
RES-MF	71,332	71,332	83,778	83,778	90,639	90,639	99,264	99,264	67,140	67,140	66,581	66,581
RES-SF	261,907	261,907	241,966	241,966	267,019	267,019	280,516	280,516	274,834	274,834	220,461	220,461
	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	1,329,088	1,839,393	1,256,957	1,787,436	2,086,002	1,751,435	1,644,745	2,049,944	1,760,608	1,464,246	1,745,573	1,208,486

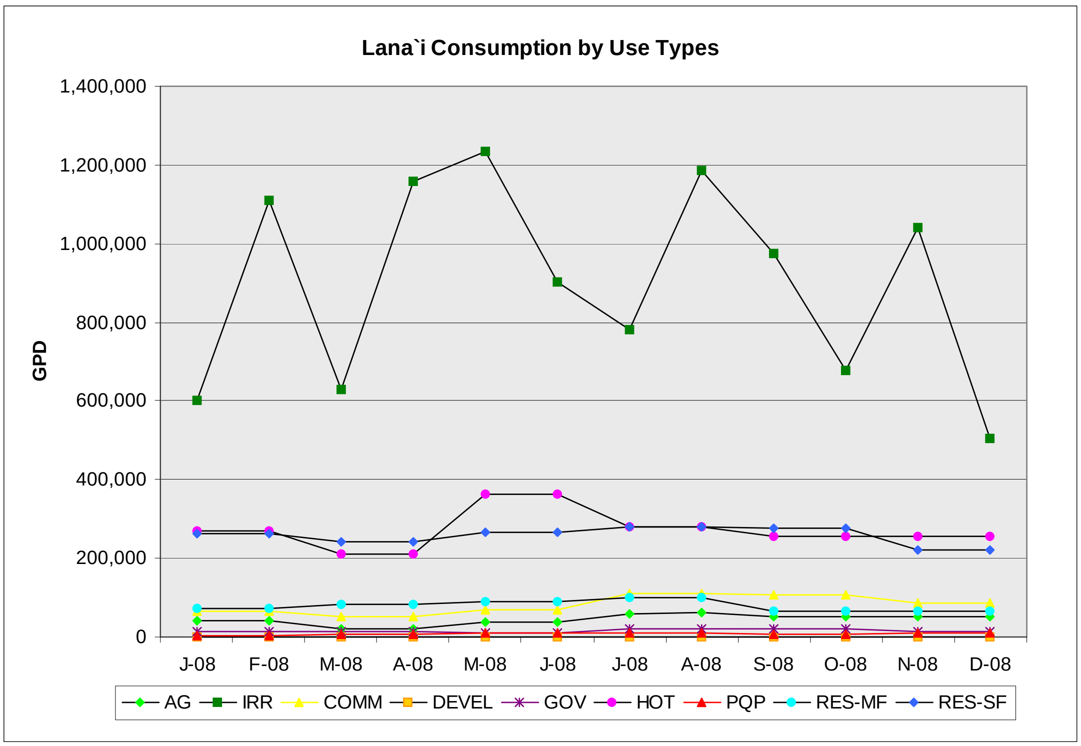
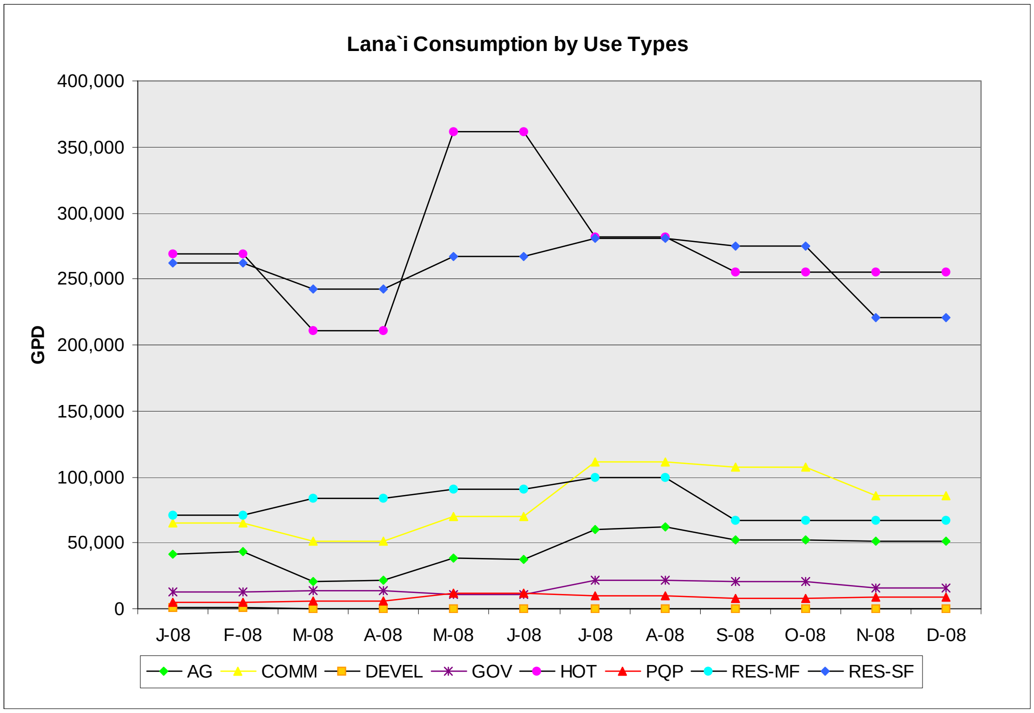


Figure 4-14 shows monthly consumption by type of use. As would be expected, the irrigation curve is dominant, with the most marked seasonal variation. Other uses appear flatter at this scale. However, as shown on the following page, these uses also demonstrate marked fluctuations. This indicates that irrigation use is a substantial component of the majority of meters, and not merely the specifically assigned irrigation meters.

FIGURE 4-15. Lana'i Consumption By Use Type - Irrigation Meters Removed To Examine Seasonal Trends of Other Use Types



Removing the irrigation curve for closer examination, in Figure 4-15, one finds that with the exception of development use, all use types exhibit seasonal trends. Even the flatter looking trends here, government use and public-quasi-public use, exhibit marked seasonal variation if shown at sufficiently detailed scale. Marked seasonal increases are generally the result of a portion of water for each use going to landscape irrigation.

To derive a conservative estimate of irrigation use by hotel and single family meters, consumption by these meters was compared to Statewide System Standards. Amounts exceeding standards were assumed to reflect irrigation. Statewide system standards generally include some assumed irrigation use, so this adjustment would yield a conservative estimate of additional irrigation use. Based upon discussion with LWCI staff and community members, it was also assumed that 2/3 of water consumption at Manele Harbor was for irrigation. The results of this adjusted analysis are shown in Figure 4-16.

Combining agricultural use with other irrigation use, the adjusted analysis resulted in an estimated 1,131,512 GPD used for irrigation island-wide (1,087,111 general irrigation. + 44,401 agriculture) or about 68% of metered use. Most of that is used in the Manele Project District Area. This estimate is actually fairly close to estimated existing use for irrigation contained in the build-out proposal by Castle and Cooke submitted July 28, 2009. It is considered likely that actual irrigation use is higher still, given the seasonal fluctuations noted above.

All of non-potable water consumed, about 760,357 GPD is used for irrigation. With the adjustment below, it is estimated that 371,155 GPD of potable water is also used for irrigation. This is likely a conservative estimate.

FIGURE 4-16. Consumption by Meter-Assigned User Classes and Adjusted User Classes

	By Meters	Adjusted
AG	44,401	44,401
OTHER IRR	897,462	1,087,111
COMM	82,007	66,772
DEVEL	411	411
GOV	15,944	15,944
HOT	272,102	123,200
PQP	8,218	8,218
RES-MF	79,865	79,865
RES-SF	257,835	232,323
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	1,658,244	1,658,244

With irrigation representing such a high proportion of total use, opportunities to offset new source development with landscape and irrigation efficiency improvements look promising. Further analysis of landscape savings opportunities is warranted. Reductions between 10% to 25% are quite often possible in resort areas where empirical consumption is so much higher than standards, and have recently been demonstrated by some South Maui hotels. Savings of this order of magnitude could yield between 100,000 GPD and 400,000 GPD. More dramatic savings are possible.

Of roughly 1.1 MGD estimated total irrigation use, roughly 610,000 GPD was classed specifically as golf course use, of which 596,009 was attributed to the *Challenge at Manele*. That tally does not include clubhouse uses and landscaping, or irrigation along related service roads.

Prior to adjustments, the largest type of use other than irrigation is hotel use. After adjustments for irrigation, the largest use is residential use, followed by hotel use. Apart from the golf courses, the hotels are the largest individual customers on Lana‘i.

In terms of per unit consumption, residential use on a per-customer basis in the hot, dry Manele Project District area far exceeds that in Lana‘i City. Combined fresh and brackish use in Manele single family homes averaged 3,200 GPD during calendar year 2008, and about 3,700 during the 18 month period from January 2008 through June of 2009. Potable use was roughly 900 to 1,000 GPD, with the remainder brackish. The highest and lowest average uses were 9,492 and 662 GPD, respectively with essentially zero fresh water use on the lowest end. Despite such high average per unit consumption, the total metered use for SF residences in Manele is only about 8% of metered consumption from Wells 2 and 4. never the less, the single family homes in Manele utilize more water than all the agriculturally classed meters on the island.

In contrast, average consumption among single family homes in Lana'i City was 221 GPD. Fifty single family accounts in Lana'i City exceeded 500 GPD, and five accounts exceeded 1,000 GPD, with a high use of 1,699 GPD. Average single family use in Koele was 503 GPD, with a high of 2,138 GPD. However the newer, Project District homes tended to use more, with an average use of about 1,000 GPD. Residences in Kaumalapau were occupied too sporadically to derive a meaningful average use.

Multi-family use per unit patterns were a bit different. Multi-family use averaged 315 GPD in Lana'i City, 546 GPD in Manele and 722 in Koele, including irrigation. The multi-family numbers in Manele may underestimate irrigation, as they are restricted to meters specifically labelled for Multi-Family irrigation and may not include some common area use. In addition, many of the units appear to be unoccupied or only sporadically occupied.

End Uses

As the major general water use on the island, at about 1.13 MGD, irrigation should be carefully inventoried by acreage, purpose, plant material, presence or absence of rain shut-offs and soil moisture sensors, irrigation equipment and control systems, weather and evapotranspiration data, and other factors, in order to identify and site-specifically tailor appropriate and effective efficiency measures.

The hotels are the island's largest individual water customers, and as such, also represent one of the largest opportunities for demand side efficiency. It would be beneficial to conduct a site specific inventory of water uses and savings opportunities at each of the hotels. Water uses at hotels generally include irrigation, pools and water features, spas, salons and exercise centers, cooling, ice-making, cooking and washing in kitchens and restaurants, guest service policies, laundries and linen washing, gastronome, cleaning and maintenance, support facilities and other uses. Specific efficiency measures for each of these uses are available in industry literature. Some discussion of such measures is found in the next chapter of this plan.

A basic analysis of domestic end uses for residents and visitors is presented in the table in Figure 4-17. Information on building vintage and changes to plumbing codes over time was used to derive estimates of the prevalence and efficiencies of various appliances and fixtures. A weighted average per capita use was then derived based upon these efficiencies. These factors were then applied to de facto population, to derive estimated domestic needs for Lana'i.

Based upon this analysis, an estimated 358,338 GPD is used for typical indoor domestic uses on Lana'i. This estimate includes indoor domestic uses of visitors as well as residents. However, it does not include all non-irrigation uses. For example, water actually consumed in cooking or drinking, or water used for cooling at the hotels, would not be reflected in this estimate.

If 100% of the calculated savings potential were achieved, these domestic uses could be reduced to 183,146 GPD, a theoretical savings potential of 175,192 GPD. It should be noted that it is rarely possible to achieve full savings potential. Certain measures may not be cost-effective, or there may be errors in estimating penetration of appliance vintages and efficiencies, or behavioral patterns that don't conform to calculations. never the less, such analysis is useful for an order of magnitude estimate of potential savings. These results are discussed further in the Supply Options chapter of this document.

Recent Production Records

FIGURE 4-17. Residential End Uses

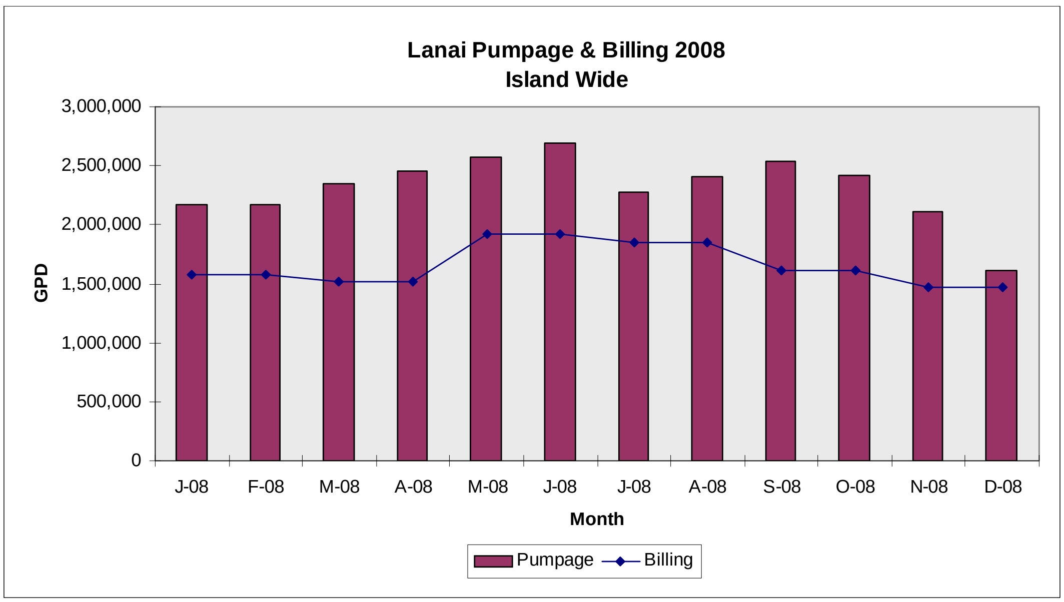
Building Vintage			**Toilets**			**Shower**			**Bath**			**Faucets**		
(From analysis based on 2007 Maui Tax Division data)	Count	Percent	Unit Water Use Gallons Per Flush		% * GPF	Unit Water Use Gallons per Minute		% * GPM	Unit Water Use Gallons per Bath			Unit Water Use Gallons Per Minute		% * GPM
Pre - 1950	601	26.72%	7.0		1.9	4.3		1.1	30.0		8.0	3.3		0.9
1950 - 1980	187	8.31%	5.0		0.4	4.3		0.4	30.0		2.5	3.3		0.3
1981 - 1993	791	35.17%	3.5		1.2	2.0		0.7	30.0		10.6	2.0		0.7
1994 - 2007	670	29.79%	1.6		0.5	1.7		0.5	30.0		8.9	1.7		0.5
Resulting Unit Water Use ==>					4.0			2.7			30.0			2.4
					~			~			~			~
Use Intensity					5.1			5.3			0.2			8.1
Daily Water Use Gallons per Capita					20.4			14.4			6.0			19.2
Daily Water Use If All Fixtures Were Highly Efficient					6.5			8.0			6.0			8.1
Savings If All Fixtures & Uses Were Water Efficient			1.6		12.2	1.7		5.4	30.0		0.0	1.7		5.4
Savings If All Fixtures Were Highly Water Efficient			1.28		13.8	1.5		6.5	30.0		0.0	1.0		11.1
			Dishwasher		% *		**Washing Machine**		% *		**Total Indoor Domestic**			
Appliance Vintage			%	GP Load	GPLoad		%	GP Load	GPLoad					
>10 Years			1.7%	14.0	0.2		1.7%	56.0	1.0					
</= 10 Years			58.8%	11.0	6.5		97.3%	43.0	41.8					
Conserving			39.5%	7.0	2.8		1.0%	27.0	0.3					
					~				~					
Unit Water Use ==>					9.5				43.1					
Use Intensity					0.1				0.4					
Daily Water Use Gallons per Capita					0.9				15.9	Daily Water Use Gallons per Capita				76.8
Daily Water Use If All Fixtures Were Efficient					0.7				10.0	Per Capita Water Use w/100% Efficient Fixtures				39.3
Savings If All Fixtures Were Water Efficient			7.0		0.2		27.0		5.9	Per Capita Savings If All Fixtures Highly Efficient				37.6
De facto Population			4,664.0											
			Daily Water Use			**Daily Use With Highly Efficient Fixtures**					**Technical Savings Potential**			
			Toilets		95,003	Toilets		30,447			Toilets		64,556	
			Showers		67,236	Showers		37,079			Showers		30,157	
			Baths		27,984	Baths		27,984	* no chg		Baths		0	
			Faucets		89,388	Faucets		37,778			Faucets		51,610	
			Dishwashers		4,417	Dishwashers		3,265			Dishwashers		1,152	
			Clothes Washers		74,310	Clothes Washers		46,593			Clothes Washers		27,716	
			Total		358,338	Total		183,146			Total		175,192	

Unaccounted-For Water

Unaccounted-For Water Island-wide

Unaccounted-for water consists of both losses and non-metered uses. Non-metered uses may include fire demand, street cleaning, illegal hook-ups, or legal services that are un-metered, as well as system leaks and losses. Unaccounted-for water is non-revenue water, and for this reason as well as resource protection, utilities strive to minimize it. However, some unaccounted-for water is unavoidable. Unaccounted-for water is typically higher in older systems than in newer ones. Based upon data provided, island-wide unaccounted-for water on Lanaʻi averaged about 28.36%, as shown in Figure 4-18.

FIGURE 4-18. Lanaʻi Pumpage and Billing - Island Wide Unaccounted-for Water



Unaccounted-For Water by Public Water System (PWS) Area

In an effort to locate this unaccounted-for water, pumpage vs. metered consumption in 2008 was plotted for the two Public Water Systems (PWSs): PWS 237, Koele, Lanaʻi City & Kaumalapau; and PWS 238, Manele-Hulopoʻe and the Irrigation Grid. This effort was undertaken before staff had data to differentiate potable vs. non-potable uses. The results are shown in Figures 4-19 & 4-20.

Recent Production Records

FIGURE 4-19. Unaccounted-for Water in PWS 237 - Koele, Lana'i City & Kaumalapau Regions

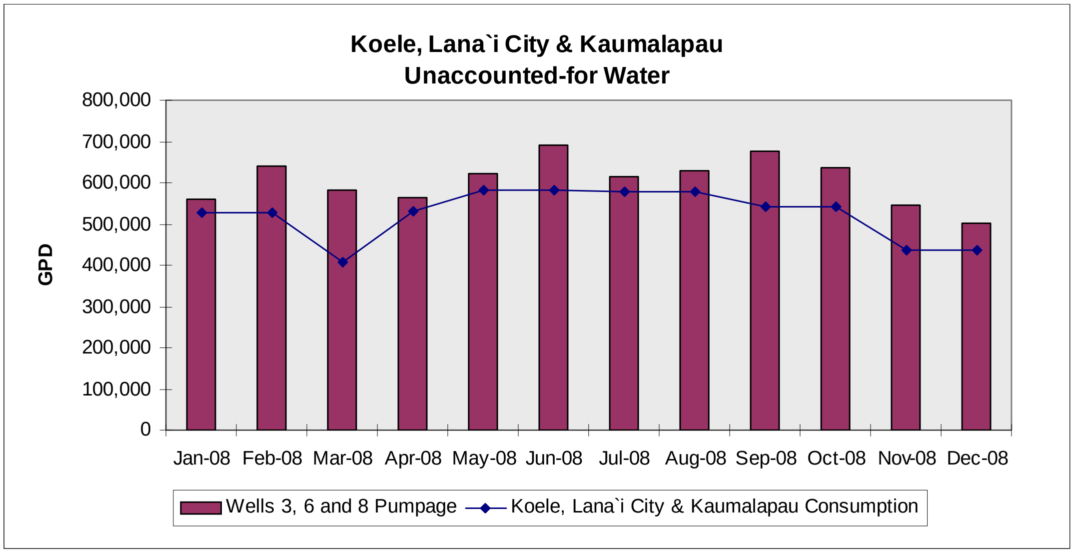
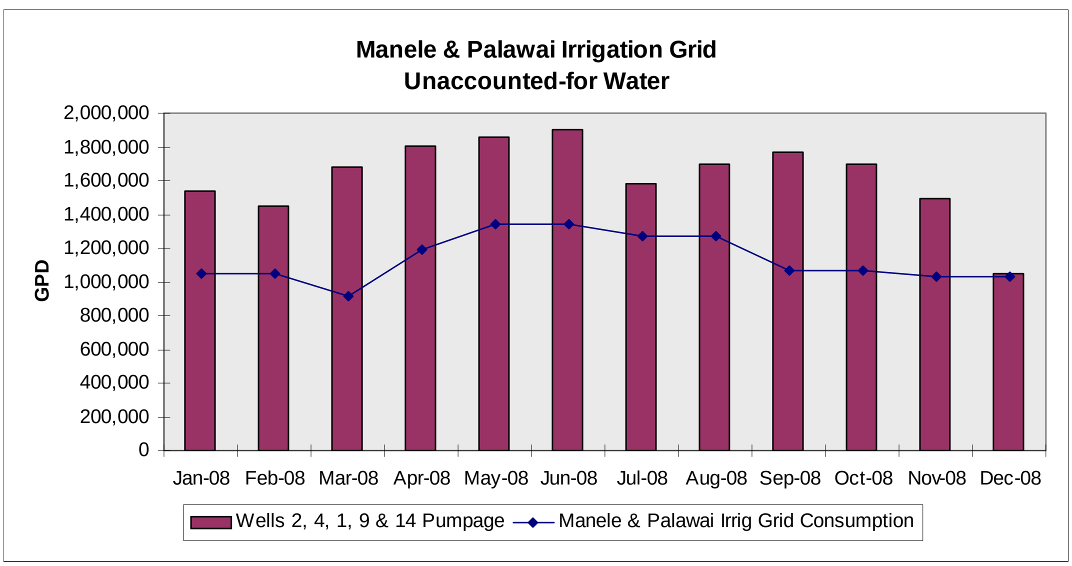


FIGURE 4-20. Unaccounted-for Water in PWS 238 - Manele & Palawai Irrigation Grid Regions



As described previously, the reading period dates in the *Periodic Water Reports* were used to re-aggregate pumpage to the actual month in which it occurred, and compare to billing for the same month. Using this re-assignment method, total pumpage in 2008 was 2,231,876 GPD. Of that, 1,626,573 GPD came from Wells 2 ,4, 1, 9 and 14, which collectively serve the Manele-Hulopo‘e area and the Palawai Irrigation Grid with potable and non-potable water; while 604,684 GPD came from Wells 3, 6 and 8, which serve Koele, Lana‘i City and Kaumalapau. Metered consumption was also summed and re-aggregated to each month based upon meter read dates.

Unaccounted-for water in PWS 238, the Manele-Hulopo‘e and the Palawai Irrigation Grid averaged about 29.21%.

Unaccounted for water in PWS 237, the Koele, Lana‘i City and Kaumalapau areas averaged about 13.52%.

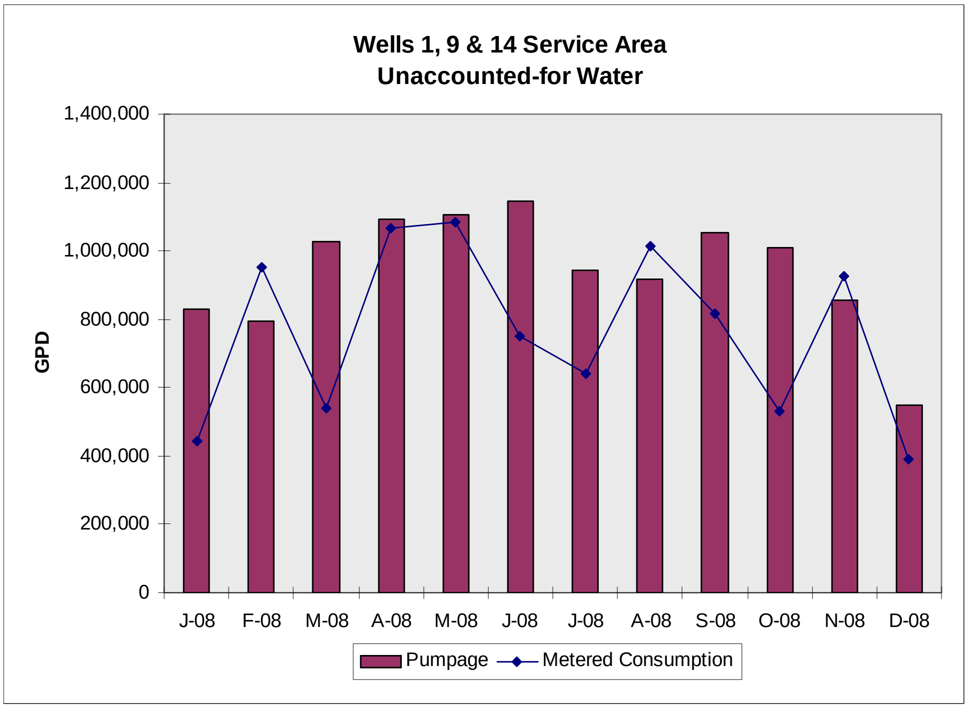
Based upon these results, it appeared that there may be substantial opportunity to offset capital investment for new source by investigating and reducing unaccounted-for water. Therefore, a second analysis was run .

With assistance from Lana‘i Water Company, Inc. (LWCI), accounts were identified as either potable, non-chlorinated fresh water or brackish water accounts. Utilizing this information, it was possible to further locate unaccounted-for water by the three sets of sources serving different areas and uses. The results of this additional analysis are shown in Figures 4-21, 4-22 and 4-23, on the following pages.

Unaccounted-For Water By Well Service Area

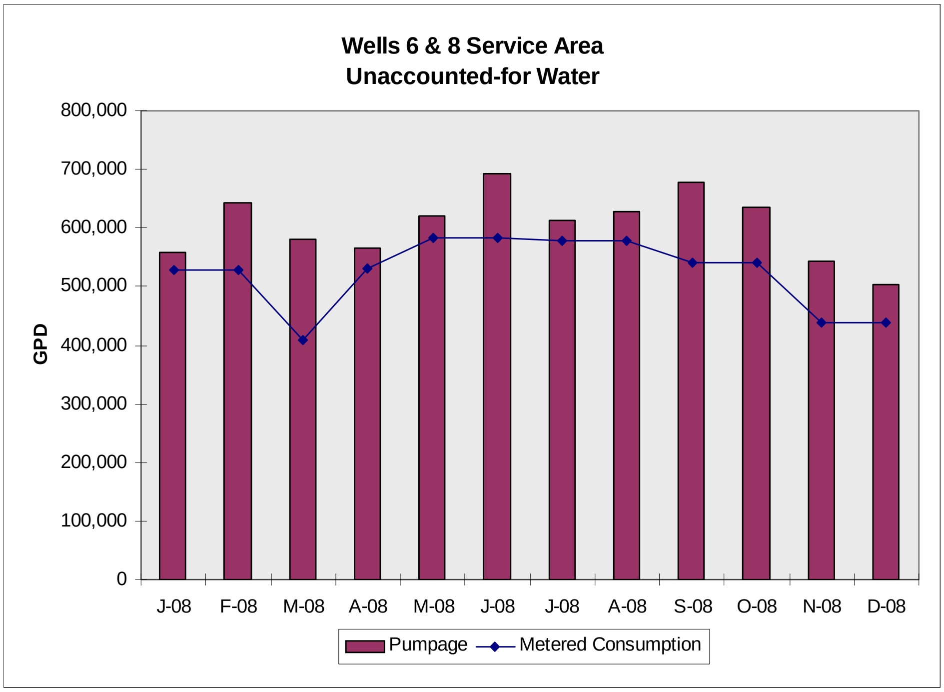
Unaccounted-for water for brackish Wells 1, 9 & 14 is shown in Figure 4-21. Unaccounted-for water for the brackish system averaged 18.76%. These losses were highly variable, reflecting reliance on the 15 MG brackish reservoir.

FIGURE 4-21. Unaccounted-For Water - Wells 1, 9 & 14 Service Area - 2008 Data



Two major sources of possible unaccounted-for water are identified. One source is un-metered roadside irrigation recently located and identified by LWCI. These will be metered soon, which should help to reduce unaccounted-for water on this system. The other major source of unaccounted-for water is the 15 million gallon (MG) open reservoir itself. This reservoir is uncovered and is located in a hot, shadeless, windy and drought-prone area. The operation of the reservoir also accounts for the variability of the unaccounted-for water. The reservoir is filled and then pumped down. The decision to fill the reservoir is made manually, rather than calling for water at a certain set point. The reservoir's capacity is more than nineteen times the 2008 metered daily brackish consumption of 760,357 GPD, so there are periods in which metered consumption exceeds source pumpage. Various methods to reduce evaporation from the reservoir are considered in the *Supply Options* Chapter of this document.

FIGURE 4-22. Unaccounted-For Water - Wells 6 and 8



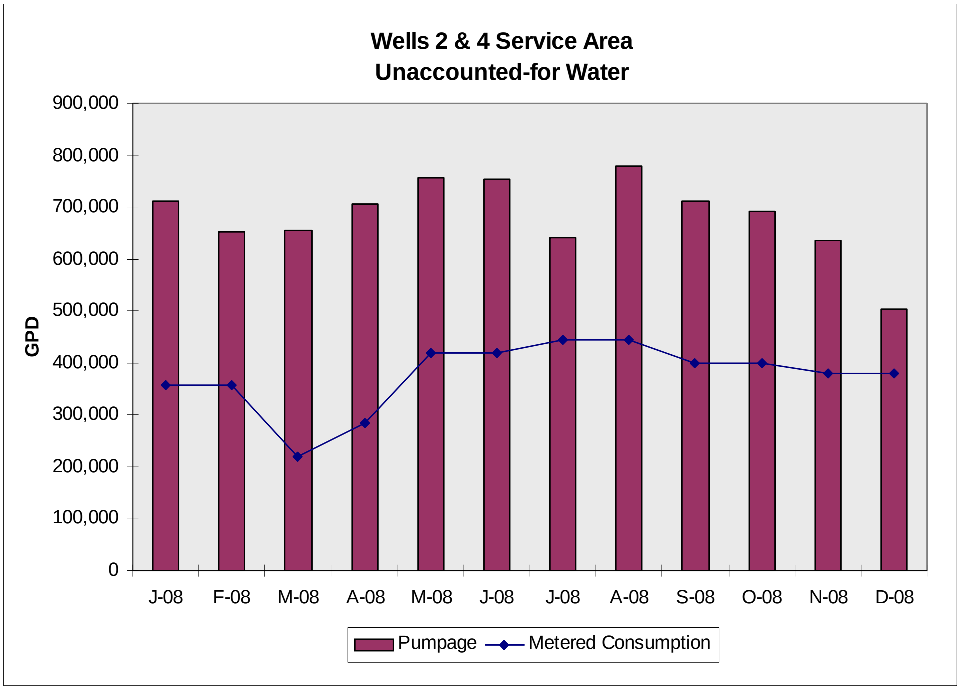
Unaccounted-for water in the areas served by Wells 6 & 8 averaged 13.52%, as shown in Figure 4-22. Potential sources of this unaccounted-for water included older pipe segments within Lana‘i City, made of asbestos-concrete or in some cases steel, as well as the long line to Kaumalapau, which is both old, substandard in size, as well as possible connections around the Kaumalapau tank and other normal losses.

Unaccounted-for water in the areas served by Wells 2 & 4 was considerably higher, at 44.61%. This data is shown in Figure 4-23. Most of these losses are believed to occur in the Palawai Irrigation Grid. Pipes in the Palawai Irrigation Grid date to the 1950's and 1960's. They are deteriorated, with frequent breaks and leaks. In addition, there are areas in the Palawai Irrigation Grid where pressures are high, which places more burden on these old pipes. Metered consumption in the Palawai Irrigation Grid is very low, but losses appear to be substantial, resulting in unnecessary pumping expense.

Although average unaccounted-for water for 2008 was 44.61%, it was noted that unaccounted-for water in December 2008 appeared to be lower, at 27%. Based on this data, it was hoped that recent installation of a PRV and replacement of a known leaking pipe segment may have resolved much of the leakage problem. To further examine the results of these measures, data were obtained for the first 6 months of 2009 to investigate whether the apparent reduction in losses at the end of 2008 would be maintained. Unfortunately, unaccounted-for water returned to roughly 2008 levels, with a year to date (YTD) average over the first six periods of 44.53%.

Recent Production Records

FIGURE 4-23. Unaccounted-For Water - Wells 2 and 4 - 2008 Data



Based on this information, certain repairs in the Palawai Grid were weighed against new sources in terms of cost benefit, as discussed in the *Supply Options* chapter of this document.

Island-wide, total losses were estimated at between 555,000 and 575,000 GPD. It would not be reasonable to expect to eliminate 100% of unaccounted-for water. However, the losses identified do appear to present some opportunities. A reduction to 15% overall unaccounted-for water might be a reasonable goal, with perhaps 12% as a goal for the Lana'i City service region. At 2008 pumping rates, such a reduction could save 243,296 GPD. To the extent that unaccounted-for water is unmetered water as vs. losses, savings would be a bit lower. However, based upon the nature of unmetered losses identified as described by utility personnel in discussions, it seems likely that savings could still exceed 200,000 GPD. On Lana'i, where some of the wells in use pump at or below this rate, this could potentially offset the capital and operational costs of a well, in addition to the potential resource savings.

Wastewater Production and Use

Wastewater flows are of interest in water planning both because they may represent potential source for certain planned uses, and because they provide information about the way water is used in systems.

There are three wastewater treatment facilities on Lana'i. These are: the Lana'i City Wastewater Treatment Facility, operated by the County of Maui; the "Auxiliary Wastewater Treatment Facility", owned and operated by Castle & Cooke Resorts, LLC, which takes County effluent at Lana‘i City and treats it further in order to use it for Koele Golf Course irrigation; and the Manele Wastewater Treatment Plant, operated by Manele Water Resources, LLC, which provides treated water to the Manele Golf Course for irrigation. Between these facilities, 294,854 GPD of irrigation water is generated and used on the island’s golf courses, bringing the total irrigation estimate to 1,426,366 GPD.

The data in Figure 4-24 were entered from records obtained from both the County of Maui Public Works Department and LWCI. Production shown here is generally about 90% of wastewater influent, but some discrepancies were noted. Water served to Koele seems to have exceeded production by the Auxiliary Wastewater Treatment Facility in 2002, 2003 and 2007. Production at the Auxiliary Wastewater Treatment Facility also appears to have exceeded influent in 2004 and 2005. Such discrepancies would be possible on a daily basis, due to the use of storage. They should not be possible on an annual basis without further accounting for possible causes. Anomalies of this sort may diminish the clarity of auditing efforts. Nationwide, production is generally 65%, of influent, with about 35% of wastewater typically being solids. Due to data uncertainty, rather than rely on empirical data only, a range of 65% to 90% was used to estimate potential reclaimed water as a percent of plant influent.

FIGURE 4-24. Wastewater Influent and Reclaimed Water Production On Lana‘i

Year	County WWTF Annual Avg	Auxilliary WWTF Influent	Auxilliary WWTF Production	Auxilliary WWTF To Koele	Manele WWTF Influent	Manele WWTF Production
1993	280,455					
1994	274,825					
1995	287,214					
1996	310,381					
1997	298,332					
1998	311,699					
1999	310,556	255,385				
2000	313,970	239,286			108,433	83,705
2001	329,819	245,407			85,050	73,468
2002	330,337	227,767	217,712	218,402	84,249	74,927
2003	325,274	203,261	187,396	215,684	85,240	80,856
2004	303,333	198,767	210,734	258,931	87,835	83,409
2005	273,452	202,044	203,420	197,720	75,282	71,674
2006	281,534	211,580	202,556	194,203	82,273	77,424
2007	312,671	216,914	205,953	210,977	84,710	80,526
2008	308,412	245,456	234,093	224,447	77,281	72,940
	303,266	224,587	208,838	217,195	85,595	77,659

Flows at the wastewater treatment facilities on Lana‘i are plotted in Figures 4-25, 4-26 and 4-27. The Lana’i City County Wastewater Treatment Plant receives about 300,000 gallons of inflow per day. Of that, about 225,000 gallons goes to the Auxiliary Plant, which produces about 205,000 GPD for irrigation. The Manele Wastewater Treatment Plant receives about 85,000 GPD of wastewater and produces about 75,000 GPD of reclaimed water for Golf Course irrigation.

Recent Production Records

FIGURE 4-25. Lana'i City - County and Auxiliary Wastewater Treatment Plant Flows

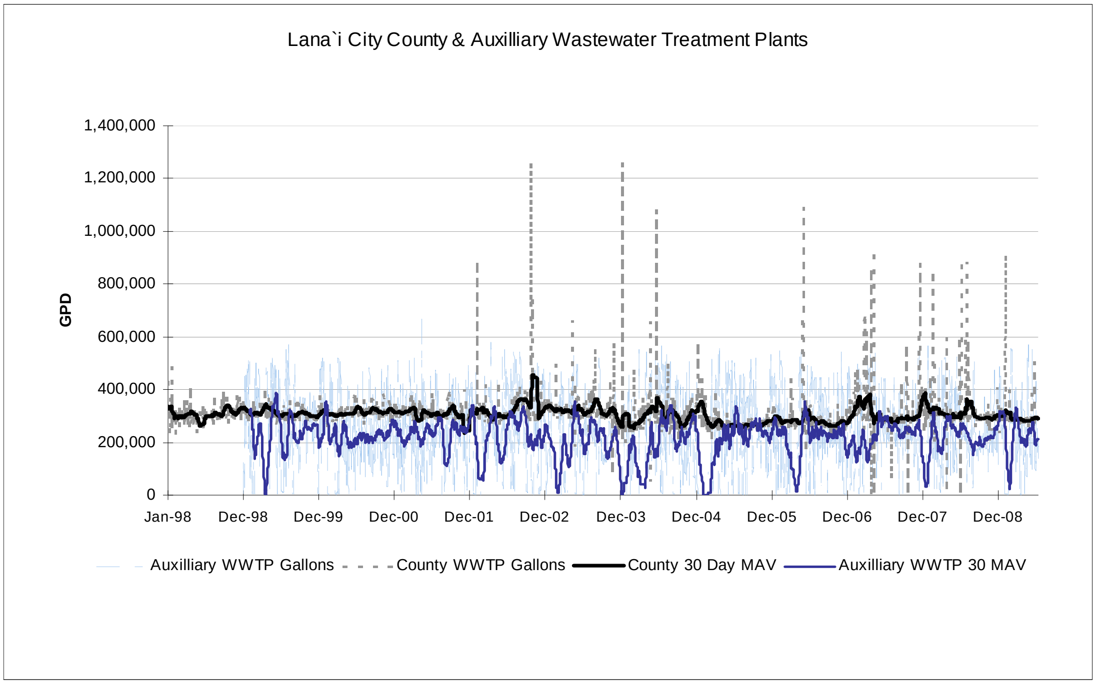


FIGURE 4-26. Lana'i City Auxiliary Wastewater Treatment Plant - Influent Minus Production

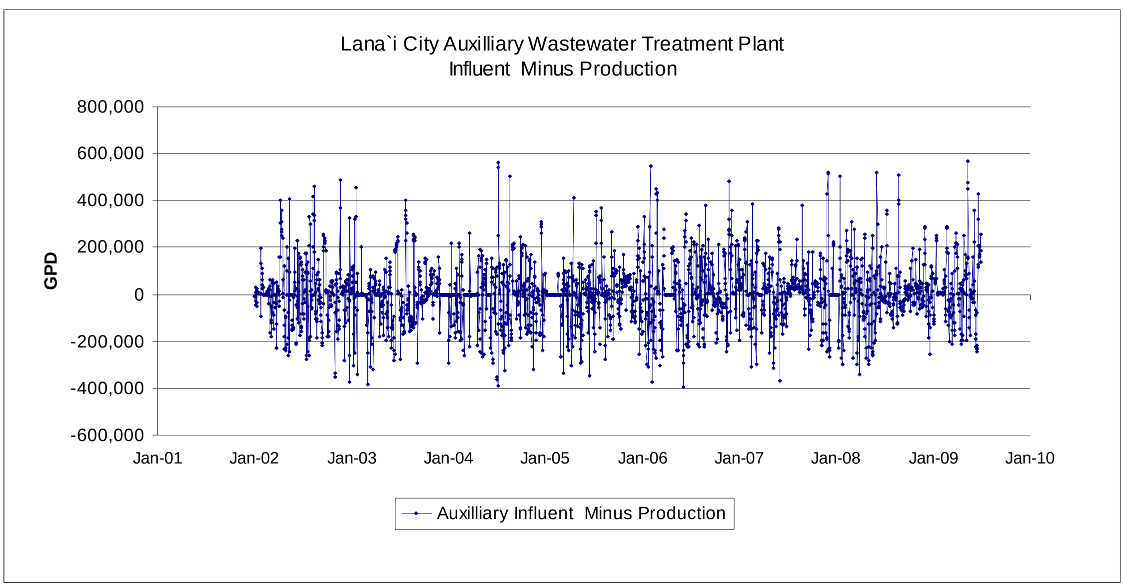
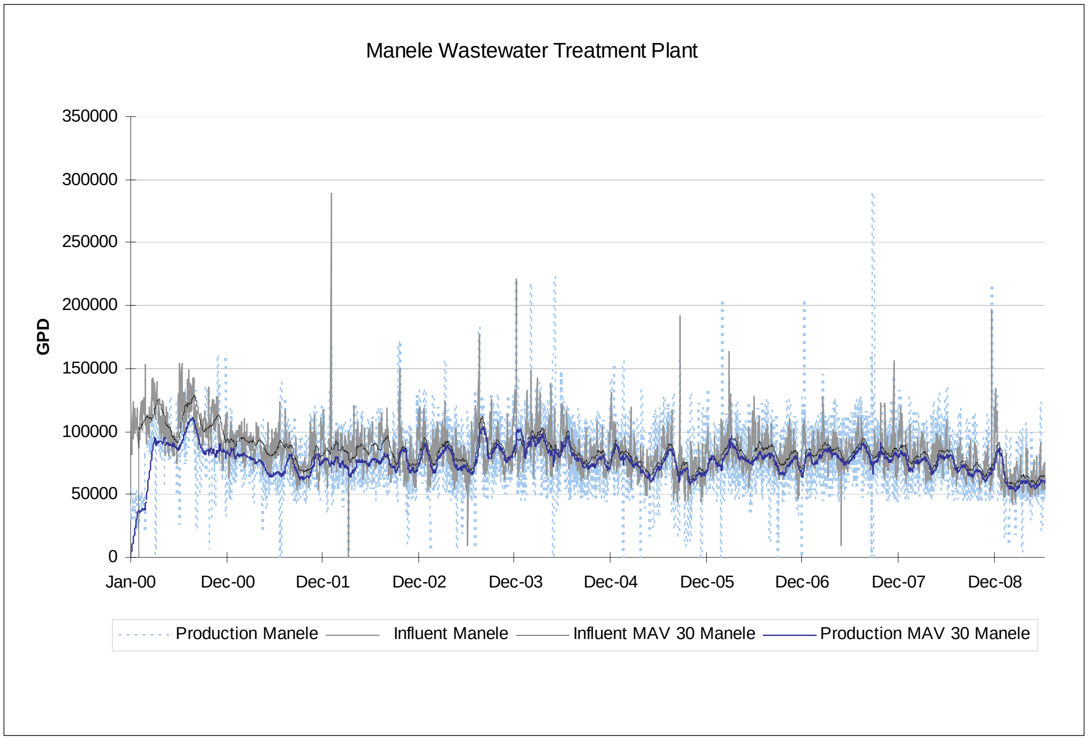


FIGURE 4-27. Manele Wastewater Treatment Plant Flows



Metered Consumption vs. Wastewater

Typically, only 10 or 15 percent of domestic indoor water use is considered consumptive. Below 85 or 90 percent of metered water use, water that does not return to the wastewater system in sewered areas is generally either used on the ground - whether for irrigation, fire suppression, construction watering, or etc. - or attributed to system losses.

Water pumpage, metered consumption and wastewater return flows are plotted in Figures 4-28 and 4-29.

In the service area of Wells 6 & 8 - 52.81% of pumped water and 60.57% of metered consumption returned to the wastewater plant as influent.

In the service area of Wells 2 & 4, only 11.35% of pumped water and 21.31% of billed water returned to the wastewater plant as influent. Since use in the irrigation grid would not be likely to return to a wastewater treatment plant in any case, this was identified and subtracted from metered use. Leaving out irrigation in the grid, 24.64% of metered water returned to the wastewater plant as influent.

These graphs seem to support the notion that the revised irrigation estimate discussed earlier, is likely to be conservative.

Recent Production Records

FIGURE 4-28. Lana'i City Pumped Water, Metered Consumption and Wastewater Influent Return

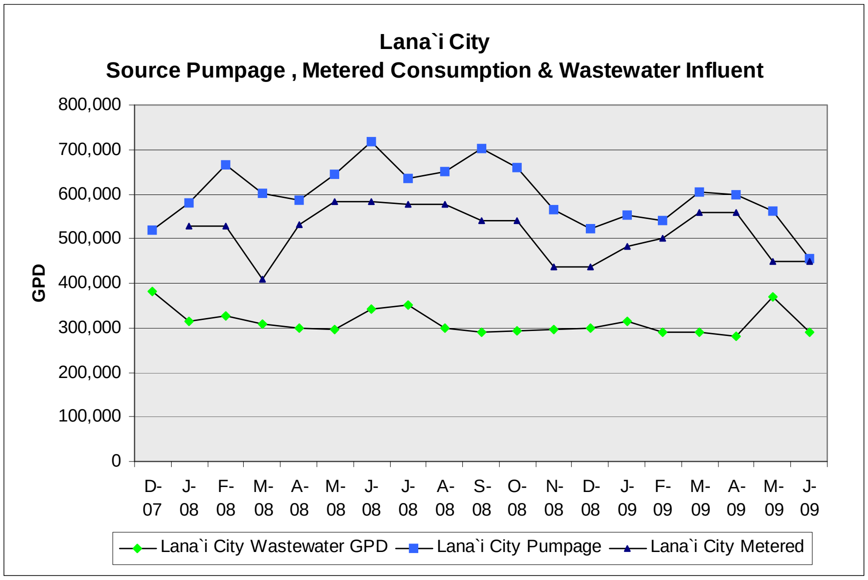
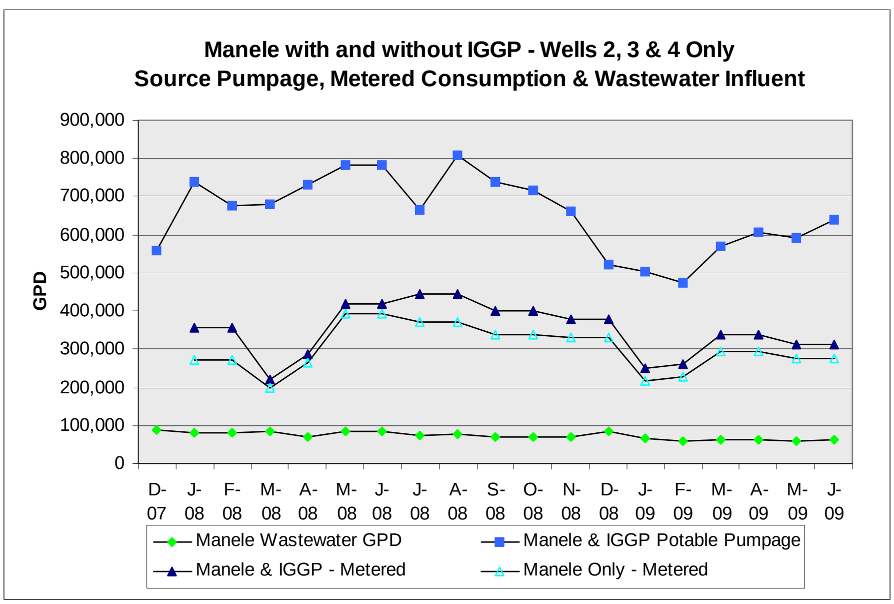


FIGURE 4-29. Manele Pumped Water, Metered Consumption and Wastewater Influent Return



Ways of Projecting Demand

The *Statewide Framework for Updating the Hawai'i Water Plan* suggests that the County Water Use and Development Plans consider multiple forecasts and scenarios. Accordingly, several forecasts and projection methods have been considered. This section discusses demand in terms of these projections and scenarios only. Analysis of demand should not be confused with water allocations. Demand analysis represents a review of trends and / or project build-outs. Allocations, on the other hand, reflect policy recommendations made by the Water Advisory Committee based upon a combination of forecasts, policy objectives and other considerations. These are discussed in the *Policy Issues* chapter of this document.

Methods of forecasting demand include analysis of time series, per capita use, econometric factors, land use build-out, end uses and other factors. These are described briefly below.

Time series forecasting looks at historical trends over time, with no explicit consideration of potential factors that may influence these trends. Such influential factors are assumed to be represented by fluctuations over the time frame utilized. The assumption embedded in this method is that change will occur at the same rate in the future as it has in the past. Therefore, a weakness in this method is that it can fail to predict when there are large shifts in the rate of change of factors that influence a given trend. For instance, on Lana'i, the decision to cease pineapple operations and focus on tourism created a drop in irrigation water consumption which would not have been predicted by a time series analysis. Nor would irrigation consumption continue over time to decline at the rate that it did while pineapple operations were being phased out. When such factors are known, adjustments can sometimes be made for these anomalous changes. For instance, time series trends of irrigation use on Lana'i could utilize irrigation data since pineapple ended. The advantage of time trend forecasting is that it can be done with limited data, and can apply to smaller regions for which disaggregated data may not be available.

Per capita analysis relies on population projections, and assumes that the same amount is used for each person. It requires population projections, a base year, and a population growth factor. This method is useful in water forecasting because population tends to be a strong indicator of water use. One weakness of this method is the assumption that each increment of population will consume the same amount of water. Per capita consumption is influenced by several factors, including socioeconomic status, climate, lot size, and type of employment. An economy that is growing in one way will have different demand patterns than an economy that is growing in another way. With the importance of tourism in the islands, de facto population seems to be a strong indicator that covers both population and some aspect of economic growth. However, even trends based on de facto population can be misleading on Lana'i due to shifts in consumption and population at the time of the end of the pineapple economy, as shown in Figure 4-31.

Econometric analysis involves statistical analysis of many factors that could influence consumption. It can yield a more accurate result, and has the advantage that if trends in one of the factors start to change, projections can easily be adjusted to reflect that change. One drawback of this method is that it requires a great deal of data, in consistent and usable format, which may not be available in sufficient disaggregation to look at smaller regions. Data used in econometric forecasting can include population, de facto population, employment, occupancy, rainfall, irrigated acreage, socioeconomic status of residences, and other factors.

Ways of Projecting Demand

Build-out analysis examines the potential consumption if all planned and proposed projects were fully developed. This is useful for estimating potential or ultimate needs over a planning period, and for understanding the potential impacts of projects and land use decisions. Build-out analysis typically does not provide adequate information on schedules, market influences or other factors to provide a meaningful forecast of growth trends over a given time frame. never the less, it is especially important to consider for areas like the island of Lana‘i, where build-out decisions can have a substantial impact on demand trends.

End use analysis involves looking at how water is used in a specific system. It requires more detailed data than other methods, but is most useful for evaluating the response of a system to demand side management programs or other conservation efforts, as well as to droughts, emergencies or other contingencies. Examples of the types of data reviewed in end use analysis include irrigated acreage, spas, pools, water features, plumbing code and age of homes and fixtures, etc. Using this type of analysis, theoretical savings versus cost estimates can be developed to help evaluate conservation measures. Again, the difficulty in this method lies in obtaining the appropriate data. There was not sufficient data for Lana‘i to provide a projection based upon end use analysis.

Demand for Lana‘i has been reviewed using the following methods:

1. Adjusted Time Trend Analysis based on historical water use.
   In performing time trend analysis, adjustments were made for the end of pineapple cultivation. Municipal and irrigation use were considered separately and irrigation time series analysis was performed using the period since the end of pineapple cultivation.
2. Modified Econometric Analysis.
   Analysis of water demand was performed using growth factors from the *Maui County Community Plan Update Program: Socioeconomic Forecast* prepared by SMS for the County of Maui Planning Department in 2006, for use in update of the general and community plans. Adjustments were made by Haiku Design and Analysis to derive the high and low forecasts based on a range of elasticities. This method is a combination of econometric and per capita analysis. The County forecast in the 2008 update was somewhat lower, but unless it was redistributed much differently, it was encompassed within the range established using the 2006 projections. At the time of this draft the 2008 breakdown by island was not yet available.
3. Build-out Analysis
   Build-out analysis and agreements from the *1997 Final Report of the Lana‘i Water Working Group - Draft WUDP* (1997 Draft) served as a starting point for analysis and discussions. As late as 2002, the Water Advisory Committee voted to retain both projection and policy numbers from this 1997 Draft. Subsequently, CCR proposals from 2004 and 2006 were considered. Also considered were scenarios in which projects were built-out at a pace consistent with time series and modified econometric demand forecasts. Analysis of proposals included a review of unit consumption rates, comparison to a list of CCR and non-CCR projects known to DWS, comparison to project district unit counts as approved, and determination of when the cumulative results of such proposals would result in various triggers or milestones being met, such as the CWRM trigger for re-opening designation proceedings. Each proposal iteration was the subject of several Water Advisory Committee meetings. An additional proposal was received on July 28, 2009 from Castle & Cooke Resorts. Although some analysis of this proposal is presented in this chapter, the Committee voted not to embark on a full consideration of the proposal at that late date in the process.

Adjusted Time Trend Analysis

As noted earlier, The *Periodic Water Reports (PWR)* have historically referenced three service areas for which water deliveries are subtotaled. These are: the “Lana‘i City” area; the area entitled “Manele, Aoki Diversified Agriculture and Ag activities near the Airport”; and the “Kaumalapau” area. The category now called “Manele, Aoki Diversified Agriculture and Ag activities near the Airport” was initially called simply “Irrigation”. It was re-titled “To Manele District, ADA (Aoki Diversified Agriculture), & Agricultural Activities Near Airport” in 2001. This breakdown of demand dates back to the time when pineapple was cultivated. During the pineapple era, it would have been a fairly reasonable breakdown of municipal versus irrigation water. The category entitled “To Manele District, ADA & Agricultural Activities Near Airport” appears to cover all consumption other than Lana‘i City and Kaumalapau, or essentially all of Manele potable (PWS 238) plus all brackish and effluent use. Kaumalapau is part of the Lana‘i City system (PWS 237). Since there is a long history of reporting and public review according to this breakdown, trends of these three sectors were analyzed using a simple time series analysis, shown in Figure 4-30.

As can be seen clearly in Figures 4-1 and 4-3, as well as 4-20, the end of pineapple cultivation caused a steep decline in demand across all sectors of water use, especially irrigation. Since that time, consumption has started to trend gradually upward again.

If the decline in pumpage due to the end of pineapple were included in a time series analysis of recent decades would lead to distorted results, with the dramatic irrigation decline masking the more gentle and slightly upward moving trends for other uses. To avoid such distortion, the three sectors of demand traditional to the *Periodic Water Report*s were analyzed using slightly different time periods. Irrigation trends were derived using data from only the period after the end of pineapple cultivation. Municipal trends were also affected by this shift, but not as strongly, and so were examined both ways.

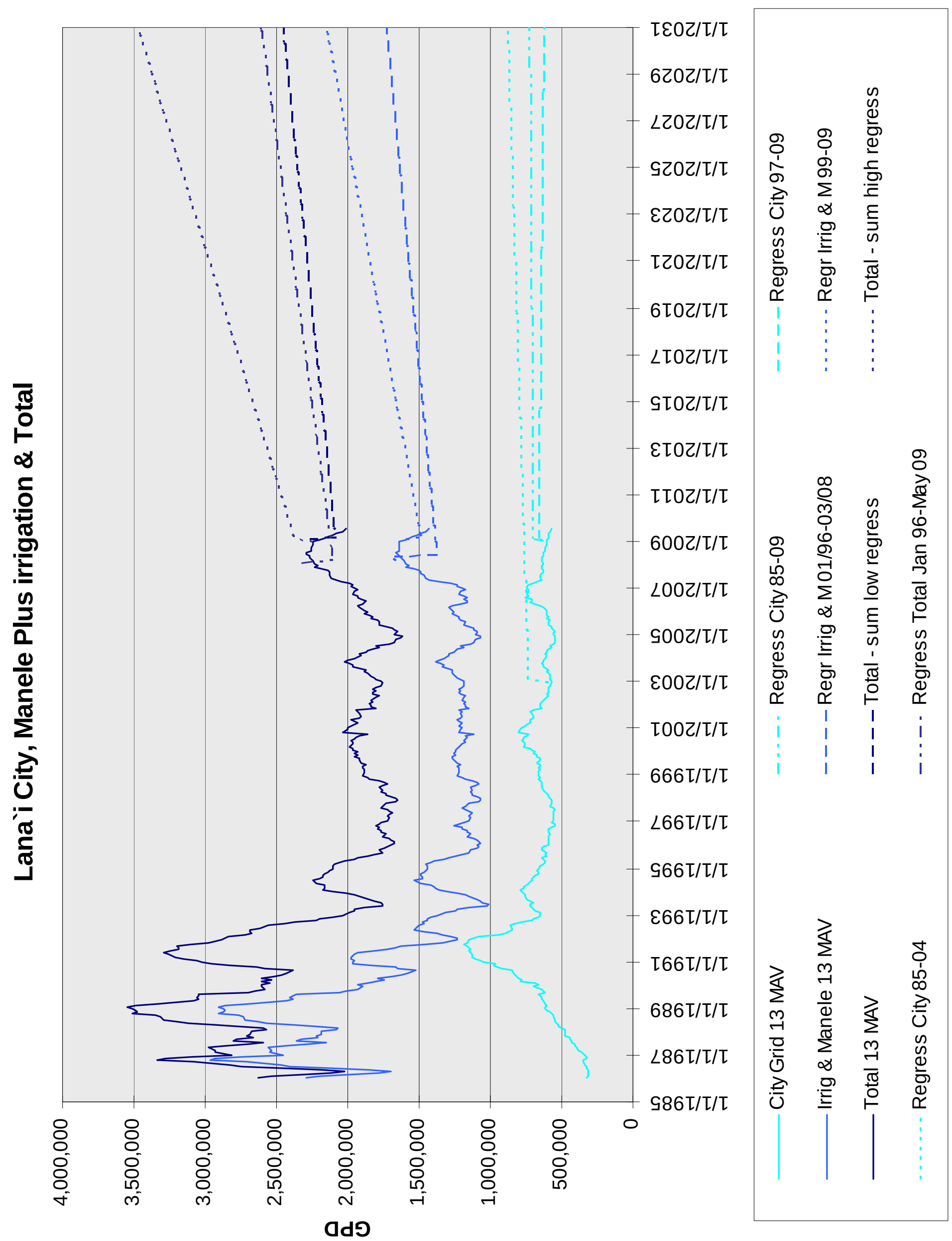
Due to analysis over different time periods, the lower and the higher of these separate trends were added to get low and high cases of the total projection, rather than projecting total use. This analysis yielded a projected range of roughly 2.4 to 3.3 MGD by the year 2030, as shown in Figure 4-30.

Consumption for Kaumalapau meters as classified for this Water Use and Development Plan analysis exceeded reported source use for Kaumalapau in the *Periodic Water Report*s, with metered MAV exceeding 15,000 GPD vs. 3,317 GPD in the *Periodic Water Report*. The lower projection resulted from use of the *Periodic Water Report* numbers, rather than meter breakdown, for projection. Investigation of this discrepancy led to the finding that certain meters, such as the meter for the “Kaumalapau Crusher”, are located above the Kaumalapau Tank, and so were classed one way in the billing analysis, but another way in the *Periodic Water Report*. Both data are accurate, and this discrepancy did not materially affect projections or other analyses in this report with the exception of Kaumalapau.

Based on this analysis, low and high case projections for the year 2030 ranged from 620,000 GPD to 871,000 GPD for Lana‘i City, from 1.7 to 2.1 MGD for “Manele District, ADA (Aoki Diversified Agriculture), & Agricultural Activities Near Airport”, aka Irrigation, and from 0 to 20,000 GPD for Kaumalapau.

Adjusted Time Trend Analysis

FIGURE 4-30. Source Use and Projected Trends on Lana‘i - Time Series of “Lana‘i City”, “Manele, Aoki Diversified Agriculture and Ag activities near the Airport”, and “Kaumalapau” as Disaggregated by *Periodic Water Reports*



Modified Econometric Analysis

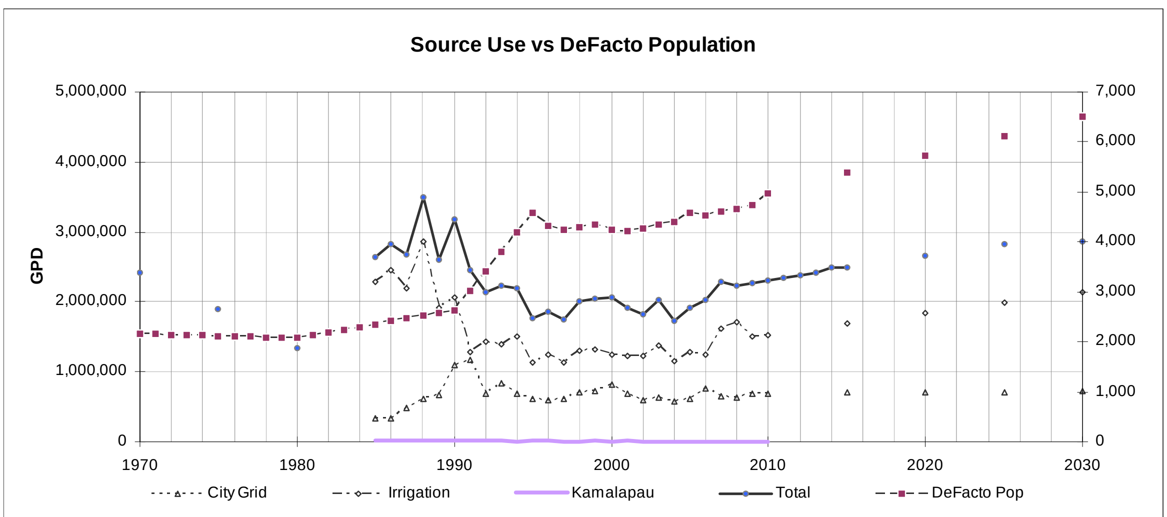
Factors Affecting Demand

Water demand within a community is generally affected by a number of factors. These are described briefly below.

Population usually has a fairly straightforward relationship to demand. As population increases, demand generally increases. However, this relationship can be masked by other factors. When a given land use or industry dominates a local economy, this can have a stronger impact on demand than population. For instance, if the relation of resident population to demand were measured over the period that brackets the end of pineapple, this examination would lead to a finding that the effects of population were minor as compared to changes in agricultural consumption. In fact, for a time there would appear to be a negative association, as plummeting irrigation use overshadowed and completely masked the population curve.

De Facto Population is the population of a region based on those present at a particular time, including temporary visitors, but excluding residents who are temporarily absent. On Lana'i, where tourism is the major economic activity, visitor counts can increase population by 30%. Therefore, de facto population is a stronger predictor of demand than resident population.

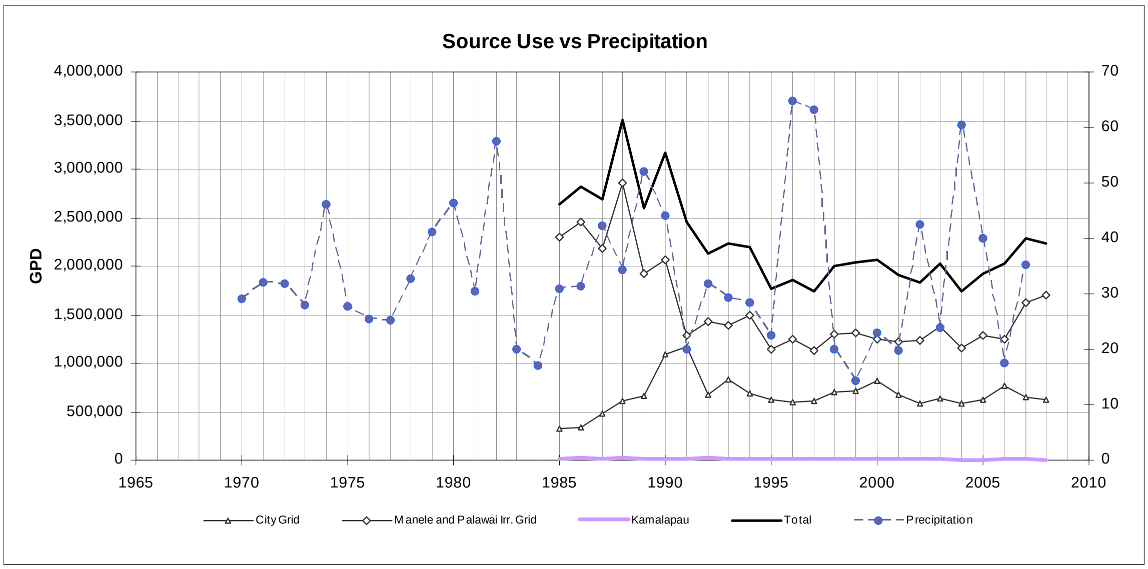
FIGURE 4-31. Source Use and De Facto Population



Modified Econometric Analysis

Climate Factors such as precipitation, temperature, wind, evapotranspiration, and seasonality can have a strong influence on demand patterns. Areas with low rainfall or higher temperatures will use more water per capita or per household than areas that are wet or cool. Rainfall on Lana‘i ranges from about 10 inches at Kaumalapau Harbor to about 42 inches at Lana‘ihale. Temperatures at sea level are typically 10 to 15 degrees higher than in Lana‘i City. This climate difference is also reflected in unit demand rates. A single family home in the hot dry area of the Manele Project District would be likely to use more water than a home in Lana‘i City, even if other factors were the same. Seasonal trends can also be pronounced even in areas with fairly stable climates. Demand increases during the hot, dry summer months.

FIGURE 4-32. Source Use and Precipitation



Demographic Factors include such measures as households, persons per household, household income, population age, etc. In general, more households are associated with higher demands. But this can be masked by economic changes, as discussed earlier. Higher household or per capita income is also associated in general with higher water demand. Those with higher income tend to have more acreage, are more likely to have non-essential water features, such as spas, pools, irrigated landscape etc., and to be less responsive to cost issues. Population density can be associated with higher demands. All things being equal, a square mile of land that is more highly populated will tend to use more water than a sparsely populated square mile. However, densely populated areas tend to use less water per unit than those with larger lots. A water-intensive industry, combined with sparse population in a given area, may result in higher consumption than a dense residential population alone.

FIGURE 4-33. Precipitation, De Facto Population and Demand on Lana'i 1985-1930

Year	Precip	Defacto Pop	City Grid	Irrigation	Kaumalapau	Water Total
1985	31.01	2,352	325,299	2,289,226	15,812	2,630,338
1986	31.47	2,407	336,835	2,451,918	20,363	2,809,116
1987	42.29	2,463	480,470	2,180,298	16,541	2,677,309
1988	34.25	2,518	618,566	2,870,867	22,609	3,512,042
1989	52.13	2,574	663,734	1,926,714	10,247	2,600,695
1990	43.98	2,629	1,044,910	1,964,790	14,054	3,023,754
1991	20.06	3,017	1,119,892	1,229,684	9,187	2,857,679
1992	31.85	3,406	649,969	1,369,042	19,909	2,038,921
1993	29.25	3,794	782,680	1,306,829	10,573	2,100,082
1994	28.3	4,183	663,555	1,437,118	8,585	2,109,258
1995	22.47	4,571	595,556	1,093,568	9,223	1,697,355
1996	64.82	4,239	572,606	1,190,364	9,909	1,772,879
1997	63.19	4,233	578,388	1,075,308	7,357	1,661,052
1998	20.06	4,294	662,120	1,227,522	6,146	1,895,788
1999	14.31	4,354	681,308	1,241,334	9,811	1,932,453
2000	23	4,156	783,756	1,202,486	8,854	1,995,099
2001	19.75	4,216	655,717	1,174,486	10,218	1,840,421
2002	42.58	4,277	567,818	1,187,249	7,857	1,762,925
2003	23.79	4,338	614,402	1,330,704	8,088	1,953,193
2004	60.44	4,398	557,816	1,105,607	5,305	1,668,728
2005	39.94	4,459	603,184	1,252,424	4,700	1,860,308
2006	17.55	4,527	741,151	1,202,904	8,115	1,952,169
2007	35.19	4,595	635,108	1,569,560	6,531	2,211,199
2008		4,664	601,486	1,636,420	3,316	2,241,222
2009 P7 YTD MAV		4,732	875,123	1,471,350	10,147	2,062,572
2010		4,800	889,995	1,483,727	10,225	2,383,947
2015		4,920	964,355	1,545,613	10,617	2,520,584
2020		5,207	1,038,634	1,607,431	11,007	2,657,072
2025		6,110	1,112,588	1,668,978	11,397	2,792,963
2030		6,513	1,186,542	1,730,526	11,786	2,928,854

* de facto pop by HDA method - consistent with DBEDT method

de facto = resident population + visitor census minus residents in transit

Modified Econometric Analysis

FIGURE 4-34. Population, Housing, Occupied Units, Visitor Counts, Occupancy & Employment on Lana'i

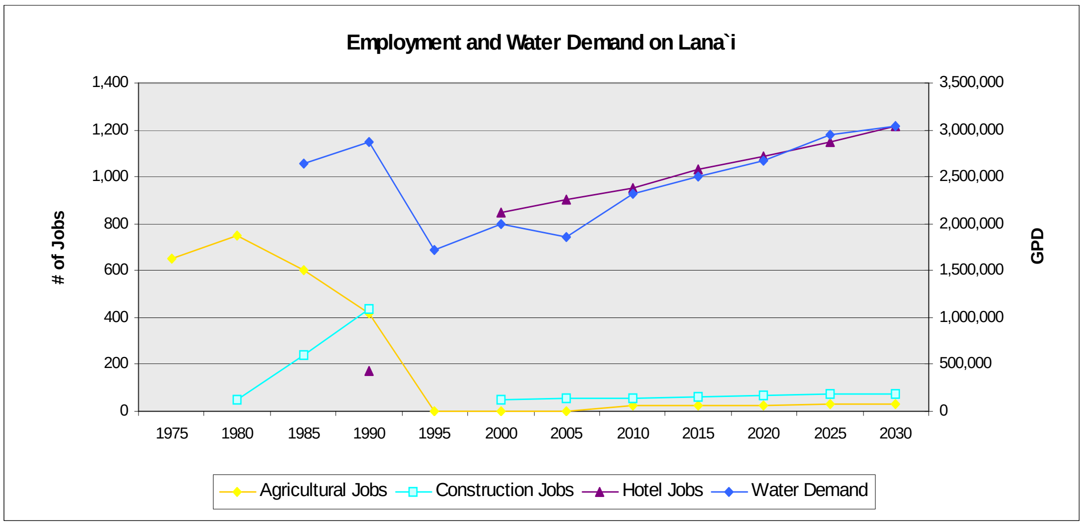
	Population **	De Facto Population **	Households **	Household Size * *	Visitor Census**	Visitor Arrivals**	Visitor Units**	Occupancy*	Occupied Units **
1970	2,204	2,200	647	3.4					
1975									
1980	2,119	2,129	611	3.06					
1985							10		
1990	2,426	2,629	847	2.86	68		113	30.00%	
1995	2,989	4,571	949				367		
2000	3,193	4,243	1,161	2.74	1,131		365	50.00%	
2005	3,452	4,587	1,285	2.69	1,224	95,024	368	54.50%	201
2010	3,735	4,963	1,415	2.64	1,325	102,920	368	59.00%	217
2015	4,046	5,377	1,555	2.6	1,466	113,811	368	65.30%	240
2020	4,308	5,725	1,680	2.56	1,577	122,796	368	70.20%	259
2025	4,598	6,110	1,817	2.53	1700	132054	368	75.70%	279
2030	4,901	6,513	1,955	2.51	1827	141856	368	81.40%	299

	Median ** HH Income	Wage & Salary Jobs**	Civilian Jobs**	Ag Jobs**	Constrx Jobs**	Hotel Jobs**	All Other Jobs**
1970							
1975				650			
1980				750	50		
1985				600	242		
1990	$29,877	1,534	1,623	416	433	173	601
1995				0			
2000	$43,271	1,630	2,088	0	50	850	1,188
2005	$50,156	1,753	2,257	0	53	903	1,302
2010	$58,955	1,891	2,442	24	58	954	1,407
2015	$63,385	2,045	2,615	26	63	1,031	1,527
2020	$68,377	2,162	2,816	27	66	1,086	1,637
2025	$73,629	2293	3006	29	71	1148	1759
2030	$78,463	2426	3204	31	75	1213	1885

** Source of these numbers is Socioeconomic Forecast: The Economic Projections for the Maui County General Plan 2030, published June 2006

Economic Factors include such measures as housing starts, jobs by industry, hotel occupancy, per capita income, etc. All of these measures can have an effect on water demand. More housing starts generally indicate a trend that is growing more quickly. Higher visitor counts or hotel occupancies can lead to higher demand, especially in an area such as Lana‘i, where tourism is both the economic base and the major consumer of water.

FIGURE 4-35. Employment and Water Demand on Lana‘i



	Ag Jobs**	Constrx Jobs**	Hotel Jobs**	All Other Jobs**	Water Demand
1970					
1975	650				
1980	750	50			
1985	600	242			2,637,564
1990	416	433	173	601	2,875,175
1995	0				1,722,507
2000	0	50	850	1,188	1,995,099
2005	0	53	903	1,302	1,860,308
2010	24	58	954	1,407	2,311,263
2015	26	63	1,031	1,527	2,504,062
2020	27	66	1,086	1,637	2,666,126
2025	29	71	1148	1,759	2,945,420
2030	31	75	1213	1,885	3,033,096

Selected Factors   De facto population combines information on population growth with information about the visitor industry. This measure was considered to be a strong predictor especially on Lana‘i, where the visitor industry is both the largest water customer and the main source of employment. In addition, the SMS forecast method, described in the following pages, was driven in many ways by de facto population. Unlike some other candidate factors, data for de facto population were available both for a sufficiently long and consistent time period, appropriately disaggregated for use with water data. Therefore, the modified econometric analysis utilized de facto population to derive forecast coefficients.

County Socio-economic Forecast

Consumption was analyzed using data and methods found in *The Maui County Community Plan Update Program: Socio-economic Forecast,* prepared by the consulting firm SMS for the County Planning Department in June of 2006. This document utilized data from a number of sources:

- The 2030 series projections prepared by the State Department of Business, Economic Development and Tourism (DBEDT), as updated with data from the U.S. 2000 Census.
- Data from the Hawaii State Department of Labor and Industrial Relations on wage & salary jobs.
- Hawaii Health Survey Data for 2000 for demographic information.
- The 2005 Visitor Plant Inventory by DBEDT, as updated with SMS survey and real property data from the Real Property Tax Branch.
- Real Property Tax data and Planning Department data on permitted development, land uses, development projects, proposed housing and visitor units.

An updated forecast was prepared in 2008. However, as of this draft disaggregated data for Lana‘i had not yet been made available. In discussion with staff planners, it appeared that the revised forecast would be likely to lower estimates somewhat.

Data from the DBEDT 2030 series projects county-level trends. SMS, the consulting firm to the Planning Department, used this county-level data and the other sources of data listed to disaggregate long term trends into island and community plan regions. A low and high projection were developed based on visitor growth increasing at half or one and a half times the anticipated rate respectively.

Data for de facto population, disaggregated by SMS, were used to project water demand. In translating projected de facto population growth into water demand, one question that needs to be addressed is how much additional water each new unit of population growth represents. Using de facto population as the primary unit of growth, the question becomes, will each new person use the same amount of water as the people in the area use now? An *elasticity* of one means that a new person in an area is expected to use water at the same rates and amounts as the average person in that area currently uses. If this is the case, then water demand will increase in consistent proportion with de facto population. An elasticity of two would mean that new people in the area tend to use twice what people now use. The coefficient used to predict demand is raised to the power of the anticipated elasticity, so if people use twice as much water, the coefficient is squared. Normally in forecasting, the elasticity used is itself derived based on other trends. On Maui, calculated elasticities hovered mainly close to 1, ranging from roughly 0.8 to 1.3. However, the availability and character of data for Lana‘i were not adequate to rely upon associations between predictive factors. In order to address the lack of certainty regarding elasticities for Lana‘i, predictive runs were made using elasticities of 1, 1.5 and 2 for the high low and base case scenarios. Several factors can drive elasticities up or down. For instance, if new development has larger lots with irrigation and water features as compared to older development, elasticity is likely to be higher than 1.

Certain additional assumptions were made. Disaggregated resident population numbers, visitor census and residents-in-transit estimates were used to arrive at estimated de facto populations for the island of Lana‘i. The SMS forecast estimated de facto population by assuming the ratio of resident population to total de facto population to remain consistent with the ratio from the year 2000. Although the principle was the same, that de facto population would equal visitors plus on-island share of residents, the calculation differed from the standard DBEDT formula, which estimates de facto population as *residents + visitors - residents in transit* (residents *plus* visitors *minus* residents in transit). After some reviews by the Department of Water Supply's water forecasting consultant, Haiku Design and Analysis (HDA), it was decided to calculate de facto population trends using the DBEDT formula of *residents + visitors - residents in transit*. This did not precisely match the numbers listed for Lana'i's de facto population in the SMS document, but seemed more consistent with estimates made for other areas, and more likely to accurately reflect the economic shifts on the island.

Data for de facto population was given in five year increments, and historical interpolation between increments was performed using county-wide historical growth trend patterns. Escalation factors generated from this data were applied to water demands to arrive at future demand.

Results of forecasts, run using time trends and using community plan escalation factors applied to island-wide pumpage, are shown below and on the facing page. Time trend projections ranged from 2.4 to 3.23 and the community plan escalation from 2.98 to 3.62, for an overall range of 2.4 to 3.23.

A decision had to be made as to whether pumpage or metered consumption would be used as a base from which to project demand. Both have advantages and disadvantages. Using pumpage to project future demand can be useful when existing unaccounted-for water trends are expected to continue, or when billing data are either unavailable or unreliable. Implicit in such a forecast is an assumption that per capita consumption and unaccounted-for water would stay more or less the same over the projection period.

FIGURE 4-36. Island-wide Water Demand Projections with SMS / HDA Escalation Factors Applied to 2008

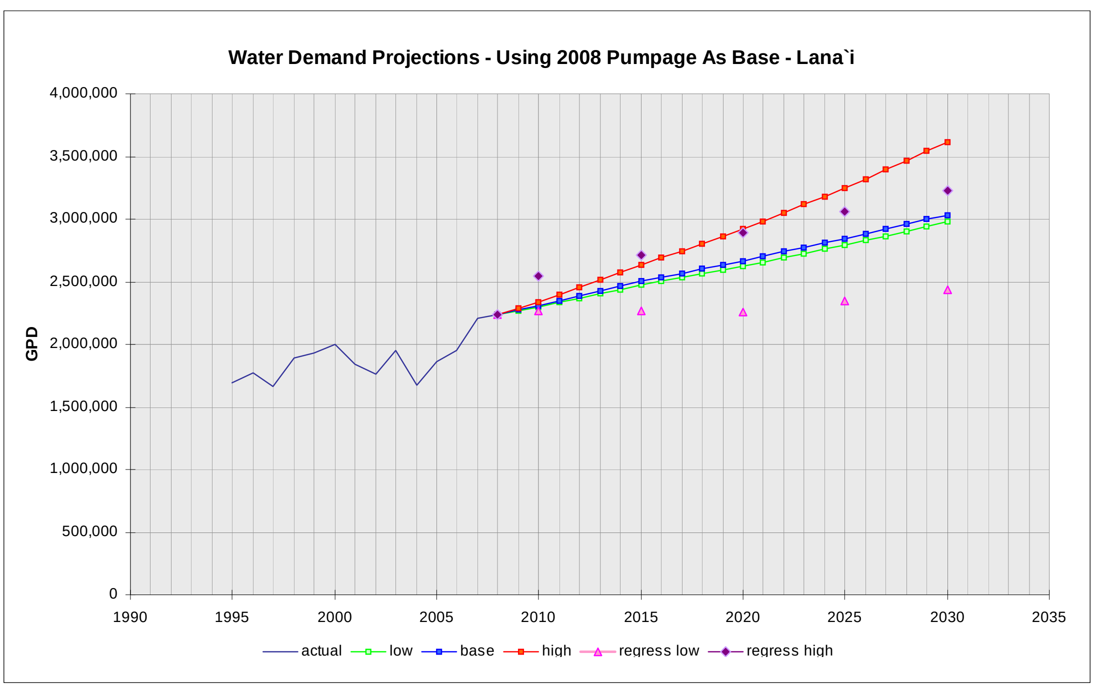


FIGURE 4-37. Total Pumpage Forecast Estimates *Uses 2008 pumpage as a base for Low, Base and High case forecasts. time trend regressions on pumpage also shown.*

	Actual	Low Case	Base Case	High Case	Regress Low	Regress High
1995	1,697,355					
1996	1,772,879					
1997	1,661,052					
1998	1,895,788					
1999	1,932,453					
2000	1,995,099					
2001	1,840,421					
2002	1,762,925					
2003	1,953,193					
2004	1,668,728					
2005	1,860,308					
2006	1,952,169					
2007	2,211,199					
2008	2,241,222	2,241,222	2,241,222	2,241,222	2,241,222	2,241,222
2009		2,270,184	2,276,243	2,290,680		
2010		2,299,146	2,311,263	2,340,138	2,263,286	2,546,116
2011		2,334,481	2,349,823	2,398,813		
2012		2,369,817	2,388,383	2,457,487		
2013		2,405,152	2,426,943	2,516,162		
2014		2,440,488	2,465,503	2,574,837		
2015		2,475,823	2,504,062	2,633,511	2,271,166	2,715,830
2016		2,505,441	2,536,475	2,690,361		
2017		2,535,059	2,568,888	2,747,210		
2018		2,564,677	2,601,300	2,804,060		
2019		2,594,295	2,633,713	2,860,909		
2020		2,623,913	2,666,126	2,917,759	2,260,134	2,887,992
2021		2,657,655	2,701,984	2,983,460		
2022		2,691,397	2,737,843	3,049,161		
2023		2,725,139	2,773,702	3,114,861		
2024		2,758,881	2,809,561	3,180,562		
2025		2,792,623	2,845,420	3,246,263	2,345,652	3,059,401
2026		2,829,458	2,882,955	3,320,451		
2027		2,866,293	2,920,490	3,394,638		
2028		2,903,129	2,958,026	3,468,825		
2029		2,939,964	2,995,561	3,543,012		
2030		2,976,799	3,033,096	3,617,200	2,431,170	3,230,809

Figures 4-36 and 4-37 show projected estimates based upon pumped demand escalated at an elasticity of 1. Projected source demands by this method ranged from 2.98 MGD for the low case to 3.62 MGD for the high case. This range was a bit higher than the time trend regression range of 2.43 to 3.23 MGD.

SMS forecast factors were applied to pumpage at these low case, base case and high case growth rates, with elasticities 1, 1.5 and 2, resulting in a range nine numbers for each method. Forecasts run this way with pumpage as the base ran from 2.98 to 5.84 MGD (with all but the highest estimate falling below 4.6 MGD). The base case range for this forecast projected pumpage between 3.03 MGD and 4.10 MGD. These results are shown in Figure 4-33.

Although the results of projections run using pumpage data are provided, the metered data ultimately proved more useful. With the benefit of metered consumption data, it is possible to get a handle on realistic consumptive needs, and to identify opportunities for specific loss-reduction measures to help meet anticipated demands. The selected forecasts project future demand using metered data, and are adjusted upward to account for targeted unaccounted-for water amounts.

Predictive runs on both pumpage and metered consumption are shown in Figures 4-38 to 4-46. These runs use base, high and low case community plan based escalation factors, applied at an elasticity of 1, 1.5 or 2..

Applying the derived escalation factors to metered demand without upward adjustment resulted in projections ranging from 2.20 to 4.32 MGD, with the base case prediction ranging from 2.2 to 3.04, and all but the highest scenario falling below 3.4 MGD.

Forecasts were adjusted upwardly by 12% for the service area of Wells 6 & 8, 15% for the service area of wells 2 & 4, and 15% for the service area of Wells 1, 9 & 14. This yielded a range of forecasts from 2.56 to 5.03 MGD, with the most likely, or base case scenario, ranging from 2.61 to 3.53 MGD. (vs. 3.03 to 4.01 using pumpage as base and taking the base case with elasticities from 1 to 2).

Prroposals by CCR assumed 12% UAFW across the board. A comparable 12% adjustment to forecasts of metered demand would result in a source requirement of roughly 2.5 to 4.9 MGD, with all but the highest scenario falling below 3.9 MGD.

Figure 4-46 shows the totals of well service areas projected separately, using metered demand as a base for escalation, with twelve percent unaccounted-for water added to the service area of Wells 6 & 8, an d 15% added to the service areas of Wells 1, 9 & 14 and Wells 2 & 4. Island-wide total demands by this method range from 2.56 MGD to 5.03 MGD, with the base case range from 2.61 to 3.53 MGD. This method was chosen as the base planning forecast, and is discussed in the next section.

Projections By Well Service Areas

Projections broken out by Well Service Area are shown on pages 4-38 to 4-46. Although unaccounted-for water between ten and fifteen percent is something of a standard industry target, it is well known that many older and smaller systems do not currently meet this target. Analysis of actual billing data showed that unaccounted-for water was currently 44.6% for fresh water service in Manele-Hulopoʻe and 18.76% for brackish water service to Manele. Twelve percent (12%) seemed a little low to be realistic for these districts, and yet the existing UAFW rates seemed too high to canonize. After examining potential measures to resolve UAFW, it was concluded that 15% might be an appropriate target for Manele-Hulopoʻe and the Palawai Irrigation Grid. The Well Service Area of Wells 6 & 8 (Lanaʻi City, Koele Project District and Kaumalapau), have existing UAFW of only 13.52%, so 12% seemed a reasonable target for that area. Failure to reach these targets would result in build-outs at even greater risk of exceeding sustainable yield than has been projected in build-out analysis discussed later.

Using metered consumption as a base and adding 12% for unaccounted-for water demand for the Well Service Areas of Wells 6 & 8 would range from 0.78 to 1.55 by 2030, with the most likely range from 0.8 to 1.1 MGD.

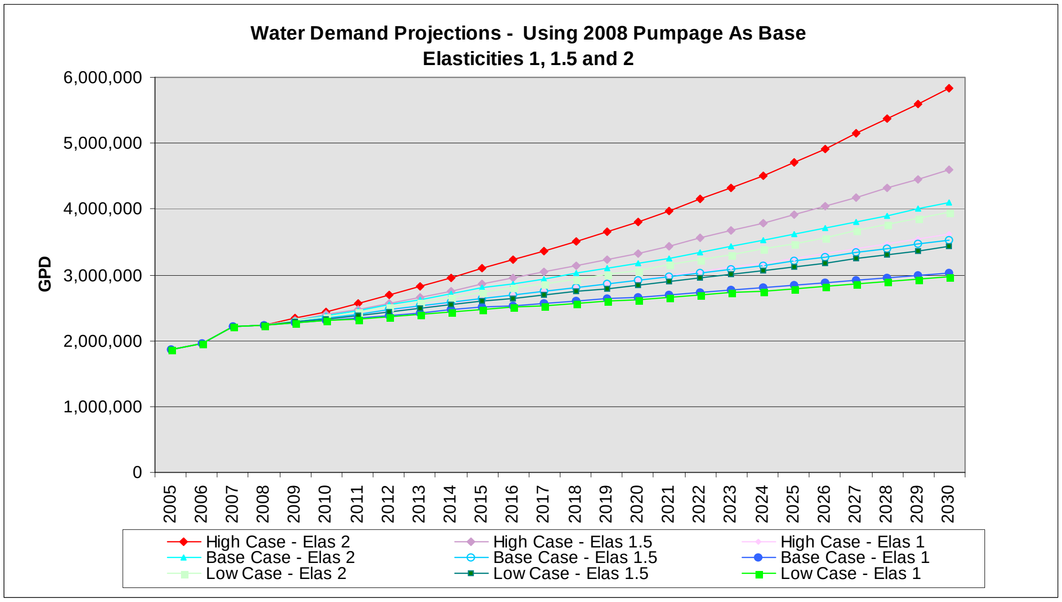
Using metered consumption as a base and adding 15% for unaccounted-for water, demand for the Well Service Areas of Wells 2 & 4 would range from 0.59 to 1.15 by 2030, with the most likely range from 0.6 to 0.81 MGD.

Using metered consumption as a base and adding 15% for unaccounted-for water, demand for the Well Service Areas of Wells 1, 9 & 14 would range from 1.19 to 2.33 MGD, with the most likely range between 1.21 and 1.64.

The forecast for Wells 1, 9 & 14 is somewhat problematic, given controversy over pumpage from brackish high level sources and declining water levels in these same sources. Although Manele Project District is not nearly built-out, brackish water use already exceeds that projected for the entire project in initial project approvals. The 1995 Phase II approval for residential and multi-family development of the Manele PD (95/PH2-001) noted that, at full build-out of the Project District, 0.65 MGD was anticipated to be utilized for golf course irrigation, to come from Wells 1, 9 & 14. Over and above this 0.65 MGD, 0.4 MGD was to be utilized for residential landscaping, of which only 0.15 MGDwas expected to come from high level brackish wells. Another 0.1 MGD was to come from basal Well 12 (which was not successful), and 0.15 was to come from the Manele Wastewater Treatment Plant, which currently serves about 0.073 MGD. The total pumpage envisioned from high level brackish sources was of 0.8 MGD at that time. The Lanaʻi Water Working Group report of February 1997 also recommended an allocation of 0.8 GPD from the high level aquifer for irrigation at Manele. Pumpage from the three brackish high level wells, 1, 9 & 14 was 943,776 GPD in 2008, although only half the hotel units and 17 out of 282 single family units have been built. Controversy surrounding the usage of potable and non-potable water from the high level aquifer, particular in regards to irrigation of Manele, continues. Fortunately, there appears to be much opportunity for conservation in Manele area landscaping.

Demand Analysis

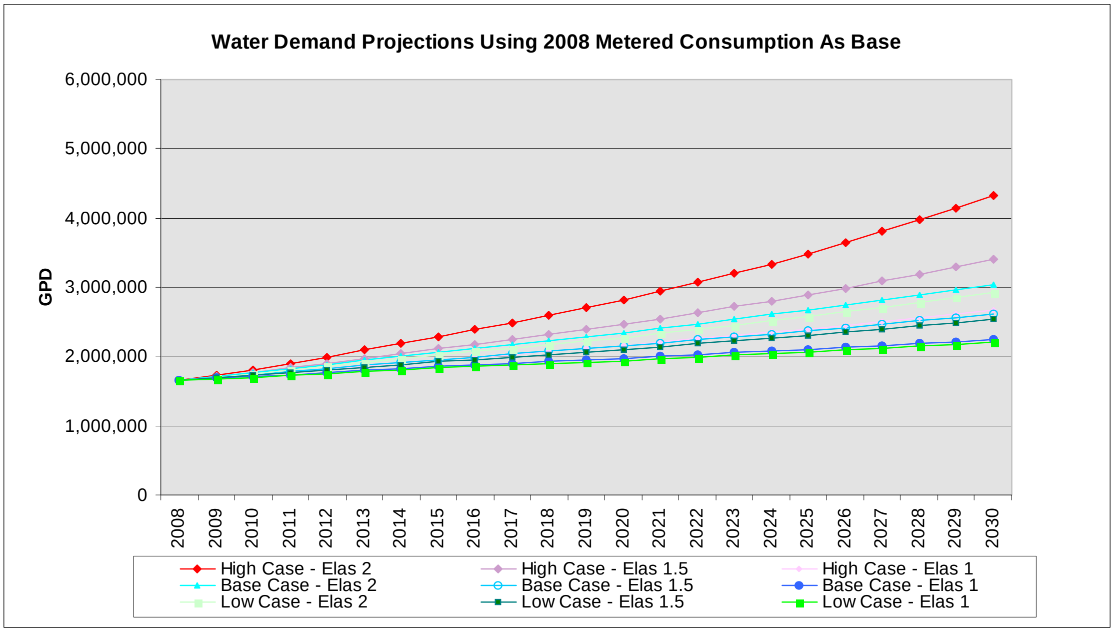
FIGURE 4-38. Island-wide Water Demand Projections Using SMS Forecast Factors with 2008 Pumpage as Base and Elasticities 1, 1.5, and 2



Pumped Water		Low Case			Base Case			High Case		
Year	Actual	Demand Elas.=1	Demand Elas =1.5	Demand Elas.=2	Demand Elas.=1	Demand Elas =1.5	Demand Elas.=2	Demand Elas.=1	Demand Elas =1.5	Demand Elas.=2
2005	1,860,308	1,860,308	1,860,308	1,860,308	1,860,308	1,860,308	1,860,308	1,860,308	1,860,308	1,860,308
2006	1,952,169	1,952,169	1,952,169	1,952,169	1,952,169	1,952,169	1,952,169	1,952,169	1,952,169	1,952,169
2007	2,211,199	2,211,199	2,211,199	2,211,199	2,211,199	2,211,199	2,211,199	2,211,199	2,211,199	2,211,199
2008	2,241,222	2,241,222	2,241,222	2,241,222	2,241,222	2,241,222	2,241,222	2,241,222	2,241,222	2,241,222
2009		2,270,184	2,284,805	2,299,520	2,276,243	2,293,957	2,311,810	2,290,680	2,315,817	2,341,230
2010		2,299,146	2,328,667	2,358,567	2,311,263	2,347,100	2,383,493	2,340,138	2,391,222	2,443,420
2011		2,334,481	2,382,556	2,431,621	2,349,823	2,406,081	2,463,686	2,398,813	2,481,716	2,567,485
2012		2,369,817	2,436,855	2,505,790	2,388,383	2,465,548	2,545,206	2,457,487	2,573,324	2,694,621
2013		2,405,152	2,491,560	2,581,073	2,426,943	2,525,497	2,628,053	2,516,162	2,666,033	2,824,830
2014		2,440,488	2,546,669	2,657,470	2,465,503	2,585,924	2,712,227	2,574,837	2,759,828	2,958,111
2015		2,475,823	2,602,178	2,734,981	2,504,062	2,646,825	2,797,728	2,633,511	2,854,699	3,094,464
2016		2,505,441	2,649,011	2,800,809	2,536,475	2,698,382	2,870,624	2,690,361	2,947,632	3,229,506
2017		2,535,059	2,696,123	2,867,420	2,568,888	2,750,269	2,944,458	2,747,210	3,041,553	3,367,433
2018		2,564,677	2,743,510	2,934,813	2,601,300	2,802,485	3,019,229	2,804,060	3,136,451	3,508,243
2019		2,594,295	2,791,172	3,002,990	2,633,713	2,855,027	3,094,938	2,860,909	3,232,315	3,651,937
2020		2,623,913	2,839,107	3,071,949	2,666,126	2,907,893	3,171,585	2,917,759	3,329,137	3,798,515
2021		2,657,655	2,894,046	3,151,464	2,701,984	2,966,756	3,257,473	2,983,460	3,442,214	3,971,508
2022		2,691,397	2,949,336	3,231,995	2,737,843	3,026,010	3,344,508	3,049,161	3,556,543	4,148,353
2023		2,725,139	3,004,973	3,313,542	2,773,702	3,085,654	3,432,691	3,114,861	3,672,110	4,329,050
2024		2,758,881	3,060,956	3,396,105	2,809,561	3,145,685	3,522,021	3,180,562	3,788,903	4,513,599
2025		2,792,623	3,117,282	3,479,684	2,845,420	3,206,100	3,612,499	3,246,263	3,906,908	4,702,000
2026		2,829,458	3,179,161	3,572,085	2,882,955	3,269,748	3,708,436	3,320,451	4,041,598	4,919,366
2027		2,866,293	3,241,444	3,665,696	2,920,490	3,333,813	3,805,631	3,394,638	4,177,801	5,141,644
2028		2,903,129	3,304,129	3,760,518	2,958,026	3,398,290	3,904,082	3,468,825	4,315,500	5,368,833
2029		2,939,964	3,367,212	3,856,551	2,995,561	3,463,178	4,003,791	3,543,012	4,454,681	5,600,934
2030		2,976,799	3,430,692	3,953,794	3,033,096	3,528,473	4,104,757	3,617,200	4,595,325	5,837,946

Modified Econometric Analysis

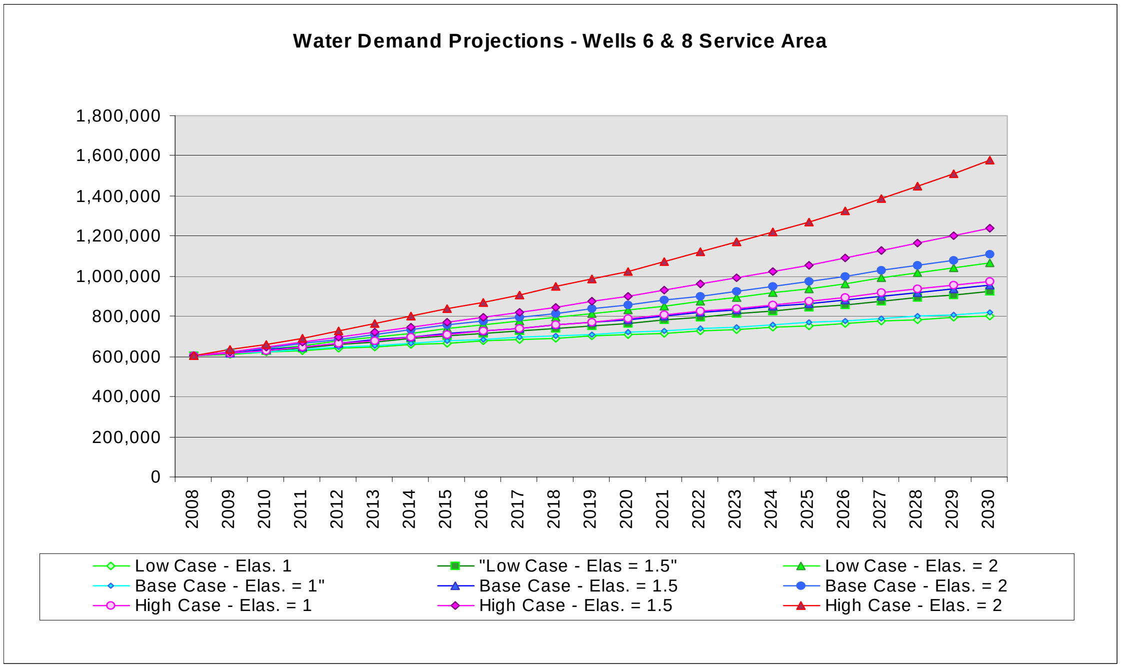
FIGURE 4-39. Water Demand Projections Using 2008 Metered Consumption as Base, with Elasticities 1, 1.5 & 2



	Low Case			Base Case			High Case		
	Demand	Demand	Demand	Demand	Demand	Demand	Demand	Demand	Demand
Year	Elas.=1	Elas.=1.5	Elas.=2	Elas.=1	Elas.=1.5	Elas.=2	Elas.=1	Elas.=1.5	Elas.=2
2008	1,658,224	1,658,224	1,658,224	1,658,224	1,658,224	1,658,224	1,658,224	1,658,224	1,658,224
2009	1,679,652	1,690,470	1,701,357	1,684,135	1,697,242	1,710,451	1,694,817	1,713,415	1,732,217
2010	1,701,080	1,722,922	1,745,044	1,710,046	1,736,561	1,763,487	1,731,410	1,769,205	1,807,826
2011	1,727,224	1,762,794	1,799,096	1,738,575	1,780,199	1,822,820	1,774,822	1,836,160	1,899,618
2012	1,753,368	1,802,968	1,853,971	1,767,105	1,824,197	1,883,134	1,818,233	1,903,938	1,993,683
2013	1,779,512	1,843,443	1,909,671	1,795,634	1,868,552	1,944,431	1,861,645	1,972,531	2,090,021
2014	1,805,656	1,884,216	1,966,195	1,824,164	1,913,260	2,006,709	1,905,057	2,041,928	2,188,632
2015	1,831,799	1,925,286	2,023,544	1,852,693	1,958,320	2,069,968	1,948,469	2,112,120	2,289,516
2016	1,853,713	1,959,937	2,072,248	1,876,674	1,996,465	2,123,903	1,990,530	2,180,879	2,389,431
2017	1,875,627	1,994,794	2,121,532	1,900,656	2,034,855	2,178,531	2,032,592	2,250,369	2,491,479
2018	1,897,540	2,029,855	2,171,395	1,924,637	2,073,488	2,233,852	2,074,654	2,320,581	2,595,661
2019	1,919,454	2,065,118	2,221,837	1,948,618	2,112,363	2,289,867	2,116,715	2,391,509	2,701,977
2020	1,941,368	2,100,584	2,272,858	1,972,600	2,151,477	2,346,576	2,158,777	2,463,145	2,810,426
2021	1,966,332	2,141,232	2,331,689	1,999,131	2,195,028	2,410,122	2,207,387	2,546,808	2,938,419
2022	1,991,297	2,182,140	2,391,272	2,025,662	2,238,869	2,474,518	2,255,998	2,631,397	3,069,263
2023	2,016,262	2,223,304	2,451,607	2,052,193	2,282,998	2,539,762	2,304,608	2,716,902	3,202,956
2024	2,041,227	2,264,725	2,512,693	2,078,724	2,327,413	2,605,855	2,353,218	2,803,314	3,339,499
2025	2,066,192	2,306,399	2,574,531	2,105,255	2,372,113	2,672,798	2,401,829	2,890,623	3,478,892
2026	2,093,445	2,352,182	2,642,896	2,133,026	2,419,205	2,743,779	2,456,718	2,990,277	3,639,716
2027	2,120,699	2,398,263	2,712,157	2,160,798	2,466,605	2,815,691	2,511,607	3,091,050	3,804,174
2028	2,147,952	2,444,642	2,782,313	2,188,569	2,514,310	2,888,533	2,566,497	3,192,931	3,972,265
2029	2,175,205	2,491,316	2,853,365	2,216,340	2,562,318	2,962,305	2,621,386	3,295,906	4,143,991
2030	2,202,459	2,538,283	2,925,313	2,244,112	2,610,629	3,037,007	2,676,275	3,399,966	4,319,350

Demand Analysis

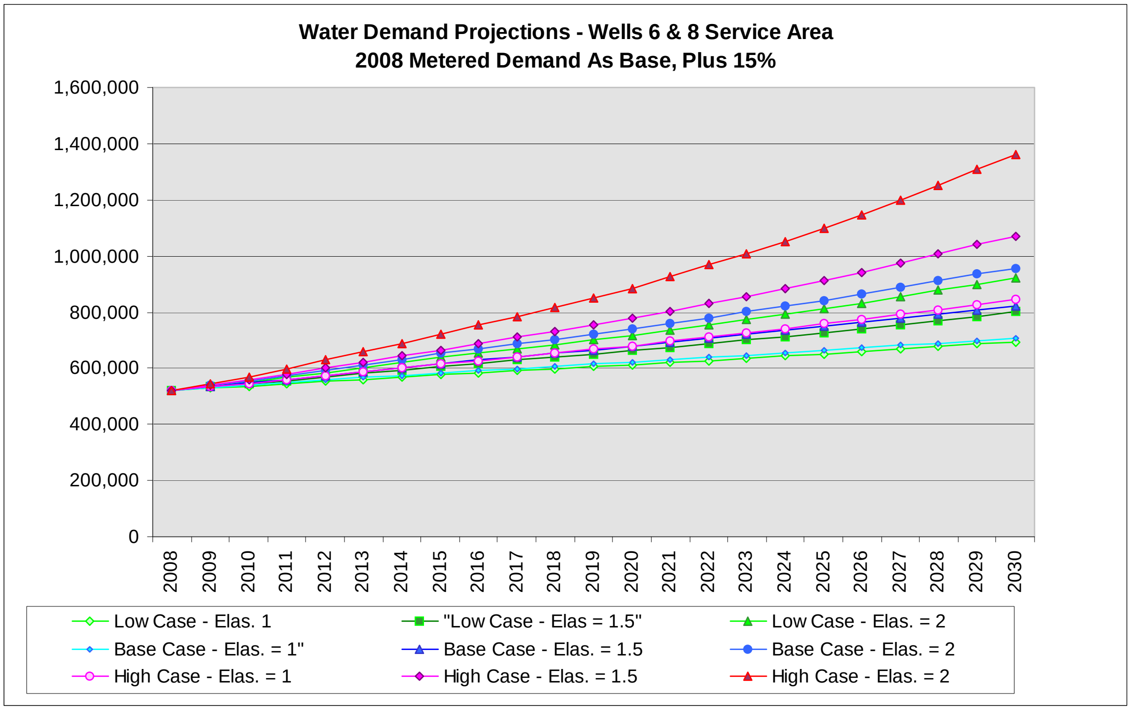
FIGURE 4-40. Wells 6 & 8 Service Area - Projections Using 2008 Pumped Demand



Year	Low Case Demand Elas.=1	Low Case Demand Elas.=1.5	Low Case Demand Elas.=2	Base Case Demand Elas.=1	Base Case Demand Elas.=1.5	Base Case Demand Elas.=2	High Case Demand Elas.=1	High Case Demand Elas.=1.5	High Case Demand Elas.=2
2008	605,046	605,046	605,046	605,046	605,046	605,046	605,046	605,046	605,046
2009	612,865	616,812	620,784	614,500	619,283	624,102	618,398	625,184	632,044
2010	620,683	628,653	636,725	623,954	633,629	643,454	631,750	645,540	659,632
2011	630,223	643,201	656,447	634,364	649,552	665,103	647,590	669,970	693,125
2012	639,762	657,860	676,469	644,774	665,606	687,110	663,430	694,701	727,447
2013	649,301	672,628	696,793	655,184	681,790	709,476	679,270	719,729	762,598
2014	658,840	687,505	717,417	665,593	698,103	732,200	695,109	745,050	798,579
2015	668,379	702,491	738,342	676,003	714,544	755,282	710,949	770,662	835,389
2016	676,375	715,134	756,114	684,753	728,462	774,961	726,297	795,750	871,846
2017	684,371	727,852	774,096	693,503	742,470	794,893	741,644	821,105	909,081
2018	692,367	740,645	792,290	702,254	756,566	815,079	756,991	846,724	947,094
2019	700,363	753,512	810,695	711,004	770,750	835,517	772,338	872,604	985,886
2020	708,358	766,453	829,311	719,754	785,022	856,209	787,686	898,742	1,025,457
2021	717,467	781,284	850,777	729,435	800,913	879,396	805,422	929,269	1,072,158
2022	726,576	796,210	872,518	739,115	816,909	902,892	823,159	960,133	1,119,900
2023	735,686	811,230	894,532	748,796	833,011	926,698	840,896	991,332	1,168,681
2024	744,795	826,343	916,821	758,476	849,217	950,814	858,633	1,022,862	1,218,503
2025	753,904	841,549	939,384	768,157	865,527	975,239	876,370	1,054,719	1,269,364
2026	763,848	858,254	964,329	778,290	882,710	1,001,139	896,397	1,091,080	1,328,045
2027	773,792	875,069	989,601	788,423	900,005	1,027,378	916,425	1,127,850	1,388,051
2028	783,736	891,991	1,015,199	798,556	917,411	1,053,956	936,453	1,165,023	1,449,384
2029	793,680	909,021	1,041,124	808,689	934,928	1,080,874	956,481	1,202,597	1,512,042
2030	803,624	926,158	1,067,376	818,822	952,556	1,108,131	976,508	1,240,566	1,576,027

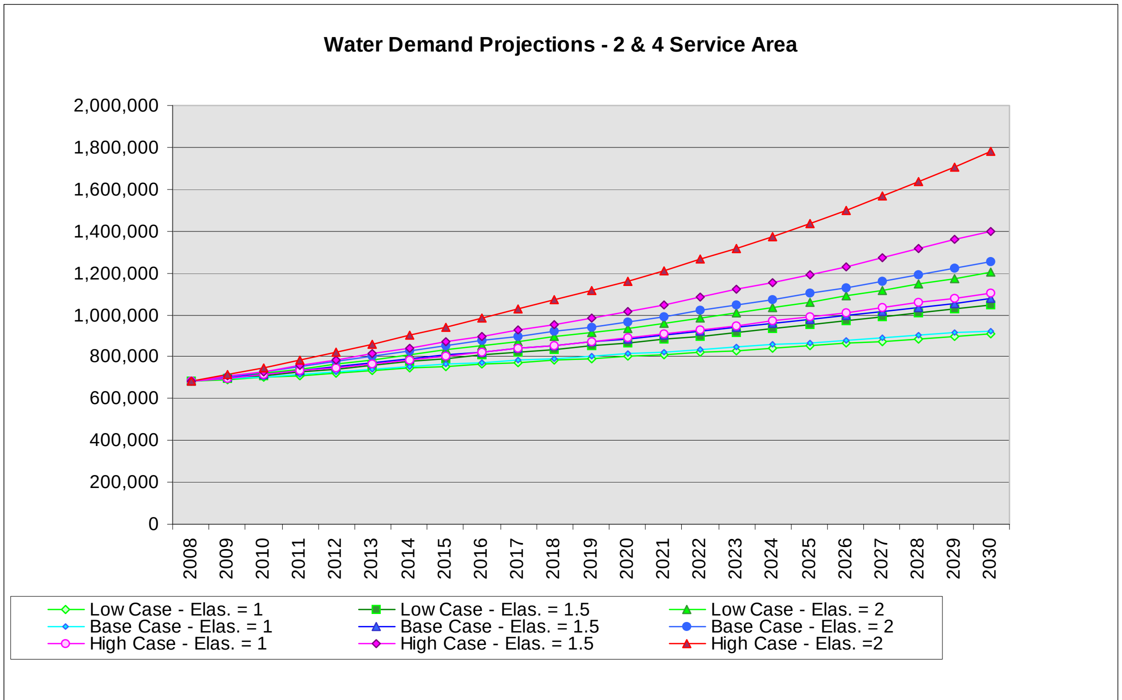
Modified Econometric Analysis

FIGURE 4-41. Wells 6 & 8 Service Area - Projections Using 2008 Metered Demand Plus 12%



	Low Case			Base Case			High Case		
Year	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2
2008	594,025	594,025	594,025	594,025	594,025	594,025	594,025	594,025	594,025
2009	601,701	605,576	609,477	603,307	608,002	612,734	607,134	613,796	620,532
2010	609,377	617,202	625,127	612,589	622,088	631,733	620,242	633,782	647,617
2011	618,743	631,485	644,489	622,809	637,720	652,988	635,794	657,767	680,499
2012	628,108	645,877	664,147	633,029	653,482	674,595	651,345	682,047	714,196
2013	637,474	660,376	684,101	643,249	669,371	696,553	666,897	706,619	748,707
2014	646,839	674,982	704,349	653,469	685,387	718,863	682,448	731,479	784,033
2015	656,205	689,695	724,893	663,690	701,528	741,524	697,999	756,624	820,173
2016	664,055	702,108	742,341	672,280	715,193	760,845	713,067	781,256	855,965
2017	671,905	714,594	759,996	680,871	728,946	780,414	728,135	806,149	892,522
2018	679,755	727,154	777,858	689,462	742,785	800,232	743,202	831,301	929,843
2019	687,605	739,787	795,928	698,053	756,711	820,298	758,270	856,709	967,928
2020	695,455	752,491	814,205	706,644	770,723	840,613	773,338	882,372	1,006,778
2021	704,399	767,053	835,280	716,148	786,324	863,377	790,751	912,342	1,052,629
2022	713,342	781,707	856,625	725,652	802,029	886,446	808,165	942,644	1,099,501
2023	722,285	796,454	878,238	735,156	817,838	909,818	825,579	973,275	1,147,394
2024	731,228	811,292	900,121	744,660	833,748	933,495	842,993	1,004,230	1,196,307
2025	740,171	826,220	922,273	754,165	849,761	957,475	860,406	1,035,507	1,246,242
2026	749,934	842,621	946,764	764,113	866,631	982,903	880,069	1,071,206	1,303,854
2027	759,697	859,129	971,575	774,062	883,611	1,008,664	899,732	1,107,306	1,362,768
2028	769,460	875,743	996,707	784,010	900,700	1,034,758	919,395	1,143,802	1,422,983
2029	779,223	892,463	1,022,160	793,959	917,898	1,061,185	939,058	1,180,691	1,484,500
2030	788,986	909,288	1,047,934	803,907	935,205	1,087,946	958,721	1,217,969	1,547,319

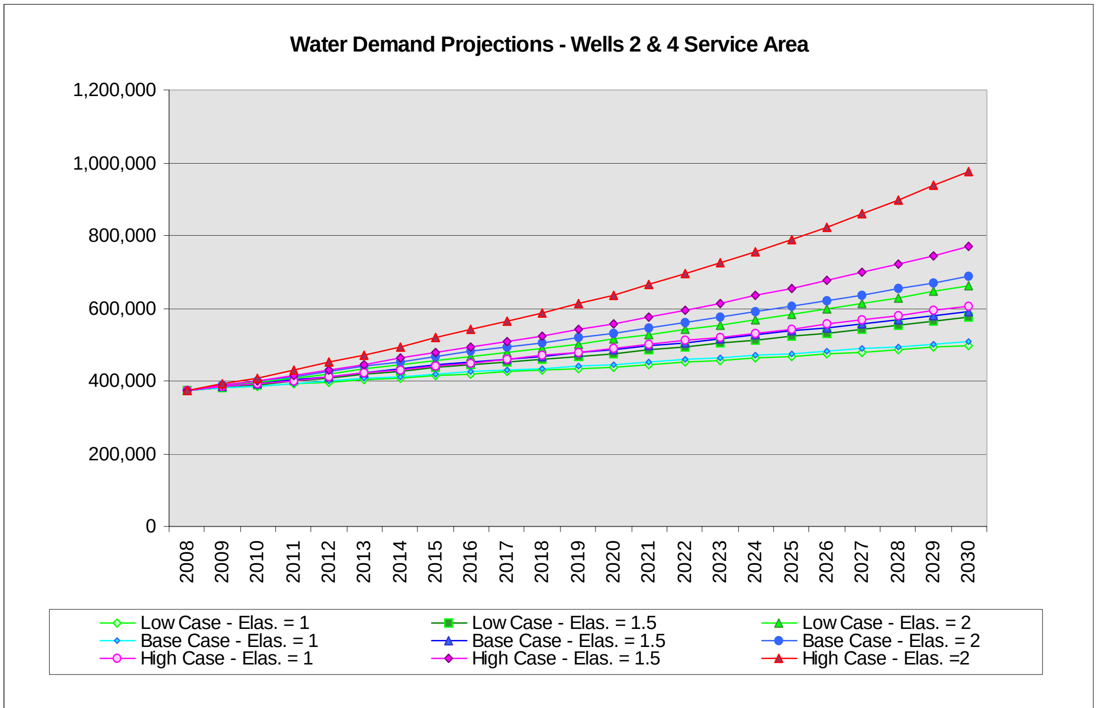
FIGURE 4-42. Wells 2 & 4 Service Area - Projections Using 2008 Pumped Demand



	Low Case			Base Case			High Case		
Year	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2
2008	683,055	683,055	683,055	683,055	683,055	683,055	683,055	683,055	683,055
2009	691,882	696,338	700,822	693,728	699,127	704,568	698,128	705,789	713,534
2010	700,708	709,705	718,818	704,401	715,323	726,415	713,202	728,770	744,679
2011	711,478	726,129	741,083	716,153	733,299	750,855	731,084	756,350	782,490
2012	722,247	742,678	763,687	727,905	751,423	775,700	748,966	784,270	821,237
2013	733,016	759,350	786,631	739,657	769,693	800,949	766,848	812,524	860,921
2014	743,785	776,146	809,914	751,409	788,109	826,603	784,730	841,110	901,541
2015	754,554	793,063	833,537	763,161	806,670	852,661	802,613	870,024	943,097
2016	763,581	807,337	853,600	773,039	822,383	874,877	819,939	898,347	984,253
2017	772,607	821,695	873,901	782,917	838,197	897,380	837,265	926,971	1,026,289
2018	781,634	836,137	894,440	792,796	854,111	920,168	854,590	955,893	1,069,204
2019	790,661	850,663	915,218	802,674	870,124	943,241	871,916	985,109	1,112,997
2020	799,687	865,272	936,235	812,552	886,236	966,601	889,242	1,014,618	1,157,670
2021	809,971	882,016	960,469	823,481	904,175	992,777	909,266	1,049,080	1,210,393
2022	820,254	898,866	985,012	834,410	922,234	1,019,302	929,290	1,083,924	1,264,289
2023	830,538	915,823	1,009,865	845,338	940,412	1,046,178	949,313	1,119,145	1,319,360
2024	840,822	932,885	1,035,028	856,267	958,707	1,073,403	969,337	1,154,740	1,375,605
2025	851,105	950,051	1,060,500	867,196	977,120	1,100,978	989,360	1,190,704	1,433,024
2026	862,331	968,910	1,088,661	878,635	996,518	1,130,216	1,011,970	1,231,754	1,499,270
2027	873,557	987,892	1,117,191	890,075	1,016,043	1,159,838	1,034,580	1,273,264	1,567,014
2028	884,784	1,006,996	1,146,089	901,515	1,035,693	1,189,843	1,057,190	1,315,231	1,636,254
2029	896,010	1,026,222	1,175,357	912,954	1,055,469	1,220,231	1,079,800	1,357,649	1,706,991
2030	907,236	1,045,569	1,204,994	924,394	1,075,369	1,251,003	1,102,410	1,400,513	1,779,225

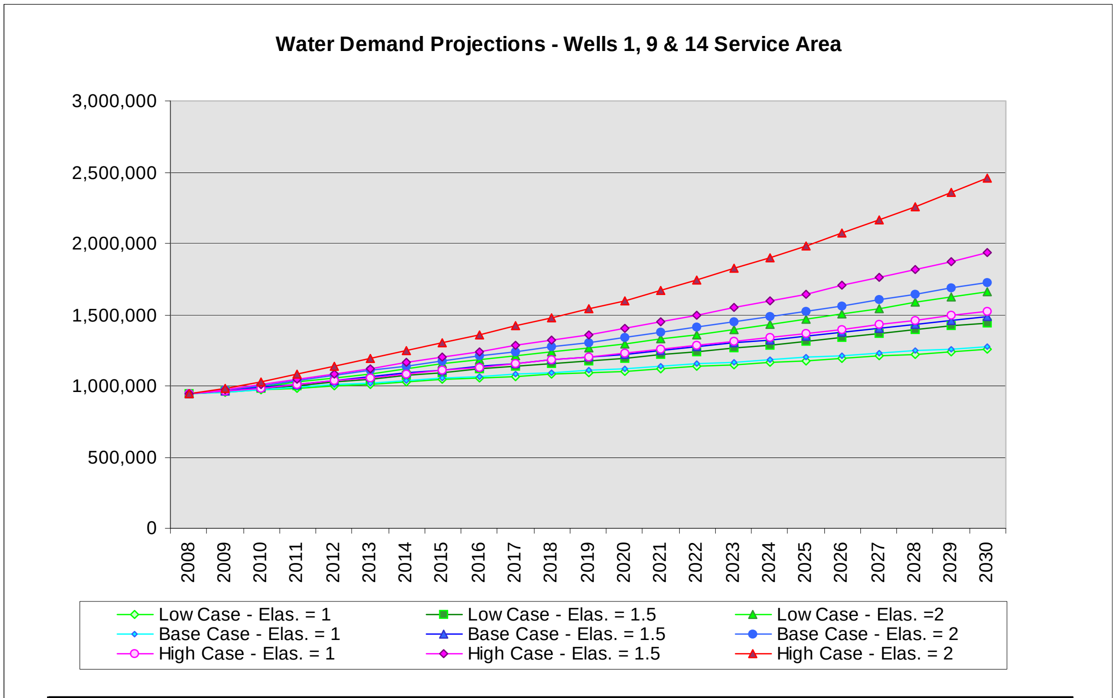
Modified Econometric Analysis

FIGURE 4-43. Wells 2 & 4 Service Area - Projections Using 2008 Metered Demand Plus 15%



	Low Case			Base Case			High Case		
Year	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2
2008	441,348	441,348	441,348	441,348	441,348	441,348	441,348	441,348	441,348
2009	447,052	449,931	452,828	448,245	451,733	455,249	451,088	456,038	461,042
2010	452,755	458,568	464,456	455,141	462,198	469,365	460,827	470,887	481,166
2011	459,713	469,180	478,842	462,734	473,813	485,157	472,382	488,707	505,597
2012	466,671	479,873	493,448	470,328	485,523	501,210	483,936	506,747	530,633
2013	473,630	490,646	508,273	477,921	497,329	517,524	495,490	525,003	556,274
2014	480,588	501,498	523,317	485,514	509,228	534,100	507,045	543,474	582,520
2015	487,547	512,429	538,581	493,108	521,221	550,937	518,599	562,156	609,371
2016	493,379	521,651	551,544	499,490	531,374	565,292	529,794	580,457	635,964
2017	499,212	530,929	564,661	505,873	541,591	579,832	540,989	598,952	663,125
2018	505,044	540,260	577,932	512,256	551,874	594,556	552,184	617,639	690,854
2019	510,876	549,646	591,358	518,639	562,221	609,465	563,379	636,517	719,151
2020	516,709	559,086	604,938	525,022	572,631	624,558	574,574	655,584	748,015
2021	523,354	569,904	620,596	532,083	584,223	641,471	587,512	677,851	782,081
2022	529,998	580,792	636,454	539,144	595,891	658,611	600,450	700,365	816,906
2023	536,643	591,748	652,513	546,206	607,636	675,976	613,388	723,123	852,490
2024	543,287	602,773	668,771	553,267	619,458	693,567	626,326	746,122	888,832
2025	549,932	613,865	685,230	560,329	631,355	711,384	639,264	769,360	925,932
2026	557,186	626,050	703,426	567,720	643,889	730,277	653,873	795,884	968,737
2027	564,439	638,315	721,860	575,112	656,505	749,416	668,482	822,705	1,012,508
2028	571,693	650,659	740,533	582,503	669,202	768,804	683,092	849,821	1,057,247
2029	578,947	663,082	759,444	589,895	681,979	788,439	697,701	877,229	1,102,953
2030	586,200	675,582	778,593	597,287	694,838	808,321	712,310	904,925	1,149,626

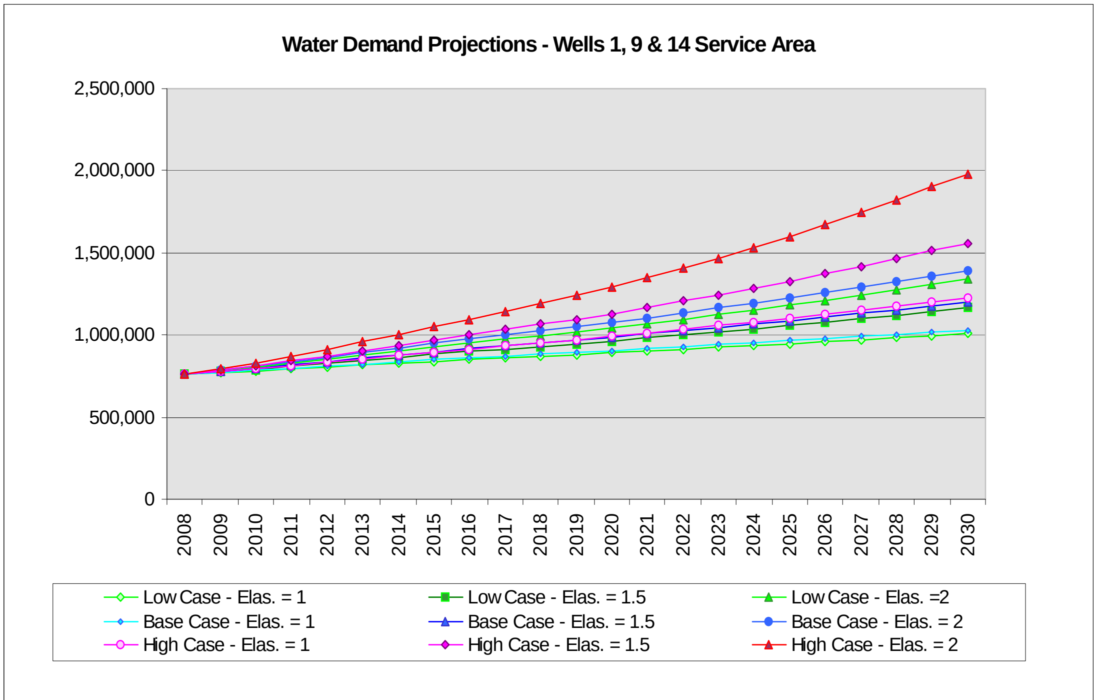
FIGURE 4-44. Wells 1, 9 & 14 Service Area - Projections Using Pumped Demand - Plus 15%



	Low Case			Base Case			High Case		
Year	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2	Demand Elas.=1	Demand Elas.=1.5	Demand Elas.=2
2008	943,776	943,776	943,776	943,776	943,776	943,776	943,776	943,776	943,776
2009	955,972	962,129	968,325	958,523	965,983	973,501	964,603	975,188	985,889
2010	968,168	980,599	993,190	973,270	988,361	1,003,686	985,430	1,006,941	1,028,922
2011	983,047	1,003,292	1,023,953	989,508	1,013,198	1,037,455	1,010,137	1,045,048	1,081,165
2012	997,927	1,026,157	1,055,185	1,005,745	1,038,239	1,071,783	1,034,845	1,083,624	1,134,702
2013	1,012,807	1,049,193	1,086,887	1,021,983	1,063,484	1,106,670	1,059,553	1,122,663	1,189,533
2014	1,027,686	1,072,399	1,119,057	1,038,220	1,088,930	1,142,116	1,084,261	1,162,161	1,245,657
2015	1,042,566	1,095,774	1,151,697	1,054,458	1,114,575	1,178,120	1,108,969	1,202,110	1,303,075
2016	1,055,038	1,115,496	1,179,417	1,068,107	1,136,286	1,208,816	1,132,908	1,241,245	1,359,941
2017	1,067,510	1,135,334	1,207,467	1,081,756	1,158,135	1,239,908	1,156,847	1,280,794	1,418,022
2018	1,079,983	1,155,289	1,235,847	1,095,405	1,180,123	1,271,394	1,180,786	1,320,756	1,477,317
2019	1,092,455	1,175,359	1,264,556	1,109,053	1,202,249	1,303,275	1,204,726	1,361,124	1,537,826
2020	1,104,927	1,195,545	1,293,594	1,122,702	1,224,511	1,335,551	1,228,665	1,401,896	1,599,550
2021	1,119,136	1,218,680	1,327,078	1,137,803	1,249,297	1,371,718	1,256,331	1,449,512	1,672,398
2022	1,133,344	1,241,962	1,360,989	1,152,903	1,274,249	1,408,369	1,283,998	1,497,656	1,746,867
2023	1,147,553	1,265,391	1,395,329	1,168,003	1,299,365	1,445,502	1,311,665	1,546,321	1,822,958
2024	1,161,762	1,288,965	1,430,096	1,183,103	1,324,644	1,483,119	1,339,331	1,595,503	1,900,671
2025	1,175,970	1,312,684	1,465,291	1,198,203	1,350,085	1,521,219	1,366,998	1,645,194	1,980,007
2026	1,191,482	1,338,741	1,504,201	1,214,009	1,376,887	1,561,618	1,398,238	1,701,912	2,071,539
2027	1,206,993	1,364,968	1,543,620	1,229,815	1,403,865	1,602,547	1,429,478	1,759,267	2,165,140
2028	1,222,504	1,391,365	1,583,550	1,245,621	1,431,016	1,644,005	1,460,718	1,817,252	2,260,810
2029	1,238,015	1,417,929	1,623,989	1,261,427	1,458,340	1,685,992	1,491,958	1,875,861	2,358,547
2030	1,253,527	1,444,661	1,664,938	1,277,233	1,485,836	1,728,509	1,523,199	1,935,086	2,458,352

Modified Econometric Analysis

FIGURE 4-45. Wells 1, 9 & 14 Service Area - Projections Using Metered Demand Plus 15%



Year	Low Case Demand Elas.=1	Low Case Demand Elas.=1.5	Low Case Demand Elas.=2	Base Case Demand Elas.=1	Base Case Demand Elas.=1.5	Base Case Demand Elas.=2	High Case Demand Elas.=1	High Case Demand Elas.=1.5	High Case Demand Elas.=2
2008	894,538	894,538	894,538	894,538	894,538	894,538	894,538	894,538	894,538
2009	906,097	911,933	917,806	908,515	915,586	922,712	914,278	924,311	934,454
2010	917,657	929,439	941,373	922,493	936,797	951,322	934,018	954,407	975,241
2011	931,760	950,948	970,532	937,883	960,338	983,330	957,437	990,526	1,024,759
2012	945,864	972,621	1,000,134	953,274	984,073	1,015,867	980,856	1,027,089	1,075,503
2013	959,967	994,455	1,030,182	968,664	1,008,000	1,048,933	1,004,274	1,064,092	1,127,473
2014	974,070	1,016,450	1,060,674	984,055	1,032,118	1,082,530	1,027,693	1,101,529	1,180,669
2015	988,174	1,038,606	1,091,611	999,445	1,056,426	1,116,655	1,051,112	1,139,394	1,235,092
2016	999,995	1,057,298	1,117,885	1,012,382	1,077,004	1,145,750	1,073,802	1,176,487	1,288,991
2017	1,011,817	1,076,102	1,144,472	1,025,319	1,097,713	1,175,220	1,096,492	1,213,973	1,344,041
2018	1,023,638	1,095,016	1,171,370	1,038,255	1,118,554	1,205,063	1,119,183	1,251,850	1,400,243
2019	1,035,459	1,114,039	1,198,582	1,051,192	1,139,525	1,235,281	1,141,873	1,290,112	1,457,596
2020	1,047,281	1,133,171	1,226,105	1,064,129	1,160,626	1,265,873	1,164,563	1,328,756	1,516,099
2021	1,060,748	1,155,099	1,257,842	1,078,441	1,184,120	1,300,153	1,190,787	1,373,889	1,585,146
2022	1,074,216	1,177,167	1,289,984	1,092,754	1,207,770	1,334,892	1,217,010	1,419,521	1,655,730
2023	1,087,683	1,199,373	1,322,532	1,107,066	1,231,575	1,370,088	1,243,233	1,465,647	1,727,851
2024	1,101,151	1,221,718	1,355,486	1,121,378	1,255,535	1,405,742	1,269,456	1,512,263	1,801,510
2025	1,114,618	1,244,199	1,388,844	1,135,691	1,279,649	1,441,855	1,295,679	1,559,362	1,876,706
2026	1,129,320	1,268,897	1,425,724	1,150,672	1,305,053	1,480,146	1,325,290	1,613,121	1,963,464
2027	1,144,022	1,293,756	1,463,087	1,165,654	1,330,623	1,518,939	1,354,900	1,667,483	2,052,181
2028	1,158,724	1,318,775	1,500,933	1,180,635	1,356,358	1,558,234	1,384,510	1,722,443	2,142,859
2029	1,173,426	1,343,954	1,539,263	1,195,616	1,382,256	1,598,031	1,414,120	1,777,994	2,235,498
2030	1,188,128	1,369,290	1,578,076	1,210,598	1,408,318	1,638,329	1,443,731	1,834,130	2,330,096

FIGURE 4-46. Well Service Area Projections - Combined Totals

Low Case - Elasticity 1

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	594,025	441,348	894,538	1,929,911
2009	601,701	447,052	906,097	1,954,850
2010	609,377	452,755	917,657	1,979,789
2011	618,743	459,713	931,760	2,010,216
2012	628,108	466,671	945,864	2,040,643
2013	637,474	473,630	959,967	2,071,071
2014	646,839	480,588	974,070	2,101,498
2015	656,205	487,547	988,174	2,131,925
2016	664,055	493,379	999,995	2,157,429
2017	671,905	499,212	1,011,817	2,182,933
2018	679,755	505,044	1,023,638	2,208,437
2019	687,605	510,876	1,035,459	2,233,941
2020	695,455	516,709	1,047,281	2,259,445
2021	704,399	523,354	1,060,748	2,288,500
2022	713,342	529,998	1,074,216	2,317,556
2023	722,285	536,643	1,087,683	2,346,611
2024	731,228	543,287	1,101,151	2,375,666
2025	740,171	549,932	1,114,618	2,404,721
2026	749,934	557,186	1,129,320	2,436,440
2027	759,697	564,439	1,144,022	2,468,158
2028	769,460	571,693	1,158,724	2,499,877
2029	779,223	578,947	1,173,426	2,531,596
2030	788,986	586,200	1,188,128	2,563,314

Base Case - Elasticity 1

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	594,025	441,348	894,538	1,929,911
2009	603,307	448,245	908,515	1,960,067
2010	612,589	455,141	922,493	1,990,223
2011	622,809	462,734	937,883	2,023,427
2012	633,029	470,328	953,274	2,056,631
2013	643,249	477,921	968,664	2,089,835
2014	653,469	485,514	984,055	2,123,038
2015	663,690	493,108	999,445	2,156,242
2016	672,280	499,490	1,012,382	2,184,153
2017	680,871	505,873	1,025,319	2,212,063
2018	689,462	512,256	1,038,255	2,239,973
2019	698,053	518,639	1,051,192	2,267,884
2020	706,644	525,022	1,064,129	2,295,794
2021	716,148	532,083	1,078,441	2,326,672
2022	725,652	539,144	1,092,754	2,357,550
2023	735,156	546,206	1,107,066	2,388,428
2024	744,660	553,267	1,121,378	2,419,306
2025	754,165	560,329	1,135,691	2,450,184
2026	764,113	567,720	1,150,672	2,482,506
2027	774,062	575,112	1,165,654	2,514,827
2028	784,010	582,503	1,180,635	2,547,149
2029	793,959	589,895	1,195,616	2,579,470
2030	803,907	597,287	1,210,598	2,611,792

High Case - Elasticity 1

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	594,025	441,348	894,538	1,929,911
2009	607,134	451,088	914,278	1,972,499
2010	620,242	460,827	934,018	2,015,088
2011	635,794	472,382	957,437	2,065,612
2012	651,345	483,936	980,856	2,116,137
2013	666,897	495,490	1,004,274	2,166,661
2014	682,448	507,045	1,027,693	2,217,186
2015	697,999	518,599	1,051,112	2,267,710
2016	713,067	529,794	1,073,802	2,316,663
2017	728,135	540,989	1,096,492	2,365,616
2018	743,202	552,184	1,119,183	2,414,569
2019	758,270	563,379	1,141,873	2,463,522
2020	773,338	574,574	1,164,563	2,512,475
2021	790,751	587,512	1,190,787	2,569,050
2022	808,165	600,450	1,217,010	2,625,625
2023	825,579	613,388	1,243,233	2,682,200
2024	842,993	626,326	1,269,456	2,738,775
2025	860,406	639,264	1,295,679	2,795,350
2026	880,069	653,873	1,325,290	2,859,232
2027	899,732	668,482	1,354,900	2,923,114
2028	919,395	683,092	1,384,510	2,986,997
2029	939,058	697,701	1,414,120	3,050,879
2030	958,721	712,310	1,443,731	3,114,762

Low Case - Elasticity 1.5

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	594,025	441,348	894,538	1,929,911
2009	605,576	449,931	911,933	1,967,440
2010	617,202	458,568	929,439	2,005,209
2011	631,485	469,180	950,948	2,051,613
2012	645,877	479,873	972,621	2,098,370
2013	660,376	490,646	994,455	2,145,477
2014	674,982	501,498	1,016,450	2,192,930
2015	689,695	512,429	1,038,606	2,240,729
2016	702,108	521,651	1,057,298	2,281,057
2017	714,594	530,929	1,076,102	2,321,625
2018	727,154	540,260	1,095,016	2,362,430
2019	739,787	549,646	1,114,039	2,403,472
2020	752,491	559,086	1,133,171	2,444,748
2021	767,053	569,904	1,155,099	2,492,056
2022	781,707	580,792	1,177,167	2,539,666
2023	796,454	591,748	1,199,373	2,587,575
2024	811,292	602,773	1,221,718	2,635,782
2025	826,220	613,865	1,244,199	2,684,284
2026	842,621	626,050	1,268,897	2,737,568
2027	859,129	638,315	1,293,756	2,791,200
2028	875,743	650,659	1,318,775	2,845,177
2029	892,483	663,082	1,343,954	2,899,488
2030	909,288	675,582	1,369,290	2,954,161

Base Case - Elasticity 1.5

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	594,025	441,348	894,538	1,929,911
2009	608,002	451,733	915,586	1,975,321
2010	622,088	462,198	936,797	2,021,082
2011	637,720	473,813	960,338	2,071,871
2012	653,482	485,523	984,073	2,123,077
2013	669,371	497,329	1,008,000	2,174,699
2014	685,387	509,228	1,032,118	2,226,733
2015	701,528	521,221	1,056,426	2,279,175
2016	715,193	531,374	1,077,004	2,323,570
2017	728,946	541,591	1,097,713	2,368,250
2018	742,785	551,874	1,118,554	2,413,213
2019	756,711	562,221	1,139,525	2,458,457
2020	770,723	572,631	1,160,626	2,503,980
2021	786,324	584,223	1,184,120	2,554,666
2022	802,029	595,891	1,207,770	2,605,690
2023	817,838	607,636	1,231,575	2,657,049
2024	833,748	619,458	1,255,535	2,708,742
2025	849,761	631,355	1,279,649	2,760,765
2026	866,631	643,889	1,305,053	2,815,573
2027	883,611	656,505	1,330,623	2,870,738
2028	900,700	669,202	1,356,358	2,926,259
2029	917,898	681,979	1,382,256	2,982,134
2030	935,205	694,838	1,408,318	3,038,360

High Case - Elasticity 1.5

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	594,025	441,348	894,538	1,929,911
2009	613,796	456,038	924,311	1,994,145
2010	633,782	470,887	954,407	2,059,075
2011	657,767	488,707	990,526	2,137,000
2012	682,047	506,747	1,027,089	2,215,883
2013	706,619	525,003	1,064,092	2,295,714
2014	731,479	543,474	1,101,529	2,376,482
2015	756,624	562,156	1,139,394	2,458,174
2016	781,256	580,457	1,176,487	2,538,199
2017	806,149	598,952	1,213,973	2,619,074
2018	831,301	617,639	1,251,850	2,700,790
2019	856,709	636,517	1,290,112	2,783,339
2020	882,372	655,584	1,328,756	2,866,712
2021	912,342	677,851	1,373,889	2,964,082
2022	942,644	700,365	1,419,521	3,062,530
2023	973,275	723,123	1,465,647	3,162,045
2024	1,004,230	746,122	1,512,263	3,262,615
2025	1,035,507	769,360	1,559,362	3,364,229
2026	1,071,206	795,884	1,613,121	3,480,210
2027	1,107,306	822,705	1,667,483	3,597,494
2028	1,143,802	849,821	1,722,443	3,716,067
2029	1,180,891	877,229	1,777,994	3,835,915
2030	1,217,989	904,925	1,834,130	3,957,024

Low Case - Elasticity 2

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	594,025	441,348	894,538	1,929,911
2009	609,477	452,828	917,806	1,980,111
2010	625,127	464,456	941,373	2,030,956
2011	644,489	478,842	970,532	2,093,863
2012	664,147	493,448	1,000,134	2,157,730
2013	684,101	508,273	1,030,182	2,222,555
2014	704,349	523,317	1,060,674	2,288,341
2015	724,893	538,581	1,091,611	2,355,086
2016	742,341	551,544	1,117,885	2,411,770
2017	759,996	564,661	1,144,472	2,469,128
2018	777,858	577,932	1,171,370	2,527,161
2019	795,928	591,358	1,198,582	2,585,867
2020	814,205	604,938	1,226,105	2,645,248
2021	835,280	620,596	1,257,842	2,713,718
2022	856,625	636,454	1,289,984	2,783,063
2023	878,238	652,513	1,322,532	2,853,283
2024	900,121	668,771	1,355,486	2,924,378
2025	922,273	685,230	1,388,844	2,996,348
2026	946,764	703,426	1,425,724	3,075,914
2027	971,575	721,860	1,463,087	3,156,522
2028	996,707	740,533	1,500,933	3,238,173
2029	1,022,160	759,444	1,539,263	3,320,867
2030	1,047,934	778,593	1,578,076	3,404,603

Base Case - Elasticity 2

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	594,025	441,348	894,538	1,929,911
2009	612,734	455,249	922,712	1,990,694
2010	631,733	469,365	951,322	2,052,420
2011	652,988	485,157	983,330	2,121,474
2012	674,595	501,210	1,015,867	2,191,671
2013	696,553	517,524	1,048,933	2,263,010
2014	718,863	534,100	1,082,530	2,335,492
2015	741,524	550,937	1,116,655	2,409,116
2016	760,845	565,292	1,145,750	2,471,887
2017	780,414	579,832	1,175,220	2,535,466
2018	800,232	594,556	1,205,063	2,599,851
2019	820,298	609,465	1,235,281	2,665,044
2020	840,613	624,558	1,265,873	2,731,044
2021	863,377	641,471	1,300,153	2,805,002
2022	886,446	658,611	1,334,892	2,879,948
2023	909,818	675,976	1,370,088	2,955,882
2024	933,495	693,567	1,405,742	3,032,804
2025	957,475	711,384	1,441,855	3,110,714
2026	982,903	730,277	1,480,146	3,193,326
2027	1,008,664	749,416	1,518,939	3,277,019
2028	1,034,758	768,804	1,558,234	3,361,796
2029	1,061,185	788,439	1,598,031	3,447,655
2030	1,087,946	808,321	1,638,329	3,534,597

High Case - Elasticity 2

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	594,025	441,348	894,538	1,929,911
2009	620,532	461,042	934,454	2,016,027
2010	647,617	481,166	975,241	2,104,023
2011	680,499	505,597	1,024,759	2,210,855
2012	714,196	530,633	1,075,503	2,320,332
2013	748,707	556,274	1,127,473	2,432,454
2014	784,033	582,520	1,180,669	2,547,222
2015	820,173	609,371	1,235,092	2,664,636
2016	855,965	635,964	1,288,991	2,780,920
2017	892,522	663,125	1,344,041	2,899,688
2018	929,843	690,854	1,400,243	3,020,939
2019	967,928	719,151	1,457,596	3,144,674
2020	1,006,778	748,015	1,516,099	3,270,893
2021	1,052,629	782,081	1,585,146	3,419,856
2022	1,099,501	816,906	1,655,730	3,572,137
2023	1,147,394	852,490	1,727,851	3,727,735
2024	1,196,307	888,832	1,801,510	3,886,649
2025	1,246,242	925,932	1,876,706	4,048,881
2026	1,303,654	968,737	1,963,464	4,236,054
2027	1,362,768	1,012,508	2,052,181	4,427,457
2028	1,422,983	1,057,247	2,142,859	4,623,090
2029	1,484,500	1,102,953	2,235,498	4,822,951
2030	1,547,319	1,149,626	2,330,096	5,027,041

Figure 4-46 shows the final sum of the three well service areas projected separately, with twelve percent unaccounted-for water added to the service area of Wells 6 & 8, and 15% added to the service areas of Wells 1, 9 & 14 and Wells 2 & 4. Island-wide total demands by this method range from 2.56 MGD to 5.03 MGD, with the base case range from 2.61 to 3.53 MGD.

The twelve percent target for Wells 6 & 8 is reasonable, and consistent with the CCR proposals, which also utilized twelve percent. This appears to be a reasonable target with existing unaccounted-for water at 13.52% and certain measures to reduce unaccounted-for water identified, such as leak detection and replacement of certain old line segments.

The fifteen percent target is reasonable for the areas of Wells 1, 9 & 15, which currently have 18.76% unaccounted-for water. Although it is less ambitious than the CCR proposal, which used twelve percent island-wide, it allows for a more conservative estimate. Measures to reduce this unaccounted- for water include the cover on the 15 MG brackish reservoir, leak detection, and metering of some previously unmetered services. With these measures, it seems that 15% might be a reasonable target.

The fifteen percent target for the areas of Wells 2 & 4 may seem highly ambitious, given 2008 calendar year unaccounted-for water of 44.61%. However, the sources of unaccounted-for water are clearly identified, and measures to address this high unaccounted-for water have been included in both the proposed capital and funding plans to be discussed in Chapter 5. Such measures include replacement of leaking pipes in the Palawai Grid, leak detection and others. The selected 15% is also more conservative than the 12% used in the CCR proposal.

Chapter 5 includes some discussion of loss reduction measures to reduce unaccounted-for water. Implementation of such loss reduction measures could be sufficient to defer the need for new well development.

Wastewater Projections

Two separate questions arise regarding wastewater generation in water planning. One is how much wastewater will be generated that will need treatment. Another, increasingly important question, is how much of the wastewater generated will actually be available for use as potential source. Buildout analysis answers the first question, predicting how much wastewater will be generated and need treatment. Projections on actual reclaimed water answer the second. While forecast estimates based on actual production go directly to potential reclaimed water source, build-out estimates, without adjustment, predict only wastewater that may need treatment. Both are presented in Figures 4-47 and 4-48, below.

FIGURE 4-47. Proposed and Projected Use of Reclaimed Water by Build-out vs. Projected Escalation Factors

Wastewater At 20 Year Build-out	2006 Proposal Wastewater By Standards	Existing Plus Calculated Addition from Units to 2030	2009 Proposal Wastewater By Standards	Existing Plus Calculated Addition from Units to 2030	Reclaimed SMS Forecast Factors Low	Reclaimed SMS Forecast Factors Low	Reclaimed SMS Forecast Factors Low
Koele PD / Lana`i City	256,000	876,308	832,910	827,758	310,923	316,803	377,812
Manele PD	360,000	248,745	375,938	248,745	96,879	98,711	117,721
	616,000	1,125,053	1,208,848	1,076,503	407,802	415,515	495,533

FIGURE 4-48. Lana'i City Reclaimed Water Projection

AWWTF - LCTY Year	Actual	Low Case Demand Elas.=1	Base Case Demand Elas.=1	High Case Demand Elas.=1
2005	203,420			
2006	202,556			
2007	205,953			
2008	234,093	234,093	234,093	234,093
2009		237,118	237,751	239,259
2010		240,143	241,409	244,425
2011		243,834	245,436	250,553
2012		247,525	249,464	256,682
2013		251,215	253,491	262,810
2014		254,906	257,519	268,939
2015		258,597	261,546	275,067
2016		261,690	264,932	281,005
2017		264,784	268,317	286,943
2018		267,877	271,703	292,881
2019		270,971	275,088	298,819
2020		274,065	278,474	304,756
2021		277,589	282,219	311,619
2022		281,113	285,964	318,481
2023		284,638	289,710	325,344
2024		288,162	293,455	332,206
2025		291,686	297,201	339,068
2026		295,534	301,121	346,817
2027		299,381	305,042	354,566
2028		303,228	308,962	362,315
2029		307,076	312,883	370,063
2030		310,923	316,803	377,812

FIGURE 4-48. Manele Reclaimed Water Projection

Manele Wastewater Year	Actual	Low Case Demand Elas.=1	Base Case Demand Elas.=1	High Case Demand Elas.=1
2005	71,674			
2006	77,424			
2007	80,526			
2008	72,940	72,940	72,940	72,940
2009		73,883	74,080	74,550
2010		74,825	75,219	76,159
2011		75,975	76,474	78,069
2012		77,125	77,729	79,978
2013		78,275	78,984	81,888
2014		79,425	80,239	83,797
2015		80,575	81,494	85,707
2016		81,539	82,549	87,557
2017		82,503	83,604	89,407
2018		83,467	84,659	91,257
2019		84,431	85,714	93,108
2020		85,395	86,768	94,958
2021		86,493	87,935	97,096
2022		87,591	89,102	99,234
2023		88,689	90,269	101,372
2024		89,787	91,436	103,511
2025		90,885	92,603	105,649
2026		92,084	93,825	108,063
2027		93,283	95,047	110,478
2028		94,482	96,268	112,892
2029		95,680	97,490	115,306
2030		96,879	98,711	117,721

Modified Econometric Analysis

FIGURE 4-49. Lana'i City AWWTF Reclaimed Water Production Projected to 2030

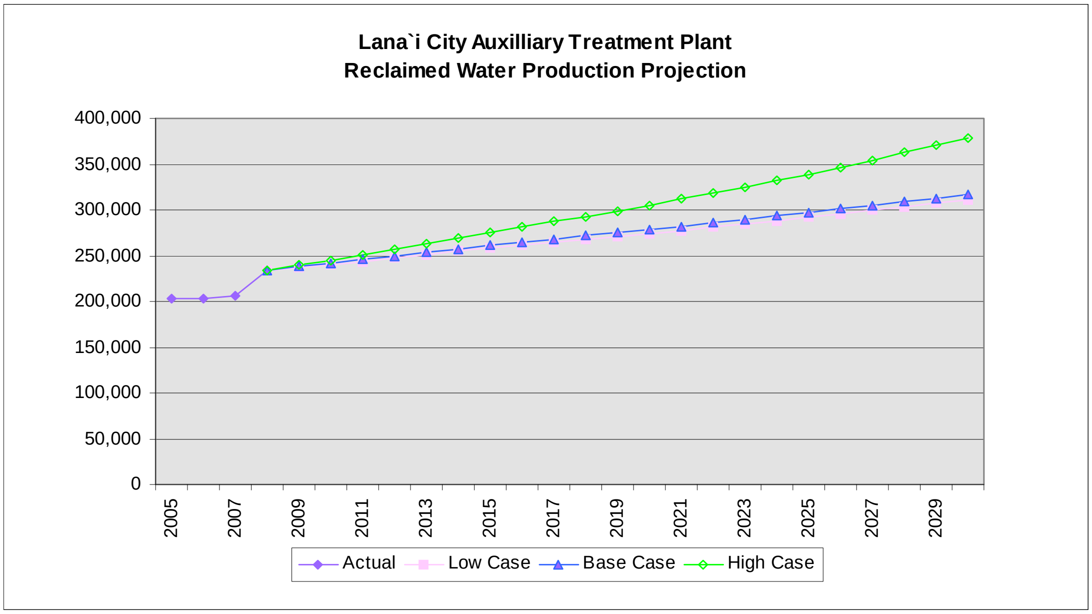


FIGURE 4-50. Manele Wastewater Treatment Facility Reclaimed Water Production to 2030

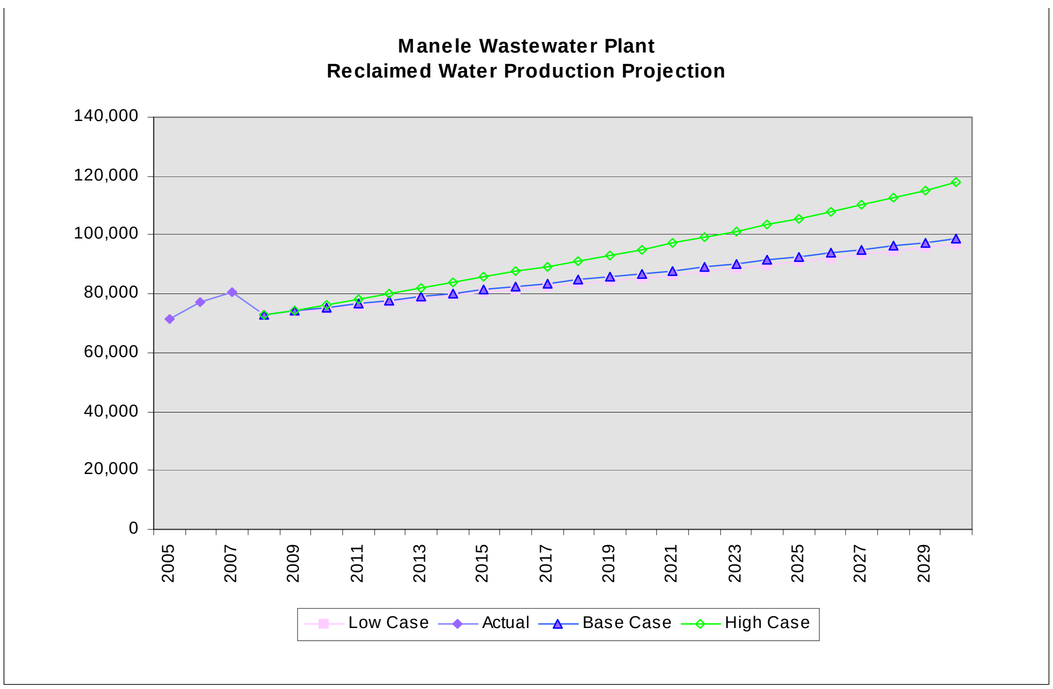
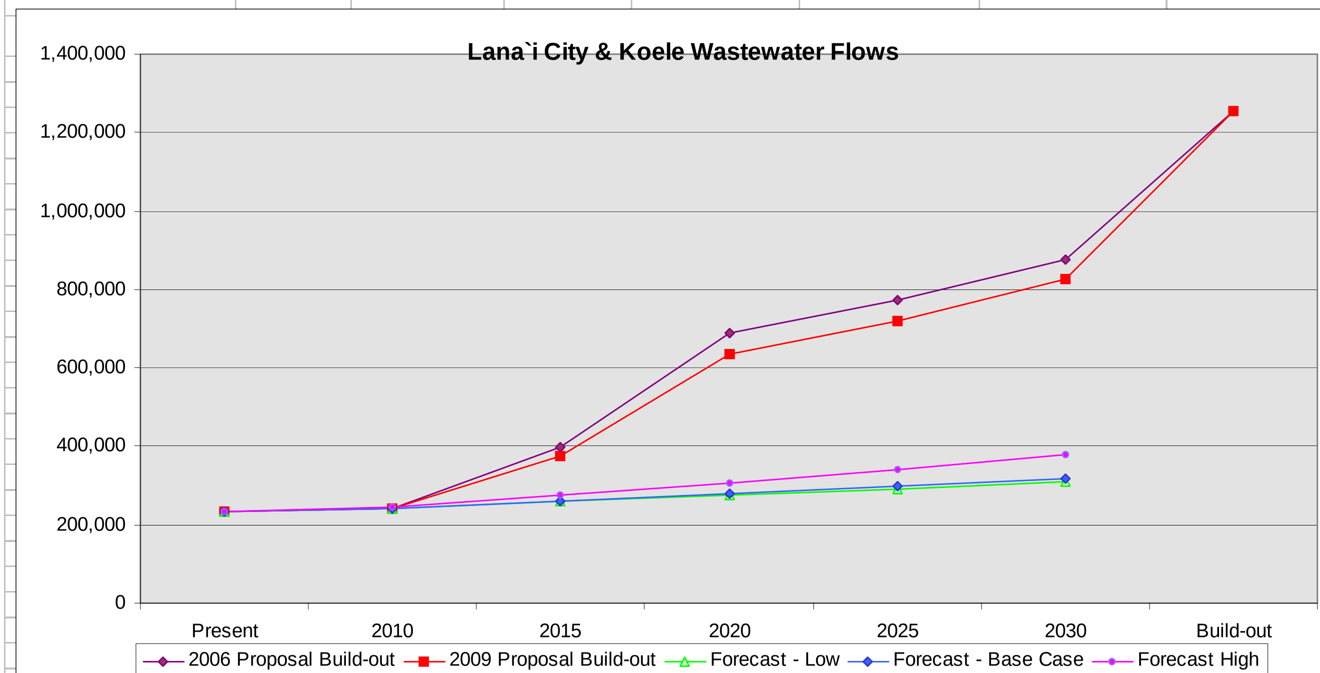


FIGURE 4-51. Wastewater Projections Compared to Build-out - Lana'i City and Koele

Koele PD / Lana`i City Reclaimed Water Use	2006 Proposal	Existing Plus Calculated Addition	2009 Proposal	Existing Plus Calculated Addition	Applying SMS Forecast Factors Low	Applying SMS Forecast Factors Base	Applying SMS Forecast Factors High
Present	1,212	234,093	1,212	234,093	234,093	234,093	234,093
2010	1,212	241,409	1,212	241,409	240,143	241,409	244,425
2015	1,685	397,363	1,618	373,913	258,597	261,546	275,067
2020	2,526	688,008	2,377	635,858	274,065	278,474	304,756
2025	2,773	771,893	2,627	719,843	291,686	297,201	339,068
2030	3,064	876,308	1,618	827,758	310,923	316,803	377,812
Build-out	4,233	1,254,773	4,233	1,254,773			

* treating 2010 as "present" but raising consumption based on forecast.



Modified Econometric Analysis

FIGURE 4-52. Wastewater Projections Compared to Build-out - Manele

Manele PD Reclaimed Water Use	2006 Proposal	Existing Plus Calculated Addition	2009 Proposal	Existing Plus Calculated Addition	Applying SMS Forecast Factors Low	Applying SMS Forecast Factors Base	Applying SMS Forecast Factors High
Present	335	72,940	335	72,940	72,940	72,940	72,940
*2010	335	75,219	335	75,219	74,825	75,219	76,159
2015	425	114,076	425	114,076	80,575	81,494	85,707
2020	650	189,216	500	136,716	85,395	86,768	94,958
2025	335	213,091	725	213,091	90,885	92,603	105,649
2030	335	248,745	900	248,745	96,879	98,711	117,721
Build-out	966	296,586	966	296,586			

* treating 2010 as "present" but raising consumption based on forecast.

The preceding figures indicate anticipated wastewater generation based upon either forecast escalation coefficients or per-standards build-out analysis. Without adjustment, build-out estimates address only how much wastewater may need treatment, these estimates can be adjusted to reflect how much reclaimed water may be available as source. An effort is made to do this below.

Wastewater generated is not the same as reclaimed water available. Wastewater standards are meant to evaluate the amount of water that may need to be treated, and to size treatment facilities accordingly. Reclaimed water availability is lower than wastewater for two reasons. The first is that only a percent of metered demand actually returns as influent to the wastewater processing plant. This percent is known as the return rate. Return rates on Lana'i are low, particularly in Manele. The standard for residential wastewater generation is 350 GPD per unit, roughly 58% of the standard for residential water use. In contrast, Manele return flows from metered water are less than 25%. This may be attributed to a number of factors, including low unit occupancy in vacation homes, high outdoor use, and high unaccounted-for water. If such trends continue, wastewater availability may remain below standard amounts. Another reason that reclaimed water availability is less than wastewater generated is the treatment process itself. Roughly 35% of wastewater is solids. Reclaimed water will be less than return flows, based on normal process reductions. The combination of normal treatment process reductions and low return rates on Lana'i mean that wastewater standards can not be translated directly into available reclaimed flows. A conservative approach is needed in estimating available reclaimed water.

FIGURE 4-53. Wastewater Return Rates - Treatment Plant Influent as Percent of Metered or Pumped Water

Area	% Metered	% Pumped
Lana'i City - Koele	60.57	52.81
Manele - Hulopo'e - Irrigation Grid	21.31	11.35
Manele - Hulopo'e without Irrigation Grid	24.64	

In the adjusted build-out estimates below, influent return flows for new growth were assumed to remain at the same percentage as flows for existing development. Available reclaimed water was assumed to be 65% of influent. This method should result in reasonable but conservative flow estimates, since percent return flows from metered use should increase with occupancy and landscape conservation.

Based upon this reclaimed water availability analysis, 400,000 to 700,000 GPD was deemed to be a reasonably prudent estimate of available reclaimed water for the planning period, depending upon the progress of build-out.

Modified Econometric Analysis

FIGURE 4-54. Range of Estimates of Available Reclaimed Water

2030 Wastewater Projection Method Using 35% Treatment Process Reduction	Lana`i City	Manele	Total
2006 Proposal per CCR - Anticipated Use of Reclaimed	256,000	360,000	616,000
2006 Proposal - Estimated Available Water If Proposal Were Built-out Using Wastewater Standards	651,533	187,213	838,746
2006 Proposal - Adjusted Reclaimed Build-out	612,007	121,209	733,216
2009 Proposal per CCR - Anticipated Use of Reclaimed	832,910	375,938	1,208,848
2009 Proposal - Estimated Available Water If Proposal Were Built-out Using Wastewater Standards	583,438	121,209	704,647
Forecast - Wastewater - Low Case	310,923	96,874	407,797
Forecast - Wastewater - Base Case	**316,803**	**98,711**	**415,514**
Forecast - Wastewater - High Case	377,812	117,721	495,533
Phase II Only Reclaimed Build-out	529,428	183,183	712,612
Phase II Only Adjusted Reclaimed Build-out	**501,464**	**119,507**	**620,971**

2030 Wastewater Projection Method Using 10% Treatment Process	Lana`i City	Manele	Total
2006 Proposal per CCR - Anticipated Use of Reclaimed	256,000	360,000	616,000
2006 Proposal - Estimated Available Water If Proposal Were Built-out Using Wastewater Standards	812,087	231,165	1,043,251
2006 Proposal - Adjusted Reclaimed Build-out	757,359	139,774	897,133
2009 Proposal per CCR - Anticipated Use of Reclaimed	832,910	375,938	1,208,848
2009 Proposal - Estimated Available Water If Proposal Were Built-out Using Wastewater Standards	717,801	139,774	857,575
Forecast - Wastewater - Low Case	310,923	96,874	407,797
Forecast - Wastewater - Base Case	**316,803**	**98,711**	**415,514**
Forecast - Wastewater - High Case	377,812	117,721	495,533
Phase II Only Reclaimed Build-out	643,019	225,585	868,603
Phase II Only Adjusted Reclaimed Build-out	**604,299**	**137,417**	**741,716**

Build-Out Analysis

Build-out analysis involves estimating how much water would be consumed if anticipated or proposed projects were fully developed. In this Chapter, build-out analysis includes review of State plans, approved project districts, pending projects, and company proposals.

System Standards

Standards for Drinking Water Demand

The Water Departments of the four counties of the State of Hawaii have promulgated *System Standards*, which govern the design and construction of water system facilities under their respective jurisdictions. Division 100 of these *System Standards* address planning issues, and provide guidelines and requirements for estimating domestic consumption and fire flows. Table 100-18 of the *System Standards* contains domestic consumption guidelines used for estimated demand of proposed projects. These guidelines are provided in Figure 4-55. In the sections analyzing projects to follow, these standards are used for estimating demand except where otherwise noted.

FIGURE 4-55. Statewide System Standards - Maui County Standards

System Standards - Maui County					
From - Division 100 - Planning - Table 100-18 Domestic Consumption Guidelines					
Average Daily Demand *					
Zoning	**Per Unit**	**Per Acre**	**Per 1,000 Square Feet**	**Per Student**	**Notes**
Single Family or Duplex	600	3,000			
Multi-Family Low Rise	560	5,000			
Multi-Family High Rise	560	5,000			
Commercial		6,000	140		
Commercial/Industrial Mix		6,000	140		
Commercial/Residential Mix		6,000	140		
Resort / Hotel	350	17,000			
Light Industry		6,000			
Schools, Parks		1,700		60	
Agriculture		5,000			

* Where two or more figures are listed for the same zoning, the daily demand resulting in higher consumption use shall govern the design unless specified otherwise.

Standards for Wastewater Demand

The County of Maui Wastewater Reclamation Division utilizes the standards presented in Figure 4-56, below, in estimating wastewater flows. These guidelines were used in deriving build-out wastewater estimates discussed above.

FIGURE 4-56. County of Maui Wastewater Flow Standards

Wastewater Flow Standards		
Type of Use	Units	Contribution (Gal/Unit/Day)
Apartment / Condo	Unit	255
Bar	Seat	15
Church, Large	Seat	6
Church, Small	Seat	4
Cottage or Ohana (600 sq. ft. max)	Unit	180
Day Care Center	Child	10
Factory	Employee	30
Golf Clubhouse	Golf Rounds	25
Hotel, Resort with Laundry	Room	350
Hotel, Average with Laundry	Room	300
Hotel, Average without Laundry	Room	250
Hospital	Bed	200
Industrial Shop	Employee	25
Laundry, Coin-operated	Machine	200
Office	Employee	20
Residence	Home	350
Restaurant, Average	Seat	80
Restaurant, Fast Food	Seat	100
Rest Home	Patient	100
Retail Store	Employee	15
School, Elementary	Student	15
School, High	Student	25
Storage, with Offices	Employee	15
Storage, with Offices & Showers	Employee	30
Store Customer Bathroom Usage	Use	5
Theater	Seat	5
Standards Used to Compute Units:		
Use	Unit Estimate	
Residential Occupancy	4 Persons per Unit	
Apartment / Condo / Occupancy	2.5 Persons per Unit	
Hotel Occupancy	2.25 Persons per Unit	
Hotel Employees	1 per Hotel room	
Office Employees	1 per 200 square feet of floor area	
Retail Warehouse Employees	1 per 350 square feet of floor area	
Strorage / Industrial Employees	1 per 500 square feet of floor area	

Consumption Per Unit Analysis

Before analyzing the impacts of proposed developments, one must establish reasonable unit quantities to use as a basis for estimating demands. Statewide System Standards are normally used to estimate the demands of proposed projects.

Adjustments to standards are made for planning purposes when empirical demands in an area are known to differ substantially from standards. This is the case in several areas on Lana‘i.

CCR proposals did not use system standards in all cases. Therefore, in analyzing build-out demands for Lana‘i, various estimates of water use per unit have been considered. These include the Statewide System Standards described above, per unit quantities suggested in several proposals from Castle & Cooke, and finally, empirical use patterns based upon a review of billing data provided. Figure 4-57 summarizes these comparisons.

There is always value in having a realistic assessment of empirical per unit consumption in a given location. Consumption is expected to be more or less than standards in different areas. Actual use patterns must be considered in order to verify that an analysis is realistic.

On the other hand, if existing use patterns vary widely from those anticipated based on use, climate and other factors, one must also consider the question of whether existing use is reasonable. At a certain point, planning for an overly large per unit demand increment can cross the line from realistic analysis into bad policy making. One wants to consider actual needs with a conservative margin. One doesn't want to condone or perpetuate excessive use by planning for it.

The Lana‘i Water Advisory Committee spent much time discussing both the accuracy and the appropriateness of the various unit-quantity estimates presented here. In the end, it was decided to use both standards and empirical data for analytical purposes, with the common understanding that actual allocations would be set separately as a matter of policy after the review.

Build-out with existing per unit consumption rates, even without such high unaccounted-for water, could cause demand to exceed sustainable yields. The combination would definitely exceed sustainable yield. Measures to address unaccounted-for water were listed earlier. The most important measure to reduce high per unit consumption rates is conservation in the landscape, followed by indoor fixture replacements and hotel conservation programs.

Build-Out Analysis

FIGURE 4-57. Consumption Per Unit Analysis

	USAGE CATEGORY	System Standards Per Acre	System Standards Per Unit Or Other As Noted	CCR Proposal 2006 UNITS	CCR Proposal 2006 QUAN	CCR Proposal 2009 UNITS	CCR Proposal 2009 QUAN	Empirical Information From Billing	Notes
									County standards note that "Where two or more figures are listed for the same zoning, the daily demand resulting in higher consumption shall govern the design, unless specified otherwise." Thus, in most cases, per-acre standards would tend to be utilized, unless unit counts are high enough to exceed them. However, in practice, when analyzing anticipated demand, empirical information about the climate and water use patterns of an area are also used to select between and or make adjustments to per-acre and per-unit standards.
	RESIDENTIAL- SINGLE FAMILY								
1.0	**LANA`I CITY RESIDENTIAL (Wells 3, 6 & 8)**								
1.1	Lana`i City Residential - Existing								
	Single Family	3000	600	gpd/unit	350	gpd/unit	350	* 222 / 346	SF unit average in LCTY is 222 GPD. However, removing entries
1.2	Lana`i City Residential -New/Future								with consumption so low that they indicate only sporadic
	Single Family	3000	600	gpd/unit	600	gpd/unit	600		occupation, the average rises to 346 GPD. Total SF use in LCTY
1.4	Affordable Housing Property (Future)	3000	600	gpd/unit	600	gpd/unit	600		per billing analysis for this document was 217,186 GPD.
1.5	DHHL Property	3000	600	gpd/unit	600	gpd/unit	600		
1.7	Kaumulapau Subdivision (Future)	3000	600	gpd/unit	600	gpd/unit	600	*	Numbers not suitable to derive estimate for Kaumalapau.
4.0	**KOELE PD RESIDENTIAL**								
4.6	Koele Single Family	3000	600	gpd/unit	600	gpd/unit	600	* 503 / 1,000	PD Max 535 Units on 214 acres.
4.1	Koele PD Redevelopment Portion	3000	600	gpd/unit	600	gpd/unit	600		Koele generally shows use around 503 GPD. However, newer homes tend to use more. Several low readings from sporadic occupation may decrease the overall average.
6.0	**MANELE PD: POTABLE (Wells 2 & 4)**								
6.4	Manele Single Family Homes	3000	600	gpd/unit	600	gpd/unit	600	*1,020 / 3,700	PD Max 282 Units on 328 acres. C&CR proposed standards total 3,100 GPD / unit, which is more than 5x County per-unit standard. However, it reflects actual use. Fresh water consumption of these homes averages about 900 GPD, while combined potable and brackish consumption averages 3,700 GPD. In addition, one of the meters currently classed in MNPD - IRR - DEVEL waters lots 77-81, which appears to be a single family area. Not clear if this means another 19,413 GPD should be attributed to Manele SF beyond what is shown here.
7.0	**MANELE PD: NON-POTABLE WATER (Wells**								
7.1	Manele Single Family-Irrigation	included		gpd/unit	2,500	gpd/unit	2,500		Assuming 1/2 acre lots, combined C&CR proposed standard of 3,100 GPD is >2x County per-acre standard, which is usually suitable for hot dry areas, such as South Maui. Combined potable and brackish use appears to be 59,451 GPD.
1.0	**Lana`i CITY RESIDENTIAL (Wells 3, 6 & 8)**								
1.1	Lana`i City Residential - Existing								
	Multi Family	5000	560	gpd/unit	350	gpd/unit	350	* 296 / 797	The average water consumption by Lana`i City MF meters was 296 GPD. However, no information was available as to how many units were on each meter. As with several user classes above, there appeared to be a great number of meters with low enough averages to seem only sporadically used. Average use of the meters using over 100 GPD was 797 GPD.
1.2	Lana`i City Residential -New/Future								
	Multi Family	5000	560	gpd/unit	600	gpd/unit	600		

FIGURE 4-57. Consumption Per Unit Analysis - Continued

	USAGE CATEGORY	System Standards Per Acre	System Standards Per Unit Or Other As Noted	CCR Proposal 2006 UNITS	CCR Proposal 2006 QUAN	CCR Proposal 2009 UNITS	CCR Proposal 2009 QUAN	Empirical Information From Billing	Notes
	RESIDENTIAL- MULTI FAMILY								
4.0	**KOELE PD RESIDENTIAL**								
4.7	Koele Multi-Family	5000	560	gpd/unit	600	gpd/unit	600	722	PD Max 156 Units on 26 acres. 10 ac. now per proposal. MF use in KOPD totals 25,287. Assuming 35 units (27 Villas plus 8 Pines), average per-unit MF consumption is 722 GPD.
4.8	Koele Common Areas Irrigation	included	included	gpd/acre	2,000	gpd/acre	2,000		Normally irrigation is included in per-acre or per-unit estimate. County per-acre standards would allow for up to 50,000 GPD. However, these per-acres standards are usually only accurate in hot dry areas, more like Manele. 25,287 for a reported 10 acres currently irrigated would be within this standard, but still high for the climate at that location. Proposed standard of 600 GPD/unit plus 2,000 GPD / acre would result in 145,000 GPD at build-out, vs. 130,000 per standards.
6.0	**MANELE PD: POTABLE (Wells 2 & 4)**								
6.5	Manele Multi-Family	5000	560	gpd/unit	300	gpd/unit	300	1,403	PD Max 184 Units on 55 acres. Total residential & MF irrigation 96,791 for 69 units total. This does not include common area irrigation w/in the PD. Proposal is for 1,500 GPD per unit note even counting common area irrigation. Standards are normally expected to INCLUDE irrigation. No estimate is given of MF irrigated acreage apart from common area estimate.
7.0	**MANELE PD: NON-POTABLE WATER (Wells**								
7.2	Manele Multi-Family-Irrigation	included	included	gpd/unit	1,200	gpd/unit	1,200		Normally 560 gpd / unit or 5,000 gpd / acre includes irrigation. No acreage provided for this area as distinct from common areas.
7.3	Manele Common Areas Irrigation	included	included	gpd/acre	2,500	gpd/acre	2,500		Total irrigation 86,944 out of 96790 combined total above.
	COMMERCIAL								
2.0	**Lana`i CITY NON-RESIDENTIAL + CAVENDIS**								
1.6	Kaumulapau Harbor	6000		LS gpd	1	LS gpd	1		In this and all other such entries, "**LS gpd**" indicates a lump sum estimate in C&CR proposal. Harbor used 608 GPD in 2008.
	Kaumalapau Commercial								Total Kaumalapau commercial use 14,508, of which 628 was KPAU harbor.
2.1	Lana`i City Govt/Comm & Inst/ LtInd/ Airport/Lar	6000		LS gpd	1	LS gpd	1		Billng breakdown for this document divides these categories further. CCR proposal combined this with Irrigation Grid. Not clear why. Meters are attributed to Wells 6 & 8.
	Lana`i City Government								10,180 GPD in 2008. Average use per account was 679 GPD.
	Lana`i City Commercial								43,311 GPD in 2008. Average use per account was 760 GPD.
*2.3	Future Commercial & BCT	6000				LS gpd	1		
4.0	**KOELE PD: POTABLE (Wells 3, 6 & 8)**								
4.5	Koele PD-Commercial (Tennis & Stables)	included in resort		LS gpd	1	LS gpd	1		Billing breakdown for this document had tennis in hotel; stables and horse paddock in Ag. Horse paddock used 77 GPD in 2008. Stables used 1,430.
3.0	**IRRIGATION GRID (Wells 2 & 4)**				1				
**3.4	New Warehouse	6000	1,000/140 sq	LS gpd	1				County standard is 6,000 GPD / acre or 1,000 GPD / 140 sq. ft.
3.5 (3.4 2009)	Future Use	6000	1,000/140 sq	LS gpd	1	LS gpd	1		Not clear what this is in 2006 or 2009 proposal.
6.0	**MANELE PD: POTABLE (Wells 2 & 4)**								
6.6	Manele Commercial	6000	1,000/140 sq	gpd/acre	5,000	gpd/acre	5,000		Manele Boat Harbor only item listed here. 21,179 GPD.
6.8	Manele Construction/Development	6000	1,000/140 sq	LS gpd	1	LS gpd	1		Estimate 51,227 includes development irrig and nursery, (which was classed as MNPD-Ag for Billing database review), plus 34 GPD non-irrigation at trailer.

Build-Out Analysis

FIGURE 4-57. Continued. Consumption Per Unit - Continued

	USAGE CATEGORY	System Standards Per Acre	System Standards Per Unit Or Other As Noted	CCR Proposal 2006 UNITS	CCR Proposal 2006 QUAN	CCR Proposal 2009 UNITS	CCR Proposal 2009 QUAN	Empirical Information From Billing	Notes
	INDUSTRIAL								
3.0	**IRRIGATION GRID (Wells 2 & 4)**				1				
**3.3	Additional Baseyard(2006) /Miki Basin Heavy In	6000	1,000/140 sq.	LS gpd	1	gpd/acre	6,000		3,460 currently at Miki Meters. More commercial in nature at present. Build-out is intended to be industrial.
	HOTEL / RESORT								
4.0	**KOELE PD: POTABLE (Wells 3, 6 & 8)**								
4.2	Koele PD-Hotel	350	17,000	gpd/unit	500	gpd/room	600	* 304 / 812	30,961 GPD hotel meters excluding irrigation. 51,880 GPD with irrigation. Per proposal, 21 acres currently irrigated. PD Max 253 units on 21.1 acres.
4.3	Koele PD-Hotel(Future)	350	17,000	gpd/unit	500	gpd/room	600		
4.4	Koele PD-Hotel Irrigation		included	gpd/acre	NA	gpd/acre	2,800		Resort standard is meant to include irrigation. Irrigation averaged about 2,470 per acre in 2008.
5.0	**KOELE PD/LANA`I CITY: WASTEWATER**								
5.1	Koele Golf Course Irrigation Effluent		included	LS gpd	1	LS gpd	1		224,447 GPD in 2008 from AWWTF.
1.0	**Lana`i CITY RESIDENTIAL (Wells 3, 6 & 8)**								
	Hotel Lana`i	350	17,000	~	~	~	~	284	Not separated from other non-residential in proposal, but separated in billing data analysis. 3,125 GPD. For smaller hotels like this, per unit GPD is usually a more appropriate estimate than per acre.
6.0	**MANELE PD: POTABLE (Wells 2 & 4)**								
6.1	Manele Hotel	350	17000	gpd/room	600	gpd/room	600	952 / 3,341.216	PD Max 500 units on 56.6 acres. High and Low meters total 228,507. 2006 proposal indicates 88,000 potable and 2009 proposal says 63,500 potable. Asked if one was potable & other irrigation but was told both were actually used for both. High Meter 160,451, Low 68,056 GPD in 2008. In addition, clubhouse and golf maintenance building meters read 4,914 and 4,595 GPD respectively, for a total of 238,016.
6.2	Manele Hotel Irrigation		included	gpd/acre	8,000	gpd/acre	8,000		Two meters called MBH landscaping ("back-of-house") read 1,279 GPD collectively. 8"" Golf Meter, Hole #4 Golf Meter and Challenge Drive Golf Irrig totaled 596,009 GPD. For a total of 597,288 GPD. Grand total of all meters 835,304 GPD. This does include golf. Proposal notes 29 irrigated acres not including golf course, which is listed in PD ordinance as 172 acres. Too much uncertainty to derive a meaningful per-acre standard.
6.3	Manele Hotel (Future)		included	gpd/room	600	gpd/room	600		
7.0	**MANELE PD: NON-POTABLE WATER (Wells**								
7.4	Manele Golf Course Irrigation		included	gpd	1	gpd	1		See above. PD - 172 acres. Golf is normally included in overall resort 17,000 gp/ac estimate, but sometimes est. independently at 5,000 g p ac. Irrigation calcs best. Was hard to split Hotel irrigation from golf irrigation & other types within the PD.
8.0	**MANELE PD: WASTEWATER**								
8.1	Manele Golf Course Irrigation Effluent		included	gpd	1	gpd	1		2006 proposal estimates 80,800. 2009 proposal estimtes 78,200. Treatment plant production records indicate 72,940 in 2008.

FIGURE 4-57. Consumption Per Unit - Continued

GE CATEGORY	System Standards Per Acre	System Standards Per Unit Or Other As Noted	CCR Proposal 2006 UNITS	CCR Proposal 2006 QUAN	CCR Proposal 2009 UNITS	CCR Proposal 2009 QUAN	Empirical Information From Billing	Notes
-PUBLIC								
ON-RESIDENTIAL + CAVENDIS								
City Recreation Area		1,700	gpd/acre	1,375	gpd/unit	1,375		
ool Expansion		1,700	gpd/acre	1,375	gpd/unit	1,375		Not clear why estimate was less than standard. No account names in billing review database. Could not identify school specifically. Commercial and Government accounts totalled above.
)TABLE (Wells 3, 6 & 8)								
uture)		1,700	gpd/acre	1,700	gpd/acre	1,700		
Course & Maintenance		1,700	LS gpd	1	LS gpd	1		14,286 GPD in 2008.
POTABLE (Wells 2 & 4)								
Domestic use and Irrigation)		1,700	gpd/acre	1,700	gpd/acre	1,700		Hulopo`e Beach Park 19,968 GPD in 2008.
Use		1,700	LS gpd	1				
; (WWTP & Lift Stations)		1,700	LS gpd	1	LS gpd	1		Manele Utilities 6,812 GPD in 2008.
GRID (Wells 2 & 4)				1				
serve		5000	LS gpd	1	LS gpd	1		
mmercial Uses		5000	LS gpd	1	LS gpd	1		28,044 GPD Ag in IGGP, 6,044 GPD in LCTY Community Garden in 2008.

State Water Projects Plan

FIGURE 4-58. State Water Projects Plan - Projected Water Requirements - GPD

Project	Pot or NonPot	2004	2005	2010	2015	2020
Lana‘i Agricultural Park	N	0	0	500,000	500,000	500,000
Manele Boat Harbor*	N	3,000	3,000	3,000	3,000	3,000
Subtotal Non-Potable		3,000	3,000	503,000	503,000	503,000
Manele Boat Harbor	P	2,000	2,000	2,000	2,000	2,000
Lana‘i High & Elementary School	P	14,400	14,400	14,400	14,400	14,400
DHHL Lana‘i**	P	12,500	12,500	12,500	12,500	12,500
Lana‘i Airport	P	1,200	1,500	1,900	2,900	3,900
Subtotal Potable	P	30,100	30,400	31,800	32,800	32,800
TOTAL	P	33,100	33,400	534,800	534,800	535,800

* SWPP identifies this as “non-potable using potable”
** Note that the estimate provided here is lower than that derived from project application materials submitted to the County.

The *State Water Projects Plan* (SWPP) indicates that the Lana‘i Agricultural Park of the Department of Agriculture will require an estimated 500,000 gallons of non-potable water over the long term. The most likely source of water for the agricultural park is fresh water from Wells 2 and 4, that is currently not chlorinated when served in the vicinity of the Palawai Irrigation Grid.

DHHL requests only 12,500 GPD to the year 2020. However, a per standards analysis of the fifty-acre DHHL Lands of Lana‘i project indicates that at build-out, this project will require 125,900 GPD. Adjustments for these two items are made in the final table compiling estimated project demands, presented after Castle & Cooke’s proposal.

The combined potable and non-potable estimates for Manele Harbor, in the amount of 5,000 GPD, are lower than the average use of 21,179 in 2008.

The projected airport requirement increases gradually, reaching 2,900 in the year 2015 and 3,900 in the year 2020. In calendar year 2008, consumption at the Department of Transportation’s airport meter averaged 1,502 GPD. There is also a meter at the airport tank. Total consumption between the two meters was 5,624 in 2008, and has exceeded 6,000 GPD in past.

Where projected demands noted in the State Water Projects Plan are lower than either existing demand or demand estimates based upon updated project plans, the latter have been used.

Project Districts

The island of Lana‘i has two Project Districts: The Koele Project District and the Manele Project District.

The Koele Project District is a 618 acre area, located just north and east of Lana‘i City, between the elevations of 1,700’ and 1,800’. At full build-out, this Project District would have 535 single family units, 156 multi-family units, 253 hotel units, 11.5 acres of park, 1 acre of public facility space, 12 acres of open space, and a 332.4 acre golf course.

The Manele Project District is an 869 acre area located at sea level on the southeastern shore of Lana‘i. At full build-out, this Project District would have 282 single family units, 184 multi-family units, 500 hotel units, 5.25 acres of commercial space, 66.33 acres of park, 2 acres of public facility space, 152.02 acres of open space, and a 172 acre golf course.

Figures 4-59 and 4-60 contain a simple build-out analysis of these Project Districts according to per acre standards. Build-out estimates are examined in two ways, both by per acre standards and by per unit standards. In deriving built and pending consumption according to per acre standards, the usual standards analysis was modified somewhat in two ways. Since there were no clear developed versus non-developed acreages, nor reliable maps from which to derive them, it was assumed that the percent of acreage developed within each land use class was equivalent to the percent of units developed. In addition, once both per unit and per acre standards had been calculated, the amount of water indicated by per unit standards was deemed “potable” in terms of source requirements. The per acre standards less the per unit standards were deemed “not necessarily potable”. Although this is slightly different from the usual analysis, it provides useful information regarding source options nonetheless.

According to the modified per acre build-out analysis, the Manele Project District would consume 3.28 MGD, of which only 0.55 GPD would need to be potable water. This analysis does not account for the relative climates of these two areas. A standard per unit analysis yields a full build-out estimate of 1.51 MGD. The fresh water requirements are the same in either analysis. The “not necessarily potable” requirement in the per unit build-out is 0.96 MGD, vs. 2.74 in the per acre analysis. In the hot, dry area of Manele, exposed to both wind and salt, the per acre analysis is likely to be more appropriate. Therefore a per-standards estimate of 3.28 MGD is used. Existing consumption in the Manele Project District area totals 1.16 MGD, of which 0.32 MGD is fresh, 0.76 MGD is brackish and 0.07 is reclaimed. At these rates, the 3.28 MGD estimate could even prove to be low, depending upon landscaping build-out.

According to the modified per acre build-out analysis described above, the Koele Project District would consume 2.81 MGD at full build-out, of which only 0.52 MGD would need to be fresh water. The standard per unit analysis, places this figure a bit lower, at 2.18 MGD. Potable water requirements are identical in the two analyses, but non-potable water requirements drop from 2.3 to 1.67 MGD. In the high elevation, cool and moist area of Koele, the lower, per unit, analysis would likely be the more appropriate of the standard methods. However, further adjustments must be made to address the fact that no potable water use is permitted on the Koele Golf Course. Adjusting the analysis to account for a range of wastewater availability and use scenarios, the total anticipated water use by the Koele Project District would range from 0.74 MGD to 1.77 MGD. At present, water use at the Koele Project District is 0.37 MGD, of which 0.15 MGD is fresh and 0.22 MGD is reclaimed water. This seems to indicate that the lower estimated range is reasonable.

FIGURE 4-59. Koele Project District - System Standards Analysis of Project District as Approved by Ordinance

Use	Acres	Max Overall Density	= Max Units	Per-Standards Build-Out Consump (per unit =p-u, per acre = p-ac)	Units Built	Per-Standards Still Pending Consump	Comments
SFR	214	2.5 units/acre	535	535x600=321,000 p-u 214x3,000=642,000 p-ac 321,000 nnp	13	522x600=313,200 p 208.8x3,000=626,400 p-ac 313,200 nnp	97 WGR pg A2 notes 600 gpd/unit (acreage x% units not yet built)***a***
MFR	26	6 units/acre	156	156x560=87,360 p-u 26x5,000=130,000 p-ac 42,640 nnp	35	121x560=67,760 p 20.17x5,000=100,833 p-ac 33,073 nnp	97 WGR pg A2 notes 400 gpd/unit (acreage* %units not yet blt)***a***
HOT	21.1	12 units/acre	253	253x350=88,550 p-u 21.1x17,000=358,700 p-ac 270,150 nnp	102 20 ac. i	151*350=52,850 p 12.59x17,000=214,086 p-ac 161,236 *	97 WGR pg A2 500 gpd/unit (golf & water features normally part of per acre stand). 20 ac irrig already. *existing irrig would lv only 14,084
PQP	1	1 acre min.		1x1,700 p-ac, but deemed pot		1,700 p	assumed potable 20' setbacks
PRK	11.5	-	-	11.5x1,700=19,550 p-ac, but deemed pot		19,550 p	assumed potable
GLF	332.4	-	-	332.4x5,000=1,662,000 nnp revised to 1,254,773 *		up to 1,020,680 wastewater	min 50 ac for 9 hole min 110 ac for 18 hole * based upon wastewater build-out
OS	12	-	-	0 (see comment)		0	<10% lot coverage OS assumed to be non-irrigated
Subtotal	**618**			**518,160 pot** **2,295,790 np or nnp** *b*		**455,060 pot** **507,509 np or nnp** *b*	No Potable Water allowed on GC
TOTAL				**2,813,950 tot by per acre** *** 1,151,950 tot excl. golf** **2,180,160 by per unit** **1,772,933 final est., discussed pg 49**		**962,569 tot by per acre***b* **455,060** by per unit **455,060** pumped final est *	No Potable Water allowed on GC **1,475,740** total remains by final est, but of that **1,020,680** is reclaimed.

a Normally this per acre standard would apply to acreage not yet developed, but as there was no data on this, it was assumed to be proportional to percent of units built and unbuilt

b "Where two or more figures are listed for the same zoning, the daily demand resulting in higher consumption use shall govern the design unless specified otherwise" - *Water System Standards* - pg 111-3. Normally either per acre or per unit is used depending upon circumstances. For Lana'i, because unit consumption is high, per acre standards were used. Potable water needs were derived by per unit counts, with the difference assigned to "not necessarily potable".

c per unit calculations consider built-but-unoccupied units as still pending. per acre calculations consider only units-not-yet-built as pending.

FIGURE 4-60. Manele Project District - System Standards Analysis of Project District as Approved by Ordinance

Use	Acres	Max Overall Density	= Max Units	Per-Standards Build-Out Consump	Units Built	Per-Standards Still Pending Consump	Comments
SFR	328	0.86 units/acre	282	282x600=169,200 p 328x3,000=984,000 p-ac 814,800 nnp	16	267x600=160,200 p 309.39 x3,000=928,170 p-ac 767,970 nnp	97WGR pgA2 600 domestic, 1,000 irr LWAC 9/22/2000 600 pot, 1,000 n-p 451,200 gpd by these LWAC standards ***a***
MFR	55	3.34 units/acre	184	184x560=103,040 p 55x5,000=275,000 p-ac 171,960 nnp	69	115x560=64,400 p 34.375x5,000=171,875 p-ac 107,475 nnp	97WGR pg A2 300pot, 300 non-pot LWAC 9/22/2000 400pot, 400 non-pot 147,200 by these LWAC standards ***a*** 10 ac irrig per '06 prop, 16 per '09
COM	5.25			140per1000sqft=19,210 p 5.25x6,000=31,500 p-ac 12,290 nnp		140per1000sqft=19,210 p 5.25x6,000=31,500 p-ac 12,290 nnp	Min area 0.5 acres, max lot coverage 60%. 0.6 cov*5.25 ac *43,560 ft/ac / 1000 *140 = 19,209.96. '06 prop say 5 ac exist. '09 said zero.
HOT	56.6	10 units/acre	500	500x350=175,000 p 56.6x17,000=962,200 p-ac 787,200 nnp	250	250x350=87,500 p 28.3x17,000=481,100 p-ac 393,600 nnp	Initially 50 acres. Ordinance 2743 stipulated that addt'l 6.6 acres would not enable room count to exceed 500, 17 ac irrig per '06 & '09 proposals
PQP	2			2x1,700=3,400 p		2x1,700 = 3,400 p	Minimum 2 acres, 50' setbacks assumed all potable.
PRK	66.33			66.33x1,700=112,761 p-ac assume 2/3 p - 75,174 assume 1/3 nnp - 37,587		64.33x1,700=109,361 p-ac assume 2/3 p - 72,907 assume 1/3 nnp - 36,454	Minimum 10 acres, minimum 350' wide. Assumed 2/3 potable. 2006 proposal noted 0 existing irrig park acres. 2009 proposal noted 2.
GLF	172			172x5,000=860,000 np		668,949 used btwn metered use and effluent production 2008. 191,051 np	Minimum 50 acres for 9 hole, minimum 110 acres for 18 hole. C&CR estimates 8,000 gpd/acre needed. No more than 0.65 MGD groundwater allowed for irrigation of Manele GC & associated landscaping.
OS	152.02			0			

FIGURE 4-60. Manele Project District - System Standards Analysis of Project District as Approved by Ordinance

Use	Acres	Max Overall Density	= Max Units	Per-Standards Build-Out Consump	Units Built	Per-Standards Still Pending Consump	Comments
Roads	32			32x1,700=54,400 nnp		35,591 nnp	assumes 40' rdway w/5' strip irrig at PRK intensity on either side or about 20% irrig area at 1,700 gp/acre/day nnp 334/966*32*1,700 = 18,809 assumed in use
Subtotal				**545,024** ***pot per acre*** **2,738,237** ***not nec pot per-ac***		**407,617** *pot per acre* **1,547,921** *nnp per-ac* ***a, b, c, d***	per unit stds
TOTAL				**3,283,261** *total per acre* **1,509,301** *total per unit*		**1,955,538** *total per acre* **573,642** *total per unit*	per acre stds - assumes 279,200 more effluent for golf
LWAC				**1,030,000** *c, d* **1,582,441** *e,* **2,620,450** *f*			**alternate totals given various scenarios. see notes.**

a Normally this per acre standard would apply to acreage not yet developed, but as there was no data on this, it was assumed to be proportional to percent of units built and unbuilt

b "Where two or more figures are listed for the same zoning, the daily demand resulting in higher consumption use shall govern the design unless specified otherwise" - *Water System Standards* - pg 111-3 Normally either per acre or per unit is used depending upon circumstances. For Lana'i, because unit consumption is high, per acre standards were used. Potable water needs were derived by per unit counts, with the difference assigned to "not necessarily potable".

c Despite high build-out analysis - 97 WGR stipulates that allocation for entire Manele PD not exceed 1.03 MGD. LWAC minutes of 9/22/2000 and 9/27/2002 reaffirmed this allocation.

d 1,030,000 is allocation for Manele Project District set in 1997 Working Group Report. Total use other than effluent for Manele PD is not to exceed 1.03 MGD per 1997 WGR.

e Despite agreement for total not to exceed 1.03 MGD at the time, per unit standards agreed upon in the minutes of the 9/22/00 LWAC meeting would lead project consumption to total 1,582,441 gpd.

f 2,620,450 as estimated in July 12, 2006 proposal from C&CR - which has 400 vs 500 hotel rooms as approved in PD, 300 vs 184 MF units as approved in PD, and 200 vs 282 SF units as approved in PD. Of this, 1,190,000 is presumed potable, 1,070,450 non-pot and 360,000 effluent.

Status of Project Districts

Project Districts are approved in phases. Phase I approvals result in the Project District ordinance. At this stage, the overall character of the project is set, including zoning, densities, set backs and other standards. Phase II approvals include review of preliminary site plans, with proposals for drainage, parking, utilities, grading, landscape planting, architectural design, elevations, lot coverage, net buildable areas, and other proposals. Phase III approvals include the final site plans with final details on the facilities and site development issues above.

When considering the impacts of a project build-out, it is helpful to know both the physical and regulatory status of a project. Development plans that are fully permitted have a stronger chance of occurring in a given time frame than those that have not yet received land use entitlements. Fully entitled units that are not yet built can represent a sort of pent demand. If accurate and updated data are not available, this pent demand may not be adequately considered in reviewing development proposals. These questions become more important in situations where build-out estimates begin to approach sustainable yields.

Early in the Water Use and Development Plan update process, the Lana‘i Water Advisory Committee spent considerable time discussing the need for a clear record, not only of general project approvals, but also of build-out status, and a common record of conditions, agreements and understandings affecting water, so that all parties could refer to and rely upon the same information. The information in Appendix D of this document was compiled at the request of the committee in response to this discussion. Similarly, Figure 4-61 on the following pages, estimates the status of Project District approvals on Lana‘i. As of this drafting, these references require further input and update from both the County of Maui Planning Department and Castle & Cooke Resorts, and can not be considered complete. A more thorough delineation of project status is anticipated with the Community Plan update.

Project Districts are normally built in segments, so that Phase II and III approvals generally roll in over time, rather than all at once. For tracking the status of project approvals and build-out, a map showing accurate unit counts and locations is a very useful tool. Maps from permit files varied widely, and often showed different lot counts than the subject approvals allowed. This is often done because plans are still in flux, and flexibility is desired. However, even if specific details of a plan are not set in stone, an accurate count of lots on a map would be of great assistance for tracking and managing anticipated demands as well as discretionary and administrative approvals. The reasons for this will becomeven more apparent in the compiled analysis and conclusions section of this chapter. After mapping the most recent project segments available, an attempt was made to map the status of different portions of the project within the approval process. This effort is discussed on page 4-79.

FIGURE 4-61. Status Of Koele Project District

Koele PD													
Use	Acreage	Max Overall Density	PD / Phase I Units		Phase II Units		Ph III Units		Subdivided Lots		Building Permits Approved	Units Actually Built	Units Occupied
SF	214	2.5 units/acre	**535**	A	**255**		**19**		**18**		**13**	**13**	**13**
92-PH2-0004					255								
93-PH3-0001													
Pu'u Lani Ridge - Puulani & Niniwai Streets							19	A	18	A	13	13	13
Land Court Consolidation 170 (LUCA 6.0163, 6.0168, 6.0169)													
K2 - Main proj entrance / Loop rd from Konawai to Kaunaoa							58	P	58	P			
K4 - East corner of Kaunaoa							9	P	9	P			
K8 - Makai of west end upper Loop Road, near Pines							4	P	4	P			
K9 - Puunene Hillside - west and mauka of upper Loop Rd.							9	P	9	P			
Pines at Koele SF Lots (4 SF and 6 MF lots)							4	P	4	P			
06-PH3-0006													
Pines at Koele SF Lots							20	P					
Future Phases Based on "Proposed Flexible Design Standards for Koele Project District"													
K1 - Makai of Kaunaoa, mauka of Queens, 9th to Konawai							46						
K3 - East side of Loop Road							24						
K5 - Niniwai Road - Future							35						
K6 - Center makai of upper Loop Road.							32						
K7 - East end and makai of upper Loop Road							11						
K8 - Makai of west end uppper Loop Rod, near Pines, future							19						
K9 - Puunene Hillside - w. & mauka of upper Loop Rd. future							4						
K10 - Mauka and east of upper Loop Road							13						
K11 - west of 6th St and mauka of Puulani Place							66						
Future Development					280		162		517		522	522	522
Subtotal approved SF					255		19	A	18	A	13	13	13
Subtotal pending - applied for - SF					0		104	P	84	P	0	0	0
Subtotal Future SF					280		412	F	433	F	522	522	522
SUBTOTAL SF					**535**		**535**		**535**		**535**	**535**	**535**

FIGURE 4-61. Status of Koele Project District Continued

Koele PD											
Use	Acreage	Max Overall Density	PD / Phase I Units		Phase II Units	Ph III Units	Subdivided Lots	Building Permits Approved	Units Actually Built	Units Occupied
MF	22	6 units/acre	**156**	A	**100**	**65**	**0**	**35**	**35**	**35**
92-PH2-0004					100					
93-PH3-0001										
Phase I A - Koele Villas - Model Units						7	- na -	7	7	7
Phase I-A - Koele Villas - A						20	- na -	20	20	20
Phase I-A - Koele Villas - B						18	- na -			
06-PH3-0006 - Pines at Koele										
Phase I-B - Pines at Koele						20	na / 6	8	8	8
Land Court Consolidation 170 (LUCA 6.0163, 6.0168, 6.0169)										
Pines at Koele (6 lots noted above)										
06--PH3-0012 - Koele Villas										
08-PH3-0013 - Koele Villas										
Future Development					56	91		121	121	121
Subtotal approved MF					100	65		35	35	35
Subtotal pending - applied for - MF					0	0		0	0	0
Subtotal Future SF					56	91		121	121	121
SUBTOTAL MF					156	156		156	156	156
Subtotal approved residential					355	84		48	48	48
Subtotal pending residential					0	104		0	0	0
Subtotal Future SF					336	503		643	643	643
SUBTOTAL RESIDENTIAL					691	691		691	691	691

FIGURE 4-61. Status Of Koele Project District Continued

Koele PD										
Use	Acreage	Max Overall Density	PD / Phase I Units		Phase II Units	Ph III Units	Subdivided Lots	Building Permits Approved	Units Actually Built	Units Occupied
Hotel	21.1	12 units/acre	**253**	A	104	104	104	104	104	n/a
89-PH2-0004 - Golf Course					102	102	102	102	102	n/a
04-PH2-0003 - Fitness Facility & Spa										
05-PH2-0008 - Well Being Center										
05-PH3-0019										
06-PH2-0012 - two 1,900 sq. ft. suites					2	2	2	2	2	n/a
Future Development					149	149	149	149	149	n/a
subtotal approved hotel					104	104	104	104	104	n/a
subtotal future hotel					149	149	149	149	149	n/a
SUBTOTAL HOTEL					253	253	253	253	253	n/a
Public	1									
Park	11.5									
00-PH3-0009 - 5 acre park					5	5	5	5	5	n/a
subtotal approved PD park					5	5	5	5	5	n/a
subtotal future park					6.5	6.5	6.5	6.5	6.5	n/a
SUBTOTAL PARK					11.5	11.5	11.5	11.5	11.5	n/a
GC	332.4									
89-PH2-0004 - Golf Course					102	102	102	102	102	102
91-PH1-0001										
Subtotal golf					102	102	102	102	102	102
Subtotal future golf					230.4	230.4	230.4	230.4	230.4	230.4
SUBTOTAL EXISTING AND FUTURE GOLF					332.4	332.4	332.4	332.4	332.4	332.4
OS	12									

Demand Analysis

FIGURE 4-62. Status of Manele Project District

Use	Acreage	Max Overall Density	PD / Phase I Max Units		Phase II Units		Ph III Units		Subdivided Lots		Building Permits	Units Actually Built	Units Occupied
					Manele PD								
SF	**145**		**282**	A	**161**	A	**61**		**61**		15	15	
												*17	
Phase II - 95-PH2/001					**161**								
Phase III - 96 PH3/0001					**64**		**61**		**61**		**15**	**15**	
Residential Phase 1-A													
SF - Phase I-A					**33**		**33**		**33**		**14**	**14**	
Hulopo`e Drive					10	A	10		11	A	2	2	
Kapihaa Estates					7	A	7		7	A	4	4	
Lapaiki Place					3	A	3		2	A	1	1	
Lopa Place					6	A	6		6	A	2	2	
Palawai Ridge					7	A	7		7	A	5	5	
Residential Phase IB													
SF - Phase I-B					**31**		**28**	**0**	**28**	A	**1**	**1**	
Kaluakoi Estates					7	A	7		7	A	1	1	
Ocean View Estates					18	A	18		18	A	0	0	
Pu`u Pehe *					6	A	3		3	A			
Recent Apps*					**63**		**63**	P	**63**	P	**0**	**0**	
M 5 - Further Subdivision of Pu'u Pehe					11	P	11	P	11	P			
M 6 - Ocean View Estates - Huawai Place					18	P	18	P	18	P			
M 7 - Kaunolu Place and Maunalei Drive					7	P	7	P	7	P			
M 8 - West Kaunola ?					13	P	13	P	13	P			
M 9 & M 10 - Far West End of Hulopo`e Drive					14	P	14	P	14	P			
Phase II 2000 PH 2 - 0001													
Phase III 2004 PH3 - 0007													
Phase III 2004 PH3 - 0014													
Phase III 2005 PH3 - 0001													
Phase III 2005 PH3 - 0007													
Semi- Future SF - SF Remaining in 95 PH2-00`					**34**		**28**		**-63**		**0**	**0**	
Future - Future Phase II Approval					**121**		**158**		**221**		**267**	**267**	
"Future" (east - lots not shown)													
"Future" (northwest - lots not shown)													
subtotal sf approved					64	A	61	A	61	A	15	15	0
subtotal sf pending - applied for					63	P	63	P	63	P	0	0	0
subtotal future					155	F	158	F	158	F	267	267	282
SF SUBTOTAL					**282**		**282**		**282**		**282**	**282**	**282**

Build-Out Analysis

FIGURE 4-62. Status of Manele Project District Continued

	Manele PD												
Use	Acreage	Max Overall Density	PD / Phase I Max Units		Phase II Units		Ph III Units		Subdivided Lots		Building Permits	Units Actually Built	Units Occupied
MF	30	3.34 units / acre	184	A	91		91				80	69	
Phase II - 95-PH2/001													
Phase III - 96 PH3/0001													
Residential Phase 1-A													
MF - Phase I-A					**54**		**53**				**53**	**53**	
Terraces at Manele = Site A					27	A	27				26	26	
Fairway Terraces = Site B					26	A	26				27	27	
Future - MF under 95-PH2-001					1	P							
Phase II - 2000-PH2/0001													
Phase III 2004 PH3 - 0007													
Phase III 2004 PH3 - 0014													
Palms at Manele = Site C aka Terraces at Manele Incr 3 ?					**47**		**47**				**27**	**16**	
Palms Phase I					38	A	38	A			27	16	
Palms Phase II					9	P	9	P					
Phase III 2005 PH3 - 0001													
Phase III 2005 PH3 - 0007													
Future					83		84				104	115	
					---------		---------		---------		---------		---------
subtotal mf approved					91		91				80	69	
subtotal mf pending - applied for					10		9				0	0	
subtotal mf future					83		84				104	115	
MF SUBTOTAL					**184**		**184**				**184**	**184**	
subtotal sf & mf approved					**155**		**152**				**95**	**84**	
subtotal sf & mf pending - applied for					**73**		**72**				**0**	**0**	
					238		**242**				**371**	**382**	
RESIDENTIAL SUBTOTAL (MF AND SF)					**466**		**466**				**466**	**466**	

Demand Analysis

FIGURE 4-62. Status of Manele Project District Continued

Manele PD										
Use	**Acreage**	**Max Overall Density**	**PD / Phase I Max Units**		**Phase II Units**	**Ph III Units**	**Subdivided Lots**	**Building Permits**	**Units Actually Built**	**Units Occupied**
Comm	5.25								?	
Hotel	56.6	10 units / acre	**500**	A					250	
			- - - - - - - -						- - - - - - - -	
SUBTOTAL			**500**						**250**	
Public	0									
Park	66.33									
GC	138.577									
92/PH2-03										
Island Club Fitness Center at Challenge at Manele										
OS	152.02									
Roads	32									

Overall Digest Notes: Aug 21 1995 - applied 166 SF , 96 MF Phase 2 apps - Oct 95 revised to 166 SF and 54 MF units - Mar 19 03 - time ext and Ph 2 - as of then 39 SF lots subd, 43 MF lots built or in process; April 03 time ext granted til 07; Manele Sub'd Ph I A - 12 lots 5/98 (96-LPA-22); Ph 1 B - 3 lots; Land Court Consolidation 170, 20 lots: h III approval 01/05; As of 03/21/07 39 SF lots subdivided, 43 MF units either built or in process; July 23,2007 - revised to 161 SF lots and 54 MF units Phase 2.

A = approved P = Pending

Build-Out Analysis

An attempt was made to map the status of the project districts, according to status. All elements of the Project Districts have Phase I approval, as part of the ordinance. Some have Phase II approvals, while others have Phase 3 approval, subdivision approval, or in some cases building or occupancy approvals.

The first step was to plot project district sections which were not yet available from the Planning Department at the time of this draft. After that, each section could be identified as to whether it had Phase I approval, Phase II approval, Phase III approval, subdivision approval, building permits, landscaping, or was built and occupied. Several inconsistencies were noted, which made it difficlut to accurately plot phased approval status, particularly for Koele.

One example is found in the Koele Project District. One of the better maps that could be located was labelled “Overall Site Plan”. It noted specific locations of Project sections and phases, including lot alignment. Unfortunately, the text on the map refers to a total of 353 lots, while 388 are shown. The Koele Project District Ordinance allows for 535 SF homes, of which 255 have Phase II approval, and only 19 had Phase III approval as of this draft. Data gaps for Koele were wider than those for Manele. We were unable to locate a map which had a clear delineation of lots, in which the map had exactly the same count as the phase approval. DWS is not the main repository for such maps, so it may be that a particular set of information was inadvertently overlooked.

Data were generally more clear for Manele. However, there were some inconsistencies even there. For instance, Phases M-9 and M-10 of the Manele Project District have received some subdivision approvals. Fourteen (14) lots have received subdivision approval. However, the map that was available as of this draft showed thirty-two (32) lots in M-9 and M-10 phases.

The Project District approval process is intended to allow some flexibility to the developer within established parameters. Even so, a running tally of project approval status would be useful for auditing of both resource response at different levels of build-out and pending demands.

This is particularly important in light of the recommendations regarding allocation and build-out which were reached as a result of all this analysis and will be discussed in Chapter 7.

As this draft is being completed, the Planning Department is preparing for the Community Plan Process on Lanaʻi. It is anticipated and hoped that a more clear delineation of lots and lot counts than what has been shown here will be a part of that preparation.

FIGURE 4-63. Koele Project District General Site Plan

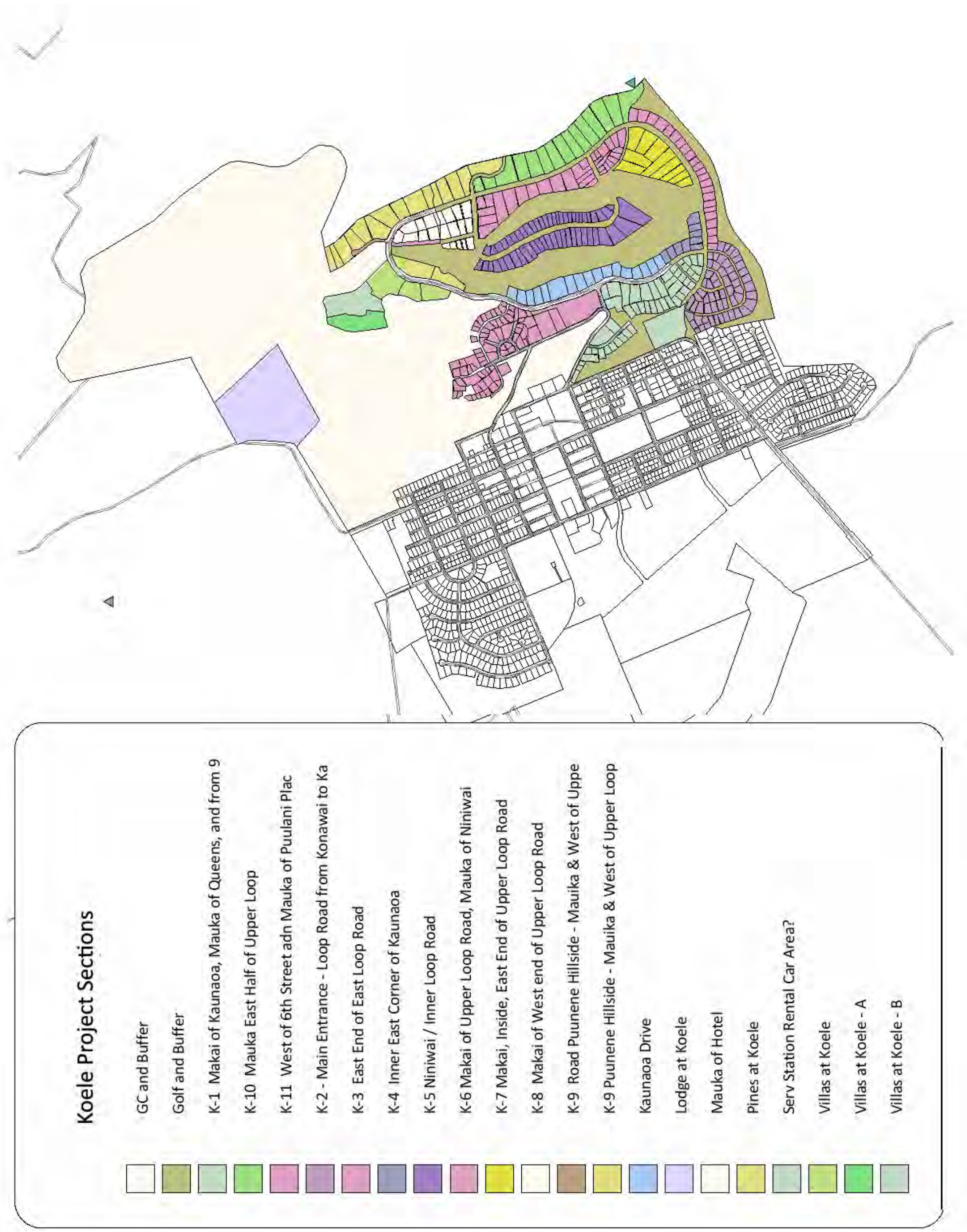


FIGURE 4-64. Manele Project District General Site Plan

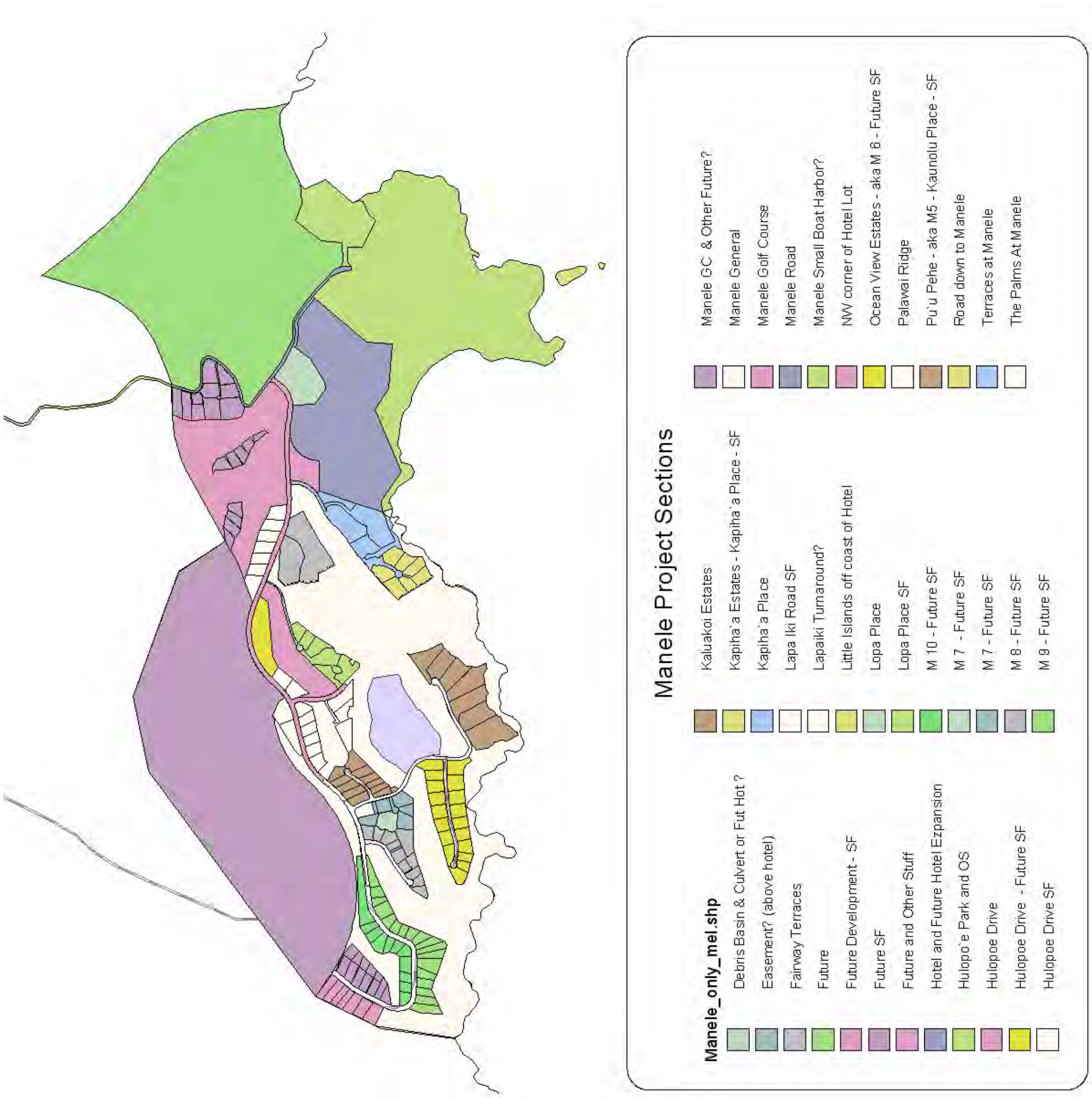


FIGURE 4-65. Koele Project Status - Phase 1, 2 and 3 - Partial Only

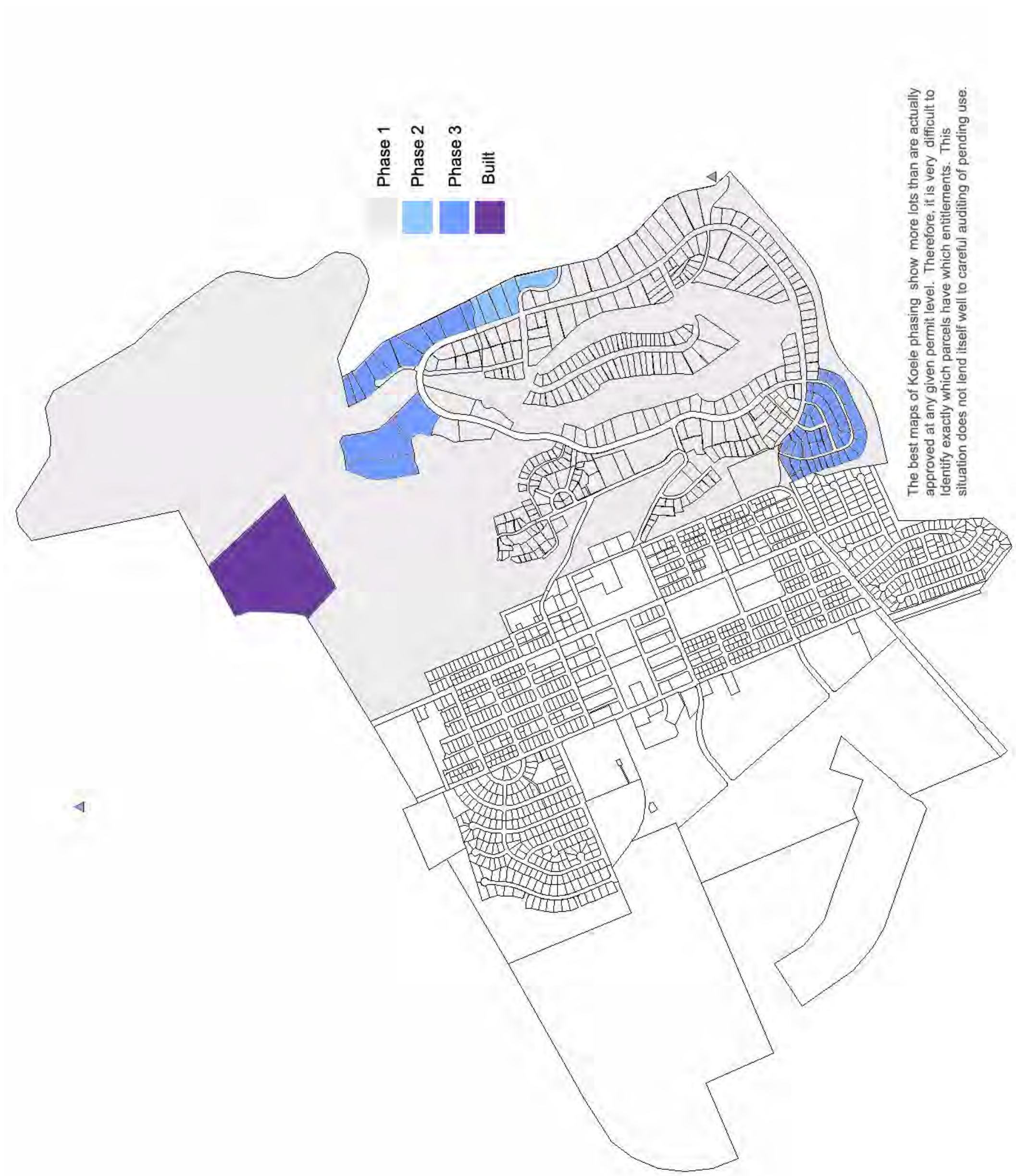
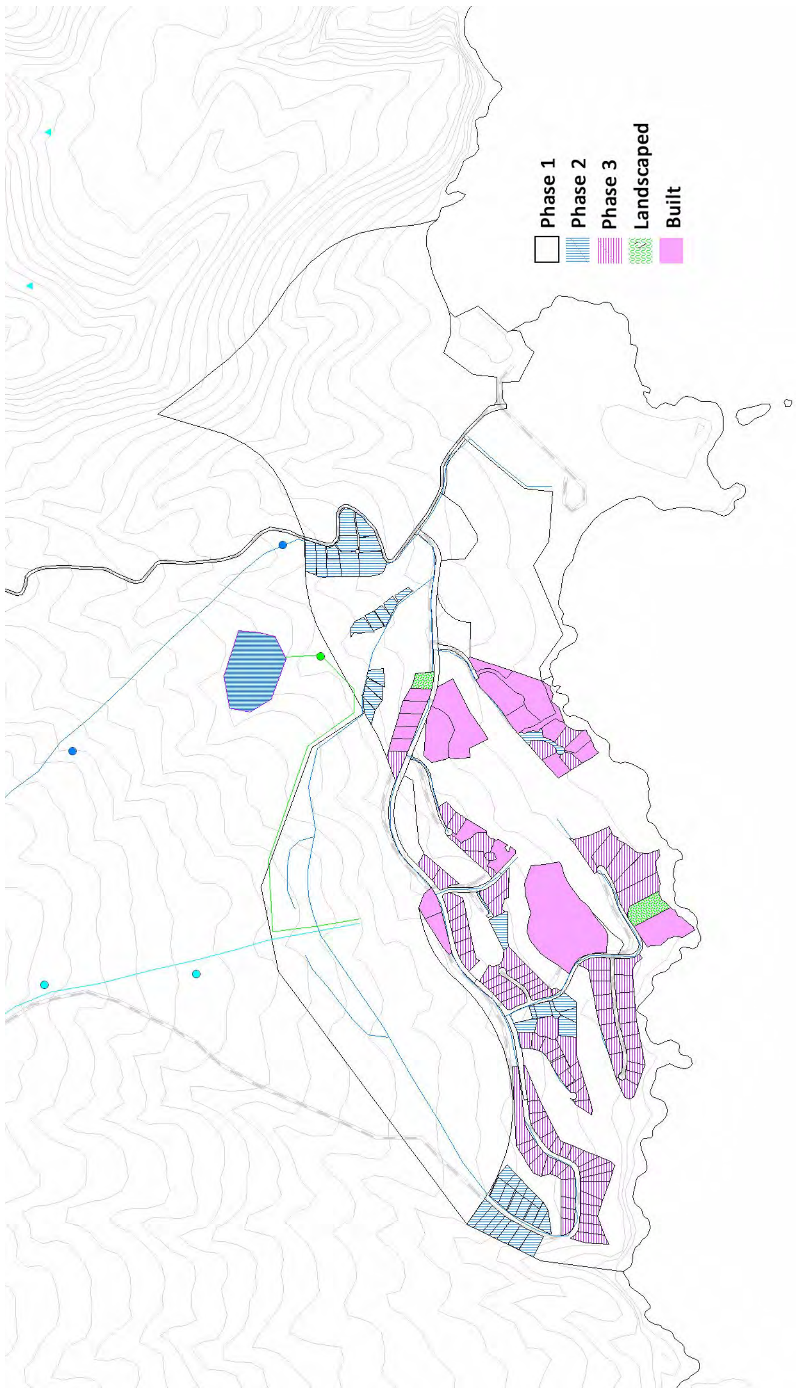


FIGURE 4-66. Manele Project Status - Phases 1, 2 and 3



Other Projects On Lana‘i - Discretionary Projects Submitted for Review

The Manele and Koele Project Districts are the major developments on Lana‘i, but they are not the only ones. Other projects in progress include the Department of Hawaiian Homelands’ development of a 50 acre residential site, an affordable housing development under Hawaii Revised Statutes (HRS) 201H-38, the completion or verification of completion of Lana‘i City Redevelopment Project under HRS 201 G-118, replacement of the Lana‘i City Senior Center, and others. Staff planners of the Department of Water Supply maintain a list of projects pending in the discretionary permit review process for each district, which is updated. The update as of June 30, 2009 is found in Figure 4-67, on the following pages.

FIGURE 4-67. Discretionary Projects Submitted For Review - Quarterly Update As Of 06/30/2009

Project Name	Acre/Units	Acre Cnsm GPD Unit Cnsm GPD	Proj'd use (gpd)	Potable	Non-Potable	Status	Comments
Koele							
Koele Project District Overall	**SF -** 214 ac at 2.5 unis/ac=535 **MF-**26 ac at 6 units/ac = 156 **Hotel -**21.1 ac at 12 units=253 **PQP -** 1 ac **Park -** 11.5 ac **GC -** 332.4 ac; min 50 ac for 11 holes; min 110 ac for 18 **OS -** 12 ac	SF 214 x3000=642000 MF 26x5000=130000 HTL 21.1x17000=358700 PQP 1x1700=1700 PARK 11.5x1700=19550 GC 332.4x5000=1662000 SF 535x600=321,000 MF 156x560=87,360 HTL 253x350=88,550 PQP 1x1700 = 1700 PARK 11.5 x1700=19550	**2,813,950 or 2,180,160**			**SF** 13 built (7800 gpd) 84 on SD process(50,400 gpd) 438 remaining (262,800 gpd) **MF** 35 built (19600 gpd) 6 lots on subdivision process (# of acres/units unkn) 67760 gpd remaining **HTL** 102 hot units built(35700 gpd) 2 applied for (700 gpd) 148 - proposed (51800 gpd) **Park** **5 acres - 8500 gpd** **6.5 remaining (**11050 gpd) **Est GPD remaining- 444,510 gpd**	Phase I - 468.3 acres Phase II - 618 acres, GC district added - land allocation increased by 150 acres additional 5 buildings with 20 MF units built - CO pending as of 2006
The Villas @ Koele 92/PH2-004 92/PD1-003 249001021 249001024 249001025-27 249001030 249002002 249018001-02	632 acres 100 townhse units 255 SF units	100x560=56,000 255x600=153,000	186,080	186,080		**SF** 13 built (7800 gpd) 242 remaining (145200 gpd) **MF** 27 built (15120 gpd) 73 remaining (40880 gpd) **Est remaining (186080 gpd)**	residential development as of 0509 - part of PD Per KIVA db, CO's for the following buildings are pending: Bldg 7 - 4 units Bldg 12 - 5 units Bldg 13 - 3 units Bldg 14 - 4 units Bldg 15 - 4 units total - 20 units

Demand Analysis

FIGURE 4-67. Discretionary Projects Submitted For Review - Quarterly Update As Of 06/30/2009 - Cont.

Project Name	Acre/Units	Acre Cnsm GPD Unit Cnsm GPD	Proj'd use (gpd)	Potable	Non-Potable	Status	Comments
Lodge at Koele Fitness Facility, Studio, & Spa PH2 20040003 249018001p	.092 ac	1200				0	time extension requested - withdrawn in 2005 part of PD - hotel
Lodge at Koele Luxury Suites PH2 2006/0001 249018001	1900 sq ft	2x350=700	700	700			part of PD - hotel
Pines At Koele 249021006		60x600=36,000	31,200	31,200		8 SF built	per KIVA db; 20 permited - issued in 12/2006; 40 building permits pending part of PD - permitted as SF
Subtotal- Koele			**217,980**	**217,980**	**0**		Pending portions of PD
Koele PD Hotel - future	148 units	148x350=51,800	51,800	51,800		proposed	C&C Proposal (2006) 07/12/06; est use - 74,000gpd (148units@500 gpd) part of PD - hotel
Koele PD - commercial - future			12,000	12,000		proposed	C&C proposal (2006) - not included in PD
Koele PD Redevelopment Portion	170 sf units	170x600=10,2000	102,000	102,000		proposed	C&C proposal (2006) - not included in PD
Sub total- Future Conceptual			**165,800**	**165,800**	**0**		
Total Koele PD			**383,780**	**383,780**			
Lana`i City and Related Areas							
Lands of Lana`i (DHHL) 249002057	50 ac 32 ac-136 SF 2 ac- 20 MF 5 ac- park & community ctr 2 ac-drainage 9 ac-roads **15 ac/35 units** **35 ac/80 units**	32X3000=96000 2 x5000 =10000 5 x1700=8500 136x600 = 81,600 20x560 = 11,200 114500 - 15600= **98900**	98,900	98,900			per Stuart Matsunaga (808) 620-9283 this parcel was resubdivided according to Land Court rules. Phase I - 15 ac- 45 lots; Phase 2 -10 lots plus 1 lot for telecom facility. no plans yet for the remaining 35 acres, may build in 5-10 years. (draft EA submitted 3/01 for comments- see also State Water Projects Plan-application date 2001)

FIGURE 4-67. Discretionary Projects Submitted For Review - Quarterly Update As Of 06/30/2009 - Cont.

Project Name	Acre/Units	Acre Cnsm GPD Unit Cnsm GPD	Proj'd use (gpd)	Potable	Non-Potable	Status	Comments
Lands of Lana`i (DHHL) 249002057 (Phase I & 2A)	15 ac/45 units	15x3000=45000 45x600 = 27,000				19 built/occupied 7 under construction 19 vacant	as of 4/09, per DHHL
Lana`i City Redevelopment Project 77 TMKs Letter from the Director of Housing & Human Concerns	SF- 214 MF - 164 SR Hsg - 24	214x600=128,400 164x560=91,840 24x560= 13,440 233680 Remaining: 201 SF 120,600 30 MF 16,800	137,400	137,400		214 /SF - 13 /SF -Plantation - - - - - - 201 SF remaining 164 MF - 48 MF Courts 36 MF Kanepuu 48 MF Iw iole - - - - - 30 MF remaining 24 Sr. Housing - 24 Hale Kupuna - - - - - - 0 Sr. Housing remaining	Pursuant to Section 201G-118, HRS anticipated increase in use - 3,900 gpd based on system standards. est cons - entire proj = 233,680 resolution 96-31 amended 7 add'l SF 7 less MF short term rental units
Plantation Homes/new dw ellings several tmks		13x600=7,800					13 SF- permitted betw een June 2006 and Dec.,2007 part of PD - SF
The Courts Apt 249004083	1.94 ac/48 units	11x4x560= 24,640				CO pending 24,640 est	11 buildings w ith 48 MF units built CO pending as of 2007 Part of Lana`i City Redevelopment Project
Kanepuu-New Apt 249014018	7.67 ac/48 units	12x3x560= 26,800				CO pending 20,160 est	12 buildings w ith 36 units built CO pending as of 2007 Part of Lana`i City Redevelopment Project
Iw iole Dormitory 249014001	83.98 ac/48 units	48 x 560 =				CO pending 26,880 est	13 buildings w ith 48 units built CO pending
Lana`i First Assembly of God CIZ 990003 249014009	.551 ac	.551x1700=937	937	937		under construction	
Lana`i Pines Sporting Clay 249002001(por) SUP 960008	14.9 ac	14.9x6000 =89,400	89,400	89,400			expansion of existing recreational facility
Lana`i Quarry 249002001(por) SUP 920011	14.8 ac	14.8x6000=88,800				operating	approved w ith conditions in 1998; time extension granted on 6/16/1999
Lana`i Kingdom Hall Meeting Room 249014021						completed	CO w as issued on 9/25/07

FIGURE 4-67. Discretionary Projects Submitted For Review - Quarterly Update As Of 06/30/2009 - Cont.

Project Name	Acre/Units	Acre Cnsm GPD Unit Cnsm GPD	Proj'd use (gpd)	Potable	Non-Potable	Status	Comments
Proposed Improvements at Lana`i Airport	1.14 ac	1.14x6000 = 6840	6,840	6,840		DOE proposal	early consultation
Lana`i City Housing Project_201-H_county of Maui	73 ac/# of units not determined yet	73x3000 = 219,000	219,000	219,000		EA early consultation	rentals & for-sale markets; SF & MF (used SF/ac std) this is part of the 115 ac lot donated by CCR to the county (per 1997 WWG report 518 units can be constructed on 115 acre lot assuming max density of 4.5units/ac)
Lana`i Senior Center 249006006 CTB 2009/0004	0.34	0.34x6000 = 2040	3,000	3,000		as of 5/29/09, DHHC is awaiting approval from CCR to do any work-demolition & construction	DHHC project-est use between 2000 & 3000 gpd
Subtotal-Lana`i City & Related Areas			**552,477**	**552,477**	**0**		
Lana`i City School Expansion	1 acre	1x1700=1,700	1,700	1,700			CCR est - 13,750gpd
Lana`i City Residential - New	712 units	712x600=427,200	427,200	427,200		**SF - 712 remaining (427,200 gpd)**	C & C proposal - existing # of units as of 2/2006 is 1062, build-out is 1774 or approximately 712 more sf units (427,200 gpd or 1,064,400 gpd at full build out)
Affordable Housing Property	65 acres/292 units	65x3000=195,000 292x600 = 175,200	175,200	175,200		CCR proposal	not part of PD
Subtotal - Future Conceptual			**604,100**	**604,100**	**0**		
Total Lana`i City & Related Areas plus future conceptual projects			**1,156,577**	**1,156,577**	**0**		
Irrigation Grid/Palawai							
Miki Basin Heavy Industrial Area 249002001(por)	14 ac	14x6000=84,000					
Miki Basin Heavy Industrial Area 249002001(por) DBA 2008/0002 CIZ 2008/0003	6 ac	6x6000=36,000	36,000	36,000		DBA & CIZ still pending	CCR Proposal 2009 incl. 120,000 GPD for this.

FIGURE 4-67. Discretionary Projects Submitted For Review - Quarterly Update As Of 06/30/2009 - Cont.

Project Name	Acre/Units	Acre Cnsm GPD Unit Cnsm GPD	Proj'd use (gpd)	Potable	Non-Potable	Status	Comments
Subtotal - Irrigation Grid/Palawai			**36,000**	**36,000**			
Kaumalapau Subdivision	45 units	45x600=27,000	27,000	27,000		proposed	C&C Proposed 2006 (& 2009)
Agriculture Reserve			500,000		500,000	proposed	LWAC Committee Item
Other AG or Commercial Uses			20,000	20,000		proposed	C&C Proposal 2006 (& 2009)
Additional Baseyard			2,000	2,000		proposed	C&C Proposal 2006
New Warehouse			1,000	1,000		proposed	C&C Proposal 2006
Future Use			27,000	27,000		proposed	C&C Proposal 2006 (& 2009, but at 2000 gpd in 2009)
Total - Future Conceptual			**577,000**	**77,000**	**500,000**		
Total - Irrigation Grid/Palawai (incl future conceptual)			**613,000**	**113,000**	**500,000**		
Manele							
Manele Project District Overall	**869.2 ac total** **SF** 328 ac@0.86 units/ac =282 units **MF** 55 ac @3.34 units/ac= 184 units **Comm l -** 5.25 ac **Hot** 56.6 ac @10 units/ac not to exceed 500 units **PQP -** 2 **Park-** 66.33 ac (min 10 ac) **GC** 172 ac **OS** 152.02 ac **Roads -** 32 ac	328x3000 = 984,000 55x5000=275,000 5.25x6000=31,500 56.6x17000=962,200 2x1700=3,400 66.33x1700=112,761 172x5000=860,000 282x600 = 169,200 184x560 = 103040 500x350 = 175,000				**SF** 15 built (9,000 gpd) 17 - on SD process (10,200gpd) 250 remaining (150,000 gpd) **MF** 69 built (38,640 gpd) 115 remaining (64,400 gpd) **HTL** 250 Htl built (87500 gpd) remaining - 0 **Est remaining - 340761 gpd**	SF 11 building permits issued on 6/2006 for The Palms at Manele _ not included in the MF built count yet **MF** 16 - Palms at Manele 26 - Terraces at Manele 27 - Fairway Terraces 69 Terraces @ Manele's Clusters 4, 7, 9 & 10 with 4 units each built - CO pending
Keiki Center and Spa at Manele Bay Hotel PH2 20040003 249017001(por)			1,200	1,200		req 2 yr time extension	amendment to preliminary design- modify Keiki ctr and eliminate spa fac - est use prior to modification 7,000 gpd - part of PD

FIGURE 4-67. Discretionary Projects Submitted For Review - Quarterly Update As Of 06/30/2009 - Cont.

Terraces at Manele Incr 3 249017008(por) DBA20000004 PH220000001 PH3 20040007 PH3 20040014 SM1 20000011	12.4ac 11 bldgs with 47-one and two story townhouse units	12.4x5000=62,000 47x560 = 26,320				26 units built	1.03 MGD - allocation for entire Manele PD ; LWAC recommends that 400 gpd of potable and 400 gpd of non potable water use be included in the CC&Rs for this project (townhouse units to be used as vacation or second homes(applicant's est use - 26,320 gpd) Clusters 4, 7, 9 & 10 with 4 unis each built - CO pending
Manele Bay Hotel - Hulopo'e Drive, Special Function Building, Pool Grill Expansion, New Br and Related Improvements 249017008 (por) SM1 20050002 PH 20050002			6,100	6,100		pending	
Manele Small Boat Harbor Ferry Improvement Project Draft EA 249017006 249017002(por)	14.5 ac		10,000	10,000		approved	additional comfort stations, new admin bldg, paved parking areas, utilities, landscaping
Palms @ Manele 249017008						16 units built	11 permitted on 6/2006
Adult Pool and Related Improvements at the Four Seasons PH2 2008/0001 SM1 2008/0013 249017001 por	0.2 ac	0.2 x 17000 = 3400	3,400	3,400		pending	applicant's est - 965 gpd pool requires 45,788 gallons to fill
Sub total - Manele PD			**20,700**	**20,700**	**0**		
Manele Hotel No. 2 (future)	150 units	150x350=52,500	52,500	52,500		proposed	C&C Proposal (2006); est use - 90,000gpd based on 600 gpd (included in PD)
Manele Hotel No. 2 irrigation (future)	12 ac		84,000		84,000	proposed	C&C Proposal (2006); est use - 84,000gpd- (12 acres @ 7,000gpd)
Subtotal Future Conceptual			136,500	52,500	84,000		
Total - Manele PD (incl future conceptual)			**157,200**	**125,700**	**84,000**		
			2,310,557	**1,779,057**	**584,000**		

Castle and Cooke Proposals

During the process of working with the Lana'i Water Advisory Committee to draft and review this document, several build-out proposals by Castle & Cooke (CCR) were discussed. The most recent of these that was reviewed by the Lana'i Water Advisory Committee was dated July 12, 2006. This is presented in Figure 4-68.

An additional proposal was submitted by CCR on July 28, 2009. This report was presented to the Lana'i Water Advisory Committee, which elected not to address the proposal for this iteration of the Water Use & Development Plan.

For informational purposes, a comparison of the 2009 proposal to the 2006 proposal is included here. The 2009 proposal has not had the benefit of full committee discussion and review. However key differences between these proposals are noted in Figures 4-69 to 4-71.

The 2006 proposal by CCR identified roughly 5.4 MGD in demands at build-out, before accounting for system losses. System losses were added to potable and brackish pumped water, resulting in a total demand of about 6.1 MGD. The proposal indicated that 616,000 GPD of wastewater, plus 1.3 MGD of "alternative source" would bring pumped demands down to about 4.16 MGD.

The 2009 proposal by CCR identified roughly 6.28 MGD in demands, before accounting for system losses. System losses were added to potable and pumped water, resulting in a total demand of about 6.97 MGD. The proposal indicated that roughly 1.21 MGD in wastewater and 1.55 MGD in "alternative" source would bring pumped demands down to about 4.21 MGD.

Neither proposal includes all elements of the Project Districts, nor all known other plans for development within the community.

Neither proposal identified the alternate water sources clearly. Calculated additional wastewater generation upon build-out of either proposal, or upon build-out of proposals plus existing entitlements not included, would not be adequate to cover both the amounts attributed to wastewater and the amounts attributed to alternative source. Neither proposal identifies sufficient water source to serve these projects at build-out levels, let alone at build-out with existing unaccounted-for water rates.

FIGURE 4-68. Castle & Cooke Proposal - (July 12, 2006 version)

Castle & Cooke Proposal July 12, 2006											
					DEMAND PROJECTIONS (AS OF 2006)						
USAGE CATEGORY		**SOURCE**	**UNITS**	**UNITS**	**QUAN**	**EXST**	**5-YR**	**10-YR**	**15-YR**	**BUILDOUT**	**COMMENTS**
SUMMARY OF DEMANDS:											
POTABLE WATER DEMAND											
1.0	**LANA'I CITY RESIDENTIAL**					**353,400**	**557,700**	**879,100**	**977,100**	**1,157,100**	
2.0	**LANA'I CITY NON-RESIDENTIAL+CAVENDISH**					**130,100**	**187,750**	**229,750**	**251,750**	**273,950**	
3.0	**IRRIGATION GRID**					**30,500**	**518,000**	**535,000**	**542,000**	**550,000**	
4.0	**KOELE PD: POTABLE**					**144,000**	**311,200**	**486,600**	**524,600**	**566,400**	
6.0	**MANELE PD: POTABLE**					**392,100**	**584,400**	**790,100**	**971,700**	**1,070,450**	
	NON POTABLE WATER										
7.0	**MANELE PD: NON-POTABLE**					**672,600**	**846,900**	**883,000**	**1,064,500**	**1,190,000**	
SUMMARY OF SOURCE											
	LOSSES					10.9%	12.0%	12.0%	12.0%	12.0%	
	POTABLE HIGH LEVEL GROUNDWATER					**1,179,000**	**2,453,000**	**3,319,000**	**3,313,000**	**3,411,000**	
	NON-POTABLE HIGH LEVEL					**755,000**	**962,000**	**753,000**	**810,000**	**752,000**	
	ALTERNATE WATER SOURCE FOR NON POTABLE USE					**0**	**0**	**250,000**	**400,000**	**600,000**	
	ALTERNATE WATER SOURCE FOR POTABLE USE					**0**	**0**	**0**	**400,000**	**700,000**	
	ALTERNATE WATER SOURCE*					**0**	**0**	**250,000**	**800,000**	**1,300,000**	
	TOTAL GROUNDWATER PUMPED (EXCLUDE ALT. WATER					**1,934,000**	**3,415,000**	**4,072,000**	**4,123,000**	**4,163,000**	
SUMMARY OF WASTEWATER (SOURCE = DEMAND)											
5.0	**KOELE PD: WASTEWATER**					**199,000**	**218,000**	**238,000**	**247,000**	**256,000**	
8.0	**MANELE PD: WASTEWATER**					**80,800**	**165,000**	**237,000**	**273,000**	**360,000**	
SUMMARY OF TOTAL WATER SUPPLY/DEMAND						**2,213,800**	**3,798,000**	**4,797,000**	**5,443,000**	**6,079,000**	
(POTABLE, NON-POTABLE, ALTER. WATER, RECLAIMED											
*** - NOTE: For purposes of this proposal, "Alternate Water Source" refers to water other than ground water from the primary and secondary high level**											
1.0	**LANA'I CITY**	POT				353,400	557,700	879,100	977,100	1,157,100	
1.1	Lana'i City Residential - Existing	POT	each	gpd/	350	343,500	371,700	371,700	371,700	371,700	Increased water use 27% -

1.2	Lana'i City Residential - New	POT	each	gpd/ unit	600		60,000	295,800	320,400	427,200	Utilized COM standards.
1.3	County Lana'i City Recreation Area	POT	acres	gpd/ acre	1,375	9,900	11,000	11,000	11,000	11,000	Current use but unmetered.
1.4	Affordable Housing Property	POT	each	gpd/ unit	600	0	60,000	87,600	132,000	175,200	Based on 65 acres & 4.5 units/acre.
1.5	DHHL Property	POT	each	gpd/ unit	600	0	45,000	90,000	112,200	135,000	Based on 50 acres & 4.5 units/acre. 50% compl. In intermediate future.
1.6	Kaumulapau Harbor	POT	LS gpd	LS gpd	1		1,000	5,000	7,000	10,000	
1.7	Kaumulapau Subdivision	POT	each	gpd/ unit	600	0	9,000	18,000	22,800	27,000	50% developed in intermediate future.
2.0	**LANA'I CITY NON-RESIDENTIAL+CAVENDISH**	POT				130,100	187,750	229,750	251,750	273,950	
2.1	Lana'i City Govt / Comm & Inst / Lt Ind / Airport	POT	gpd	LS gpd	1	130,100	174,000	216,000	238,000	260,200	Existing demand updated due to better data. Future prorated w/population increase.
2.2	Lana'i City School Expansion	POT	gpd	gpd/ acre	1,375		13,750	13,750	13,750	13,750	
3.0	**IRRIGATION GRID**					30,500	518,000	535,000	542,000	550,000	
3.1	Agriculture Reserve	POT	LS gpd	LS gpd	1	30,500	500,000	500,000	500,000	500,000	
3.2	Other Ag or Commercial Uses	POT	LS gpd	LS gpd	1	0	7,000	14,000	17,000	20,000	
3.3	Additional Base Yard	POT	LS gpd	LS gpd	1	0	1,000	2,000	2,000	2,000	
3.4	New Warehouse	POT	LS gpd	LS gpd	1	0	1,000	1,000	1,000	1,000	
3.5	Future Use	POT	LS gpd	LS gpd	1	0	9,000	18,000	22,000	27,000	
4.0	**KOELE PD: POTABLE**	POT				144,000	311,200	486,600	524,600	566,400	
4.1	Koele PD Redevelopment Portion	POT	each	gpd/ unit	600	0	72,000	87,000	94,200	102,000	75 acres. 50% developed in intermediate future.
4.2	Koele PD-Hotel	POT	each	gpd/ unit	500	36,600	51,000	51,000	51,000	51,000	Assumes 20% increase in intermediate term.
4.3	Koele PD-Hotel (Future)	POT	each	gpd/ unit	500	0	0	74,000	74,000	74,000	
4.4	Koele PD-Hotel Irrigation	POT	acres	gpd/ acre	NA	58,500	60,000	60,000	60,000	60,000	More hardscape will be used in the future. Max use at 60,000 gpd
4.5	Koele PD-Commercial	POT	LS gpd	LS gpd	1	2,700	6,000	9,000	11,000	12,000	Assumes commercial use increase by 50% & 100%
4.6	Koele Single Family	POT	each	gpd/ unit	600	12,300	31,200	91,200	120,000	153,000	Existing demand increased by 25% - better data. Units incr. by 1.
4.7	Koele Multi-Family	POT	each	gpd/ unit	600	13,500	30,600	54,000	54,000	54,000	Existing demand increased by 25% - better data. Units decr. by 10.

4.8	Koele Common Areas Irrigation	POT	acres	gpd/ acre	2,000	4,400	20,000	20,000	20,000	20,000	
4.9	Koele Parks	POT	acres	gpd/ acre	1,700	0	20,400	20,400	20,400	20,400	Existing demand increased by 80% - better data. Units incr by 10.
4.10	Cavendish Golf Course	POT	gpd	LS gpd	1	16,000	20,000	20,000	20,000	20,000	Based on highest use of last 3 years + 4,000 gpd.
5.0	**KOELE PD: WASTEWATER**	WW				199,000	218,000	238,000	247,000	256,000	
5.1	Koele Golf Course	WW	LS gpd	LS gpd	1	199,000	218,000	238,000	247,000	256,000	Normal rainfall year. Present
6.0	**MANELE PD: POTABLE**	POT				392,100	584,400	790,100	971,700	1,070,450	
6.1	Manele Hotel	POT	rooms	gpd/	600	88,000	150,000	150,000	150,000	150,000	Assumed that full capacity of
6.2	Manele Hotel Irrigation	POT	acres	gpd/ acre	8,000	179,000	179,000	179,000	232,000	232,000	
6.3	Manele Hotel No. 2 (Future)	POT	rooms	gpd/ room	600	0	0	90,000	90,000	90,000	Existing demand increased by 80% - better data. Units incr by 10.
6.4	Manele Single Family Homes	POT	each	gpd/ unit	600	0	37,800	60,000	90,000	120,000	
6.5	Manele Multi-Family	POT	each	gpd/ unit	300	12,800	33,600	45,000	52,500	90,000	
6.6	Manele Commercial	POT	acres	gpd/ acre	5,000	17,300	25,000	35,000	45,000	51,250	Assume 50% increase in intermediate term
6.7	Manele Utilities	POT	LS gpd	LS gpd	1	12,900	40,000	66,000	79,000	92,000	Ultimate plant size at 4x current. Assume linear use.
6.8	Manele Construction / Development	POT	LS gpd	LS gpd	1	29,900	31,000	31,000	31,000	31,000	Increase reflects actual metered water use
6.9	Manele Parks (Including Hulopo'e	POT	acres	gpd/	1,700	23,000	34,000	56,100	112,200	112,200	Assumes 50% developed in
6.10	Manele Public Use	POT	LS gpd	LS gpd	1	29,200	54,000	78,000	90,000	102,000	Assume Public park use triples in ultimate phase.
7.0	**MANELE PD: NON-POTABLE WATER**					672,600	846,900	883,000	1,064,500	1,190,000	
7.1	Manele Single Family - Irrigation	NPHLGW and ALT	each	gpd/ unit	2,500	37,000	187,500	250,000	437,500	500,000	
7.2	Manele Multi-Family - Irrigation	NPHLGW and ALT	each	gpd/ unit	1,200	86,100	134,400	180,000	210,000	360,000	
7.3	Manele Common Areas Irrigation	NPHLGW and ALT	acres	gpd/ acre	2,500	40,400	40,000	40,000	40,000	40,000	Water use decr. by 180% to account for actual projected future use.

7.4	Manele Golf Course Irrigation	NPHLGW and ALT	gpd	gpd	1	509,100	485,000	413,000	377,000	290,000	Based on 650,000 gal/day less WW effluent.
8.0	**MANELE PD: WASTEWATER**	WW				80,800	165,000	237,000	273,000	360,000	
8.1	Manele Golf Course Irrigation	WW	gpd	gpd	1	80,800	165,000	237,000	273,000	360,000	WW effluent generation = 75% of domestic water usage based on 2002 data.

NOTES:

ITEM NO.	COMMENT
1.1 & 1.2	Per capita use: Actual=323 gpd/unit. Use 350 gpd/unit for existing and Maui County Std=600 gpd/unit for future units.
1.0	Includes single family, multiple family and common areas.
1.4	65 Acres of the 115 acres is allocated for affordable housing. The remaining 50 acres is allocated to school expansion (2.2)
2.1	Includes Commercial, Institutional, Light Industrial and Lanaʻi Airport
2.2	Lanaʻi City School Expansion. Expect that most water usage will be due to irrigation (assumption is 10 Acre out of 50 acres is landscape)
4.4	Koele Hotel irrigation is expected to decline because more hardscape will be used. A maximum of 60,000 gpd is used.
5.0 & 8.0	R-1 water includes both Lanaʻi City WRF and the Manele District WRF. For existing 199,000 gpd to EAK and 80,800 gpd to CAM.
7.4 & 8.1	For 5/10/BO periods 650,000 gpd total irrigation water assumed for CAM. At CAM, the amount of brackish water use is reduced as the amount of R-1 water increases.
Summary	Loss of 12% is assumed for planning purposes. CCR goal is to minimize all losses and actual is expected to be less then 12%.
a	Includes Residential plus Kpau Harbor
"D"	For Manele PD refer to Table A-2 of 1997 Draft WUDP for determination of Manele PD NP irrigation and Potable Usage.

LEGEND

POT	POTABLE HIGH LEVEL GROUNDWATER
NPHLGW	NON-POTABLE HIGH LEVEL GROUNDWATER (WELLS #1,9,14)
ALT	ALTERNATE SOURCE (BASAL WELLS, DESAL, RUNOFF, WW INCREASE)
WW	WASTEWATER
GPD	GALLONS/DAY
LS gpd	LUMP SUM GALLONS/DAY

CATEGORIES

3.2	Lanaʻi City Other Ag / Commercial		6.7	Manele Utilities	
		Kamalapau Harbor			Manele Wastewater Treatment
		ADA (Aoki Homes)			Manele Terrace Pump Station
		Miki Lumber Yard			Road E Lift Station
		Lanaʻi Waste Disposal	6.8	Manele Construction/Development	
		Lanaʻi AWWTP			Manele Crusher
		Airport			Manele Trailer Ice Machine
		MECO Powerplant			Rock Cutting
4.5	Koele Commercial				Development
		Koele Hotel Horse			MANELE RD MAKAI METR

		STABLES HORSE							Manele Road - Pine Trees			
		Koele Hotel Tennis							MANELE RD TREES TOPS			
		Exp at Koele Golf Course							Manele Standpipe			
		Exp at Koele Course							ROAD E STANDPIPE METER			
6.6	Manele Commercial						6.1	Manele Public Use				
		Trilogy							Hulopo'e Beach Park - High			
		Manele Golf Course							Hulopo'e Beach Park - Low			
		Manele Golf Course							Boat Harbor			
		Manele Golf Comfort							Kila Kila Boat Harbor			
		Future Commercial Use										
This Table is for planning purposes only. Castle & Cooke's development plans are subject to change, and therefore, it is intended that this Table be reviewed and revised on a periodic basis. The projected demand for the various uses and service areas indicated herein are only estimates and are not intended to limit consumption in specific locations or projects.												

Build-Out Analysis

FIGURE 4-69. Comparison of Demand Summaries - 2006 and 2009 Proposals

PROJECTED DEMAND AND ALLOCATIONS 2006 and 2009 DRAFTS		DEMAND PROJECTIONS									
	USAGE CATEGORY	EXST 2006 ACTUAL OR ESTIMATE (GPD)	EXST 2009 ACTUAL OR ESTIMATE (GPD)	2006 5-YR (GPD)	2009 5-YR (GPD)	2006 10-YR (GPD)	2009 10-YR (GPD)	2006 15-YR (GPD)	2009 15-YR (GPD)	2006 BUILDOUT-20-YR (GPD)	2009 BUILDOUT-20-YR (GPD)
SUMMARY OF DEMANDS:											
	POTABLE WATER DEMAND	1,050,100	857,500	2159050	2,045,810	2,920,550	2,700,038	3,267,150	3,135,564	3,617,900	3,496,879
1.0	LANA`I CITY RESIDENTIAL (WELLS 3, 6 & 8)	353,400	322,200	557,700	509,700	879,100	789,700	977,100	883,500	1,157,100	1,064,700
2.0	LANA`I CITY NON-RESIDENTAIL + CAVENDISH (WELLS 3, 6 & 8)	130,100	75,200	187,750	111,510	229,750	140,838	251,750	178,964	273,950	228,529
3.0	IRRIGATION GRID (WELLS 2 & 4)	30,500	10,900	518,000	574,000	535,000	637,000	542,000	639,000	550,000	642,000
4.0	KOELE PD: POTABLE (WELLS 3, 6 & 8)	144,000	136,700	311,200	320,200	486,600	510,400	524,600	552,400	566,400	593,200
6.0	MANELE PD: POTABLE (WELLS 2 &4)	392,100	312,500	584,400	530,400	790,100	622,100	971,700	881,700	1,070,450	968,450
	NON-POTABLE WATER DEMAND										
7	MANELE PD: NON-POTABLE WATER (WELLS 1, 9 &14)	672,600	808,600	846,900	981,900	883,000	1,125,000	1,064,500	1,285,000	1,190,000	1,572,500
SUMMARY OF SOURCE REQUIREMENTS											
	LOSSES	10.90%	11.00%	12.0%	12.00%	12.0%	12.00%	12.0%	12.00%	12.0%	12.00%
	POTABLE HIGH LEVEL GROUNDWATER	1,179,000	963,000	2,453,000	2,325,000	3,319,000	3,068,000	3,313,000	3,263,000	3,411,000	3,374,000
	NON-POTABLE HIGH LEVEL GROUNDWATER	755,000	830,800	962,000	760,939	753,000	672,706	810,000	680,360	752,000	834,153
	**ALTERNATE WATER SOURCE FOR NON-POTABLE USE	0		0		250,000		400,000		600,000	
	**ALTERNATE WATER SOURCE FOR POTABLE USE	0		0		0		400,000		700,000	
	ALTERNATE WATER SOURCE*	0	78,200	0	355,061	250,000	605,294	800,000	1,079,640	1,300,000	1,552,847
	TOTAL GROUNDWATER PUMPED (EXCLUDE ALT. WATER AND WW)	1,934,000	1,793,800	3,415,000	3,085,939	4,072,000	3,740,706	4,123,000	3,943,360	4,163,000	4,208,153
SUMMARY OF WASTERWATER (SOURCE)											
5.0	KOELE PD/LANA`I CITY: WASTEWATER	199,000	222,200	218,000	392,261	238,000	625,794	247,000	706,015	256,000	832,910
8.0	MANELE PD: WASTEWATER	80,800	78,200	165,000	184,800	237,000	217,500	273,000	320,625	360,000	375,938
SUMMARY OF TOTAL WATER SUPPLY/DEMAND (POTABLE, NON-POTABLE, ALTER. WATER, RECLAIMED)		2,213,800	2,172,400	3,798,000	4,018,061	4,797,000	5,189,294	5,443,000	6,049,640	6,079,000	6,969,848

POT	POTABLE HIGH LEVEL GROUNDWATER
NPHLGW	NON-POTABLE HIGH LEVEL GROUNDWATER (WELLS #1, 9,14)
ALT	ALTERNATE SOURCE (BASAL WELLS, DESAL, RUNOFF, WWINCREASE)
WW	WASTEWATER

FIGURE 4-70. Facilities Comparison of 2006 and 2009 Proposals - Unit Counts or Acres

	USAGE CATEGORY	2006 EXST.	2009 EXST.	2006 5-YR	2009 5-YR	2006 10-YR	2009 10-YR	2006 15-YR	2009 15-YR	2006 BUILD-OUT (20-YR)	2009 BUILD-OUT (20-YR)	2006 UNITS	2009 UNITS
1.0	**Lana`i CITY RESIDENTIAL (Wells 3, 6 & 8)**												
1.1	Lana`i City Residential - Existing	1,062	1,062	1,062	1,062	1,062	1,062	1,062	1,062	1,062	1,062	gpd/unit	gpd/unit
1.2	Lana`i City	0	0	100	100	**493**	450	**534**	500	**712**	700	gpd/unit	gpd/unit
1.3	Country Lana`i City Recreation Area	8	8	8	8	8	8	8	8	8	8	gpd/acre	gpd/unit
1.4	Affordable Housing Property (Future)	0	0	**100**	50	**146**	100	**220**	150	**292**	240	gpd/unit	gpd/unit
1.5	DHHL Property	0	0	**75**	45	**150**	90	**187**	135	**225**	135	gpd/unit	gpd/unit
1.7	Kaumulapau Subdivision	0	0	15	15	30	30	38	38	45	45	gpd/unit	gpd/unit
2.0	**Lana`i CITY NON-RESIDENTIAL + CAVENDISH (Wells 3,6 & 8)**												
1.6	Kaumulapau Harbor	0	**3,300**	1,000	1,000	5,000	5,000	7,000	7,000	10,000	10,000	LS gpd	LS gpd
2.1	Lana`i City Govt/Comm & Inst/ LtInd/ Airport/Lana`i WWTP/Lana`i.	**130,100**	75,200	**174000**	97,760	**216,000**	127,088	**238,000**	165,214	**260,200**	214,779	LS gpd	LS gpd
2.2	Lana`i City School Expansion		0	10	10	10	10	10	10	10	10	gpd/acre	gpd/unit
*2.3	Future Commercial & BCT		0		5,000		5,000		5,000		5,000		LS gpd
3.0	**IRRIGATION GRID (Wells 2 & 4)**												
3.1	Agriculture Reserve	**30,500**	0	500000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	LS gpd	LS gpd
3.2	Other Ag or Commercial Uses	0	**10,900**	7000	**13,000**	14,000	**15,000**	17,000	17,000	20,000	20,000	LS gpd	LS gpd
**3.3	Additional Baseyard(2006) /Miki Basin Heavy Industrial(2009)	0	0	1000	10	**2,000**	20	2,000	20	2,000	20	LS gpd	gpd/acre
***3.4	New Warehouse	0		1000		1,000		1,000		1,000		LS gpd	
(3.4 in	Future Use	0	0	9000	**1,000**	**18,000**	2,000	**22,000**	2,000	**27,000**	2,000	LS gpd	LS gpd
4.0	**KOELE PD: POTABLE (Wells 3, 6 & 8)**												
4.1	Koele PD Redevelopment Portion	0	0	120	120	145	145	157	157	170	170	gpd/unit	gpd/unit
4.2	Koele PD-Hotel	102	102	102	102	102	102	102	102	102	102	gpd/unit	gpd/room
4.3	Koele PD-Hotel(Future)	0	0	0	0	148	148	148	148	148	148	gpd/unit	gpd/room
4.4	Koele PD-Hotel Irrigatiopn	20	**21**	20	**21**	20	**21**	20	**21**	20	**21**	gpd/acre	gpd/acre
4.5	Koele PD-Commercial (Tennis & Stables)	1	**1,400**	6000	6,000	9,000	9,000	**11,000**	9,000	**12,000**	9,000	LS gpd	LS gpd
4.6	Koele Single Family	14	**18**	52	52	152	152	200	200	255	255	gpd/unit	gpd/unit
4.7	Koele Multi-Family	27	27	51	51	90	90	90	**100**	90	**100**	gpd/unit	gpd/unit
4.8	Koele Common Areas Irrigation	10	10	10	10	10	10	10	10	10	10	gpd/acre	gpd/acre
4.9	Koele Parks (Future)	12	12	12	12	12	12	12	12	12	12	gpd/acre	gpd/acre
4.10	Cavendish Golf Course & Maintenance	**16,000**	13,800	20000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	LS gpd	LS gpd
5.0	**KOELE PD/Lana`i CITY: WASTEWATER**												
5.1	Koele Golf Course Irrigation Effluent	199,000	**222,200**	218000	**222,200**	238,000	238,000	247,000	247,000	256,000	256,000	LS gpd	LS gpd

Build-Out Analysis

FIGURE 4-70. Facilities Comparison of 2006 and 2009 Proposals - Unit Counts or Acres - Continued

Comparison of 2006 and 2009 DRAFTS

USAGE CATEGORY		FACILITY PROJECTIONS - UNIT OR ACRE COUNTS										FLOW			
		2006 EXST.	2009 EXST.	2006 5-YR	2009 5-YR	2006 10-YR	2009 10-YR	2006 15-YR	2009 15-YR	2006 BUILD-OUT (20-YR)	2009 BUILD-OUT (20-YR)	2006 UNITS	2009 UNITS	2006 QUAN	2009 QUAN
6.0	**MANELE PD: POTABLE (Wells 2 & 4)**														
6.1	Manele Hotel	250	250	250	250	250	250	250	250	250	250	gpd/roon	gpd/room	600	600
6.2	Manele Hotel Irrigation	17	17	17	17	17	17	29	29	29	29	gpd/acre	gpd/acre	8,000	8,000
6.3	Manele Hotel (Future)	0	0	0	0	150	0	150	150	150	150	gpd/roon	gpd/room	600	600
6.4	Manele Single Family Homes	0	**17**	63	63	100	100	150	150	200	200	gpd/unit	gpd/unit	600	600
6.5	Manele Multi-Family	51	**69**	112	112	150	150	175	175	300	300	gpd/unit	gpd/acre	300	300
6.6	Manele Commercial	**5**	0	5	5	7	7	9	9	10	10	gpd/acre	gpd/acre	5,000	5,000
6.7	Manele Utilities (WWTP & Lift Stations)	**12,900**	7,000	40000	40,000	66,000	66,000	79,000	79,000	92,000	92,000	LS gpd	LS gpd	1	1
6.8	Manele Construction/Development	29,900	**30,000**	31000	31,000	31,000	31,000	31,000	31,000	31,000	31,000	LS gpd	LS gpd	1	1
6.9	Manele Parks (Domestic use and Irrigation)	-	**2**	20	20	33	33	66	66	66	66	gpd/acre	gpd/acre	1,700	1,700
**6.10	Manele Public Use	28,200		54000		78,000		90,000		102,000		LS gpd		1	
7.0	**MANELE PD: NON-POTABLE WATER (Wells 1, 9 & 14)**														
7.1	Manele Single Family-Irrigation	8	**17**	75	**63**	100	100	**175**	150	200	200	gpd/unit	gpd/unit	2,500	2,500
7.2	Manele Multi-Family-Irrigation	51	**69**	112	112	150	150	175	175	300	300	gpd/unit	gpd/unit	1,200	1,200
7.3	Manele Common Areas Irrigation	16	16	16	16	16	**18**	16	**20**	16	**25**	gpd/acre	gpd/acre	2,500	2,500
7.4	Manele Golf Course Irrigation	Actual Current	603,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	650,000	gpd	gpd	1	1
8.0	**MANELE PD: WASTEWATER**														
8.1	Manele Golf Course Irrigation Effluent	Actual Current	78,200		184,800		217,500		320,625		375,938	gpd	gpd	1	1

FIGURE 4-71. Comparison of 2006 and 2009 Castle & Cooke Proposals - Demand

Comparison of 2006 and 2009 DRAFTS		DEMAND PROJECTIONS									
USAGE CATEGORY		EXST 2006 ACTUAL OR ESTIMATE (GPD)	EXST 2009 ACTUAL OR ESTIMATE (GPD)	2006 5-YR (GPD)	2009 5-YR (GPD)	2006 10-YR (GPD)	2009 10-YR (GPD)	2006 15-YR (GPD)	2009 15-YR (GPD)	2006 BUILDOUT-20-YR (GPD)	2009 BUILDOUT-20-YR (GPD)
1.0	**Lana`i CITY RESIDENTIAL (Wells 3, 6 & 8)**	**353,400**	322,200	**557,700**	509,700	**879,100**	789,700	**977,100**	883,500	**1,157,100**	1,064,700
1.1	Lana`i City Residential - Existing	**343,500**	309,000	371,700	371,700	371,700	371,700	371,700	371,700	371,700	371,700
1.2	Lana`i City		0	60,000	60,000	**295,800**	270,000	**320,400**	300,000	**427,200**	420,000
1.3	Country Lana`i City Recreation Area	9,900	9,900	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000
1.4	Affordable Housing Property (Future)	0	0	**60,000**	30,000	**87,600**	60,000	**132,000**	90,000	**175,200**	144,000
1.5	DHHL Property	0	0	**45,000**	27,000	**90,000**	54,000	**112,200**	81,000	**135,000**	81,000
1.7	Kaumulapau Subdivision	0	0	9,000	9,000	18,000	18,000	22,800	22,800	27,000	27,000
2.0	**Lana`i CITY NON-RESIDENTIAL + CAVENDISH (Wells 3,6 & 8)**	**130,100**	75,200	**187,750**	111,510	229,750	**1,408,383**	**251750**	178,964	**273,950**	228,529
1.6	Kaumulapau Harbor		**3,300**	1,000	1,000	5,000	5,000	7,000	7,000	10,000	10,000
2.1	Lana`i City Govt/Comm & Inst/ Ltlnd/ Airport/Lana`i WWTP/Lana`i...	**130,100**	75,200	**174,000**	97,760	**216,000**	127,088	**238000**	165,214	**260,200**	214,779
2.2	Lana`i City School Expansion		0	13,750	13,750	13,750	13,750	13750	13,750	13,750	13,750
*2.3	Future Commercial & BCT				5,000		5,000		5,000		5,000
3.0	**IRRIGATION GRID (Wells 2 & 4)**	**30,500**	10,900	518,000	**574,000**	535,000	**637,000**	542,000	**639,000**	550000	**642,000**
3.1	Agriculture Reserve	**30,500**	0	500,000	500,000	500,000	500,000	500,000	500,000	500000	500,000
3.2	Other Ag or Commercial Uses	0	**10,900**	7,000	**13,000**	14,000	**15,000**	17,000	17,000	20000	20,000
**3.3	Additional Baseyard(2006) /Miki Basin Heavy Industrial(2009)	0	0	1,000	60,000	2,000	120,000	2,000	120,000	2000	120,000
***3.4	New Warehouse	0		1,000		1,000		1,000		1000	
3.5 (3.4 in 2009)	Future Use	0	0	9,000	**1,000**	**18,000**	2,000	**22,000**	2,000	**27000**	2,000
4.0	**KOELE PD: POTABLE (Wells 3, 6 & 8)**	**144,000**	136,700	311,200	**320,200**	486,600	**510,400**	524,600	**552,400**	566400	**593,200**
4.1	Koele PD Redevelopment Portion	0	0	72,000	72,000	87,000	87,000	84,200	94,200	102000	102,000
4.2	Koele PD-Hotel	**36,600**	30,000	51,000	**61,200**	51,000	**61,200**	51,000	**61,200**	51000	**61,200**
4.3	Koele PD-Hotel(Future)	0	0	0	0	74,000	**88,800**	74,000	**88,800**	74000	**88,800**
4.4	Koele PD-Hotel Irrigatiopn	**58,500**	51,000	**60,000**	58,800	**60,000**	58,800	**60,000**	58,800	**60000**	58,800
4.5	Koele PD-Commercial (Tennis & Stables)	**2,700**	1,400	6,000	6,000	9,000	9,000	**11,000**	9,000	**12000**	9,000
4.6	Koele Single Family	12,300	**15,500**	31,200	31,200	91,200	91,200	120,000	120,000	153000	153,000
4.7	Koele Multi-Family	13,500	**20,600**	30,600	30,600	54,000	54,000	54,000	**60,000**	54000	**60,000**
4.8	Koele Common Areas Irrigation	4,400	4,400	20,000	20,000	20,000	20,000	20,000	20,000	20000	20,000
4.9	Koele Parks (Future)	0	0	20,400	20,400	20,400	20,400	20,400	20,400	20400	20,400
4.10	Cavendish Golf Course & Maintenance	**16,000**	13,800	20,000	20,000	20,000	20,000	20,000	20,000	20000	20,000
5.0	**KOELE PD/Lana`i CITY: WASTEWATER**	199,000	**222,200**	218,000	**392,261**	238,000	**625,794**	247,000	**706,015**	256000	**832,910**
5.1	Koele Golf Course Irrigation Effluent	199,000	**222,200**	218,000	**392,261**	238,000	**625,794**	247,000	**706,015**	256000	**832,910**

FIGURE 4-71. Comparison of 2006 and 2009 Castle & Cooke Proposals - Demand - Continued

Comparison of 2006 and 2009 DRAFTS		DEMAND PROJECTIONS									
USAGE CATEGORY		EXST 2006 ACTUAL OR ESTIMATE (GPD)	EXST 2009 ACTUAL OR ESTIMATE (GPD)	2006 5-YR (GPD)	2009 5-YR (GPD)	2006 10-YR (GPD)	2009 10-YR (GPD)	2006 15-YR (GPD)	2009 15-YR (GPD)	2006 BUILDOUT-20-YR (GPD)	2009 BUILDOUT-20-YR (GPD)
6.0	**MANELE PD: POTABLE (Wells 2 & 4)**	**392,100**	312,500	**584,400**	530,400	**790,100**	622,100	**971,700**	881,700	**1,070,450**	968,450
6.1	Manele Hotel	**88,000**	63,500	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
6.2	Manele Hotel Irrigation	**179,000**	165,600	179,000	179,000	179,000	179,000	232,000	232,000	232,000	232,000
6.3	Manele Hotel (Future)	0	0	0	0	**90,000**	0	90,000	90,000	90,000	90,000
6.4	Manele Single Family Homes	0	**15,300**	37,800	37,800	60,000	60,000	90,000	90,000	120,000	120,000
6.5	Manele Multi-Family	**12,800**	9,800	33,600	33,600	45,000	45,000	52,500	52,500	90,000	90,000
6.6	Manele Commercial	**17,300**	0	25,000	25,000	35,000	35,000	45,000	45,000	51,250	51,250
6.7	Manele Utilities (WWTP & Lift Stations)	**12,900**	7,000	40,000	40,000	66,000	66,000	79,000	79,000	92,000	92,000
6.8	Manele Construction/Development	29,900	**30,000**	31,000	31,000	31,000	31,000	31,000	31,000	31,000	31,000
6.9	Manele Parks (Domestic use and Irrigation)	**23,000**	21,300	34,000	34,000	56,100	56,100	112,200	112,000	112,200	112,000
***6.10	Manele Public Use	29,200		54,000		78,000		80,000		102,000	
7.0	**MANELE PD: NON-POTABLE WATER (Wells 1, 9 & 14)**	672,600	**808,600**	846,900	**981,900**	883,000	**1,125,000**	1,064,500	**1,285,000**	1,190,000	**1,572,500**
7.1	Manele Single Family-Irrigation	**37,000**	33,700	**187,500**	157,500	250,000	250,000	**437,500**	375,000	500,000	500,000
7.2	Manele Multi-Family-Irrigation	86,100	**87,200**	134,400	134,400	180,000	180,000	210,000	210,000	360,000	360,000
7.3	Manele Common Areas Irrigation	40,400	**84,700**	40,000	40,000	40,000	**45,000**	40,000	**50,000**	40,000	**62,500**
7.4	Manele Golf Course Irrigation	509,100	**603,000**	485,000	**650,000**	413,000	**650,000**	377,000	**650,000**	290,000	**650,000**
8.0	**MANELE PD: WASTEWATER**	**80,800**	78,200	165,000	**184,800**	**237,000**	217,500	273,000	**320,625**	360,000	**375,938**
8.1	Manele Golf Course Irrigation Effluent	**80,800**	78,200	165,000	**184,800**	**237,000**	217,500	273,000	**320,625**	360,000	**375,938**
	Subtotal Pumped Fresh	1,050,100	857,500	2,159,050	2,045,810	2,920,550	3,967,583	3,267,150	3,135,564	3,617,900	3,496,879
	Subtotal Pumped Brackish	672,600	808,600	846,900	981,900	883,000	1,125,000	1,064,500	1,285,000	1,190,000	1,572,500
	Pumped Subtotal	**1,722,700**	**1,666,100**	**3,005,950**	**3,027,710**	**3,803,550**	**5,092,583**	**4,331,650**	**4,420,564**	**4,807,900**	**5,069,379**
	PUMPED SUBTOTAL plus Anticipated Unaccounted-For Water - 12%	1,957,614	1,893,295	3,415,852	3,440,580	4,322,216	5,787,026	4,922,330	5,023,368	5,463,523	5,760,658
	RECLAIMED	**279,800**	**300,400**	**383,000**	**577,061**	**475,000**	**843,294**	**520,000**	**1,026,640**	**616,000**	**1,208,848**
	TOTAL pumped and reclaimed, but without losses	**2,002,500**	**1,966,500**	**3,388,950**	**3,604,771**	**4,278,550**	**5,935,877**	**4,851,650**	**5,447,204**	**5,423,900**	**6,278,227**
	Less Unidentified "Alternative" Sources per Proposals					4,072,216	5,181,732	4,122,330	3,943,728	4,163,523	4,207,811
	TOTAL plus Anticipated Unaccounted-For Water - 12% *(Losses are NOT counted twice)*	2,237,414	2,193,695	3,798,852	4,017,641	4,797,216	6,630,320	5,442,330	6,050,008	6,079,523	6,969,506

Compiled Analysis

Several sources of data pertaining to 20 year build-outs on Lana‘i have been reviewed and presented in preceding pages of this chapter. These include the Project Districts according to standards, other known proposed projects submitted to the Department of Water Supply for review, and company proposals. Analyses presented include forecasted trends, build-out per standards, build-outs per CCR proposed standards, and predictive analysis using hybrids of standards, proposals and forecasted trends, for both drinking water and wastewater. The results of these analyses are compiled and compared in Figures 4-69 to 4-71.

Comparison of Build-out Proposals with Build-out Plus Existing Partial Entitlements

Neither the 2006 nor the 2009 proposal from Castle & Cooke Resorts, LLC (CCR) included full build-out of the Project Districts at the maximum densities permitted. Conversely, some items not included in the Project District zoning ordinances were included in the proposals. In order to look at the whole picture, an additional analysis, dubbed the “build-out plus” scenario, was compiled. This “build-out plus” scenario included the sum of the 2006 proposal plus existing partial entitlements not included in CCR proposals. Figure 4-72 shows the “build-out plus” scenario compiled side by side with the 2006 and 2009 proposals. Total demands in the “build-out plus” scenario, 2006 proposal and 2009 proposal were 7.13 MGD, 6.08 MGD, and 6.97 MGD, respectively.

Comparison of Forecasts with Build-out Plus Existing Entitlements

Figure 4-72 compares time trend regressions and econometric forecasts, with the proposal “build-out plus” scenario. The majority of the trends converge between 3 and 4 MGD.

Build-out of Phase II Entitlements Only

Portions of the Project Districts have Phase II entitlements. An attempt was made to delineate these, in order to evaluate build-out of existing Phase II entitlements. It appears that build-out of existing Phase II entitlements, plus other known projects would represent about 5.59 MGD in total demand (4.99 without resource reserve) , of which about 3.58 MGD would have to be pumped. With 255 SF units at Koele and 161 at Manele having Phase II approvals, while less than 20 have been built in either Project District, restricting development to build-out of existing Phase II approvals plus other known projects outside the Project Districts should not create hardship.

Differences Between Proposals and Project District Entitlements

Differences between build-out of proposals and project district entitlements are delineated in Figure 4-77. The 2006 proposal for Koele includes 90 Multi-Family units, 425 Single-Family units and 250 Hotel units, while the PD allows for 156 Multi-Family, 535 Single-Family and 253 Hotel units. In Manele, the proposal calls for 200 Single-Family units, 300 Multi-Family, 400 Hotel units, and 10 acres of Commercial area, while the PD allows for 282 Single-Family units, 184 Multi-Family units, 500 Hotel units, and 5.25 acres of commercial. These differences reflect evolving company plans. Never the less, for the purpose of build-out analysis, it seemed advisable to examine the combined build-out of the proposals plus existing Project District entitlements.

A Note on System Losses In The Analysis

It should be noted that the build-out analysis included a standard 12% system loss island-wide. Actual average unaccounted-for water island-wide is about 28%. Projections and revised analysis were run with 12% assumed losses in the areas served by Wells 6 & 8 (Koele, Lana'i City, Kaumalapau), but 15% in the Palawai Irrigation Grid and Manele-Hulopo'e.

Offset of Demand with Reclaimed Water Use

Build-out of the proposed projects with current system losses could cause total demand to exceed sustainable yields. However, CCR proposes to offset pumped water use, such that both of its proposals remain under 4.3 MGD of pumped water. This is accomplished partially with reclaimed water. The 2006 proposal recommends 0.616 MGD of reclaimed water use. The 2009 proposal suggests 1.2 MGD of reclaimed water use. Analysis of reclaimed water availability suggests a range between 400,000 GPD and 700,000 GPD, depending upon the progress of build-out.

Offset of Demand with Alternate Sources of Water

The 2006 proposal recommends 1.3 MGD of alternate water use. The 2009 proposal recommends 1.55 MGD of alternate water use. These amounts are recommended above and beyond the reclaimed water use shown in the proposals. Neither plan identifies the source of the "alternate" water included. A large desalinization facility seems unrealistic within the planning period, based on costs and forecast trends.

Opportunities Identified By Demand Analysis

Notably missing from either proposal is conservation. Based upon analysis of unaccounted-for water and of landscape use, there appears to be great potential for conservation savings, which could contribute a portion of the water needed from "alternate" sources. Based upon analysis of the billing data, certain conservation opportunities have been identified for evaluation and inclusion in the source plan in Chapter 5 and the allocation discussion in Chapter 7. These are:

- Replacement of leaking pipe in the Palawai Irrigation Grid
- Landscape Conservation
- Fixture and appliance replacement program
- Cover on the 15 MG Reservoir to reduce evaporative losses
- Annual audit and leak detection
- Hotel incentives program
- Rate structure tiered to encourage conservation

FIGURE 4-72. Compiled Analysis

	`	Build-Out Plus Estimate By Standards Review	Built-Out Already	Remaining	EXST 2006 ACTUAL OR ESTIMATE (GPD)	EXST 2009 ACTUAL OR ESTIMATE (GPD)	2006 BUILD-OUT TO 2030 20-YR (GPD)	2009 BUILDOUT TO 2030 20-YR (GPD)	2006 REMAINING	2009 REMAINING
1.0	**LANA`I CITY RESIDENTIAL (Wells 3, 6 & 8)**	**923,787**	**507,316**	**416,471**	**353,400**	**318,900**	**1,157,100**	**1,064,700**	**366,500**	**315,800**
1.1	Lana`i City Residential - Existing	362,862	268,127	94,735	343,500	309,000	371,700	371,700	28,200	62,700
1.2	Lana`i City Residential -New/Future	~	~	~		0	427,200	420,000	427,200	420,000
1.3	Country Lana`i City Recreation Area	13,600	9,900	3,700	9,900	9,900	11,000	11,000	1,100	1,100
1.4	Affordable Housing Property (Future)	257,025	0	219,000	0	0	175,200	144,000	175,200	144,000
1.5	DHHL Property	125,900	27,000	98,900	0	0	135,000	81,000	135,000	81,000
1.7	Kaumulapau Subdivision	27,000	~	45,000	0	0	27,000	27,000	27,000	27,000
	Lana'I City Re-Development Project	137,400	0	137,400					0	0
2.0	**LANA`I CITY NON-RESIDENTIAL + CAVENDISH (Wells 3,6 & 8)**	**163,334**	**87,472**	**47,905**	**130,100**	**75,200**	**273,950**	**228,529**	**143,850**	**153,329**
1.6	Kaumulapau Harbor	21,117	14,058	7,059		3,300	10,000	10,000	10,000	6,700
2.1	Lana`i City Govt/Comm & Inst/ Ltlnd/ Airport/Lana`i WWTP/Lana`i...	110,198	81,428	28,770	130,100	75,200	260,200	214,779	130,100	139,579
	Lana`i City Agriculture	8,179	6,044	2,135						
2.2	Lana`i City School Expansion	17,000	0	17,000		0	13,750	13,750	13,750	13,750
*2.3	Future Commercial & BCT	incl in 2.1	~	~				5,000	0	5,000
	Airport Improvements	6,840	0	6,840					0	0
3.0	**IRRIGATION GRID (Wells 2 & 4)**	**658,953**	**28,044**	**630,909**	**30,500**	**10,900**	**550000**	**642,000**	**519,500**	**631,100**
3.1	Agriculture	37,953	28,044	9,909	30,500	0	500000	500,000	469,500	500,000
	Agricultural Reserve	500,000		500,000						
3.2	Other Ag or Commercial Uses (included in forecasts above)				0	10,900	20000	20,000	20,000	9,100
**3.3	Additional Baseyard(2006) /Miki Basin Heavy Industrial(2009)	120,000	0	120,000	0	0	2000	120,000	2,000	120,000
***3.4	New Warehouse	1,000	0	1,000	0		1000		1,000	0
3.5	Future Use (included in forecasts above)	~	~	~	0	0	27000	2,000	27,000	2,000
									0	0
4.0	**KOELE PD: POTABLE (Wells 3, 6 & 8)**	**771,960**	**227,386**	**708,882**	**144,000**	**136,700**	**566400**	**593,200**	**422,400**	**456,500**
4.1	Koele PD Redevelopment Portion	102,000	0	102,000	0	0	102000	102,000	102,000	102,000
4.2	Koele PD-Hotel	35,700	35,700	0	36,600	30,000	51000	61,200	14,400	31,200
4.3	Koele PD-Hotel(Future)	52,850	0	52,850	0	0	74000	88,800	74,000	88,800
4.4	Koele PD-Hotel Irrigation	105,500	100,000	161,236	58,500	51,000	60000	58,800	1,500	7,800
4.5	Koele PD-Commercial (Tennis & Stables)	incl. in 4.2	~	~	2,700	1,400	12000	9,000	9,300	7,600
4.6	Koele Single Family	219,000	7,800	211,200	12,300	15,500	153000	153,000	140,700	137,500
4.7	Koele Multi-Family	87,360	19,600	67,760	13,500	20,600	54000	60,000	40,500	39,400
4.8	Koele Common Areas Irrigation	130,000	50,000	80,000	4,400	4,400	20000	20,000	15,600	15,600
4.9	Koele Parks (Future)	19,550	0	19,550	0	0	20400	20,400	20,400	20,400
4.10	Cavendish Golf Course & Maintenance	20,000	14,286	14,286	16,000	13,800	20000	20,000	4,000	6,200
									0	0
5.0	**KOELE PD / LANA`I CITY: WASTEWATER**	**303,749**	**224,447**	**79,302**	**199,000**	**222,200**	**256000**	**832,910**	**57,000**	**610,710**
5.1	Koele Golf Course Irrigation Effluent	303,749	224,447	79,302	199,000	222,200	256000	832,910	57,000	610,710

FIGURE 4-72. Compiled Analysis Continued

	USAGE CATEGORY	BUILD-OUT Estimate By Standards Review	Built-Out Already = EXST	Remaining	EXST 2006 ACTUAL OR ESTIMATE (GPD)	EXST 2009 ACTUAL OR ESTIMATE (GPD)	2006 BUILD-OUT TO 2030 20-YR (GPD)	2009 BUILDOUT TO 2030 20-YR (GPD)	2006 REMAINING	2009 REMAINING
6.0	**MANELE PD: POTABLE (Wells 2 & 4)**	**1,711,268**	**646,628**	**1,064,640**	**392,100**	**312,500**	**1,070,450**	**968,250**	**678,350**	**655,750**
6.1	Manele Hotel	87,500	87,500	0	**88,000**	63,500	150,000	150,000	62,000	86,500
					179,000					
6.2	Manele Hotel Irrigation	962,200	393,600	568,600		165,600	232,000	232,000	53,000	66,400
6.3	Manele Hotel (Future)	87,500	0	87,500	0	0	90,000	90,000	90,000	90,000
6.4	Manele Single Family Homes	169,200	9,600	159,600	0	**15,300**	120,000	120,000	120,000	104,700
6.5	Manele Multi-Family	103,040	38,640	64,400	**12,800**	9,800	90,000	90,000	77,200	80,200
6.6	Manele Co	31,500	21,179	10,321	**17,300**	0	51,250	51,250	33,950	51,250
6.7	Manele Utilities (WWTP & Lift Stations)	10,724	6,812	3,912	**12,900**	7,000	92,000	92,000	79,100	85,000
6.8	Manele Construction/Development	31,000	29,900	1,100	29,900	**30,000**	31,000	31,000	1,100	1,000
6.9	Manele Parks (Domestic use and Irrigation)	112,761	19,968	92,793	**23,000**	21,300	112,200	112,000	89,200	90,700
***6.10	Manele Public Use (per CCR. technically should be considered included)	102,000	29,200	72,800	29,200		102,000		72,800	0
	Manele Area Agricultural Use (uses forecast, no addt'l ag specifically planned)	13,843	10,229	3,614						
7.0	**MANELE PD: NON-POTABLE WATER (Wells 1, 9 & 14)**	**1,690,000**	**797,793**	**1,068,467**	**672,600**	**808,600**	**1,190,000**	**1,572,500**	**517,400**	**763,900**
7.1	Manele Single Family-Irrigation	600,000	4,800	771,460	**37,000**	33,700	500,000	500,000	463,000	466,300
7.2	Manele Multi-Family-Irrigation ! Based on 300 units. Only 184 apprvd. In PD.	360,000	107,475	252,525	86,100	**87,200**	360,000	360,000	273,900	272,800
7.3	Manele Common Areas Irrigation	80,000	80,000	0	40,400	**84,700**	40,000	**62,500**	-400	-22,200
7.4	Manele Golf Course Irrigation	650,000	605,518	44,482	509,100	**603,000**	290,000	**650,000**	-219,100	47,000
									0	0
8.0	**MANELE PD: WASTEWATER**	**98,711**	**72,940**	**25,771**	**80,800**	**78,200**	**360,000**	**375,938**	**279,200**	**297,738**
8.1	Manele Golf Course Irrigation Effluent	98,711	72,940	25,771	**80,800**	78,200	360,000	**375,938**	279,200	297,738
	RESOURCE RESERVE (600 Kgal recommended but not shown here.)									
	TOTAL	6,321,762	2,592,026	4,042,347	2,002,500	1,963,200	5,423,900	6,278,027	2,984,200	3,884,827
	without wastewater included	5,919,302	2,298,334	4,004,428	1,722,700	1,662,800	4,807,900	5,069,379	2,648,000	2,976,379
	Subtotal Pumped Fresh	4,229,302	1,496,846	2,368,807	1,050,100	854,200	3,617,900	3,496,679	2,130,600	2,212,479
	Subtotal Fresh Pumped Water With Losses	4,806,025	1,679,962	2,658,594	1,178,563	958,698	4,111,250	3,973,499	2,391,246	2,483,141
	Subtotal Pumped Brackish	1,690,000	797,793	1,068,467	672,600	808,600	1,190,000	1,572,500	517,400	763,900
	Subtotal Brackish Pumped Water w/Losses (CCR 10.9% 1st yr., calcs on lef	1,920,455	895,391	1,199,177	754,882	907,520	1,352,273	1,786,932	587,955	868,068
	PUMPED SUBTOTAL	5,919,302	2,294,639	3,437,274	1,722,700	1,662,800	4,807,900	5,069,179	2,648,000	2,976,379
	PUMPED SUBTOTAL with 12% Unaccounted-For Water	**6,726,480**	**2,575,352**	**3,857,771**	**1,933,446**	**1,866,218**	**5,463,523**	**5,760,431**	**2,979,200**	**3,351,210**
	Reclaimed	402,460	297,387	105,073	279,800	300,400	616,000	1,208,848	336,200	908,448
	Alternate Reclaimed Scenario - (not used in totals on this table)	1,151,359	307,033	844,326						
TOTAL	PUMPED AND RECLAIMED w/losses - (No Unidentified Source On This Sprea	7,128,940	2,872,739	3,962,844	2,213,246	2,166,618	6,079,523	6,969,279	3,315,400	4,259,658

Demand Analysis

FIGURE 4-73. Forecasts Compared to Build-ouit

Well service areas - metered consumption - run seperately and combined

12% uafw added to service areas of wells 6 & 8. 15% uafw added to service areas of 2&4 and 1,9 & 14.

	Low Case			Base Case			High Case			Build
	Demand	Demand	Demand	Demand	Demand	Demand	Demand	Demand	Demand	Out
Year	Elas.=1	Elas.=1.5	Elas.=2	Elas.=1	Elas.=1.5	Elas.=2	Elas.=1	Elas.=1.5	Elas.=2	Analysis
2008	1,929,911	1,929,911	1,929,911	1,929,911	1,929,911	1,929,911	1,929,911	1,929,911	1,929,911	2,241,222
2009	1,954,850	1,967,440	1,980,111	1,960,067	1,975,321	1,990,694	1,972,499	1,994,145	2,016,027	2,297,769
2010	1,979,789	2,005,209	2,030,956	1,990,223	2,021,082	2,052,420	2,015,088	2,059,075	2,104,023	2,350,116
2011	2,010,216	2,051,613	2,093,863	2,023,427	2,071,871	2,121,474	2,065,612	2,137,000	2,210,855	2,639,032
2012	2,040,643	2,098,370	2,157,730	2,056,631	2,123,077	2,191,671	2,116,137	2,215,883	2,320,332	2,927,949
2013	2,071,071	2,145,477	2,222,555	2,089,835	2,174,699	2,263,010	2,166,661	2,295,714	2,432,454	3,216,865
2014	2,101,498	2,192,930	2,288,341	2,123,038	2,226,733	2,335,492	2,217,186	2,376,482	2,547,222	3,505,782
2015	2,131,925	2,240,729	2,355,086	2,156,242	2,279,175	2,409,116	2,267,710	2,458,174	2,664,636	3,794,698
2016	2,157,429	2,281,057	2,411,770	2,184,153	2,323,570	2,471,887	2,316,663	2,538,199	2,780,920	3,923,298
2017	2,182,933	2,321,625	2,469,128	2,212,063	2,368,250	2,535,466	2,365,616	2,619,074	2,899,688	4,051,898
2018	2,208,437	2,362,430	2,527,161	2,239,973	2,413,213	2,599,851	2,414,569	2,700,790	3,020,939	4,180,499
2019	2,233,941	2,403,472	2,585,867	2,267,884	2,458,457	2,665,044	2,463,522	2,783,339	3,144,674	4,309,099
2020	2,259,445	2,444,748	2,645,248	2,295,794	2,503,980	2,731,044	2,512,475	2,866,712	3,270,893	4,437,699
2021	2,288,500	2,492,056	2,713,718	2,326,672	2,554,666	2,805,002	2,569,050	2,964,082	3,419,856	4,616,509
2022	2,317,556	2,539,666	2,783,063	2,357,550	2,605,690	2,879,948	2,625,625	3,062,530	3,572,137	4,795,319
2023	2,346,611	2,587,575	2,853,283	2,388,428	2,657,049	2,955,882	2,682,200	3,162,045	3,727,735	4,974,130
2024	2,375,666	2,635,782	2,924,378	2,419,306	2,708,742	3,032,804	2,738,775	3,262,615	3,886,649	5,152,940
2025	2,404,721	2,684,284	2,996,348	2,450,184	2,760,765	3,110,714	2,795,350	3,364,229	4,048,881	5,331,750
2026	2,436,440	2,737,568	3,075,914	2,482,506	2,815,573	3,193,326	2,859,232	3,480,210	4,236,054	5,610,696
2027	2,468,158	2,791,200	3,156,522	2,514,827	2,870,738	3,277,019	2,923,114	3,597,494	4,427,457	5,889,643
2028	2,499,877	2,845,177	3,238,173	2,547,149	2,926,259	3,361,796	2,986,997	3,716,067	4,623,090	6,168,589
2029	2,531,596	2,899,498	3,320,867	2,579,470	2,982,134	3,447,655	3,050,879	3,835,915	4,822,951	6,447,536
2030	2,563,314	2,954,161	3,404,603	2,611,792	3,038,360	3,534,597	3,114,762	3,957,024	5,027,041	6,726,482

Note: this is re-analysis of build-out pumpage from the proposal - but is NOT the build-out plus scenario

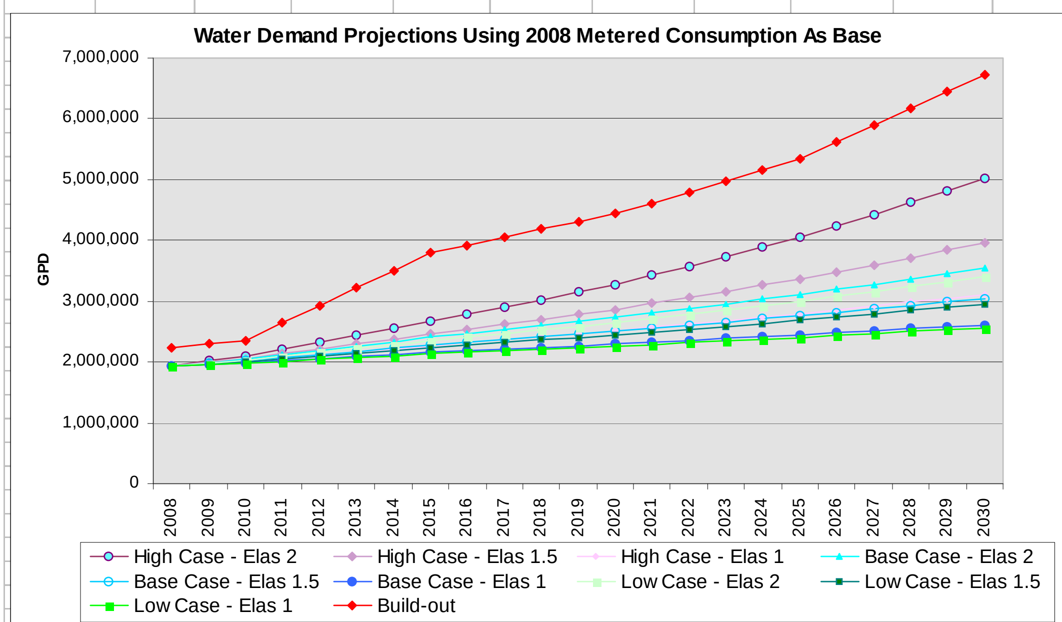


FIGURE 4-74. Build-out Analysis By 5 Year Increments

	Use Per Standards	Existing Units	Existing Demand	2015	2015 Demand	2020	2020 Demand	2025	2025 Demand	2030	2030 Demand	2030 PD Not in Proposal	2030 Demand w/ PD Not in Proposal
LANA`I CITY RESIDENTIAL (Wells 3, 6 & 8)			**361,127**		**521,072**		**636,560**		**743,910**		**851,060**		**923,787**
Lana`i City Residential - Existing		1,062	268,127	1,062	299,572	1,062	318,960	1,062	340,410	1,062	362,860		362,862
Lana`i City Residential -New/Future		0		100		493		534		712			
Country Lana`i City Recreation Area	1,700	8	13,600	8	13,600	8	13,600	8	13,600	8	13,600		13,600
Affordable Housing Property (Future)	600	0	0	100	60,000	146	87,600	220	132,000	292	175,200		257,025
DHHL Property	600	0	0	75	45,000	150	90,000	187	112,200	225	135,000		125,900
Kaumulapau Subdivision	600	0	0	15	9,000	30	18,000	38	22,800	45	27,000		27,000
Lana`i City Redevelopment Project			79,400		93,900		108,400		122,900		137,400		137,400
LANA`I CITY NON-RESIDENTIAL + CAVENDISH (Wells 3,6 & 8)			**120,076**		**133,875**		**143,038**		**152,994**		**163,336**		**163,336**
Kaumulapau Harbor		14,058	15,604		17,434		18,562		19,811		21,119		21,119
Lana`i City Govt/Comm & Inst/ Ltlnd/ Airport/Lana`i WWTP etc.			81,428		90,978		96,866		103,380		110,198		110,198
Lana`i City Area Agriculture			6,044		6753		7190		7673		8179		8,179
Lana`i City School Expansion	1,700	10	17,000	10	17,000	10	17,000	10	17,000	10	17,000		17,000
Future Commercial & BCT - All Other													
Airport Improvements			0		1,710		3,420		5,130		6,840		6,840
IRRIGATION GRID (Wells 2 & 4)			**528,044**		**592,333**		**659,361**		**656,604**		**658,953**		**658,953**
Agriculture			28,044		31,333		38,361		35,604		37,953		37,953
Agriculture Reserve	set	500,000	500,000		500,000		500,000		500,000		500,000		500,000
Other Ag or Commercial Uses													
Miki Basin Heavy Industrial Baseyard (2009)	6,000	0	0	10	60,000	20	120,000	20	120,000	20	120,000		120,000
New Warehouse	1000	0	0	1	1,000	1	1,000	1	1,000	1	1,000	1	1,000
Future Use		0	0		0		0		0		0		0
KOELE PD: POTABLE (Wells 3, 6 & 8)			**243,056**		**357,010**		**506,500**		**542,500**		**583,300**		**771,960**
Koele PD Redevelopment Portion	600	0	0	120	72,000	145	87,000	157	94,200	170	102,000	170	102,000
Koele PD-Hotel	350	102	35,700	102	35,700	102	35,700	102	35,700	102	35,700	102	35,700
Koele PD-Hotel(Future)	350	0	0	0	0	148	51,800	148	51,800	148	51,800	151	52,850
Koele PD-Hotel Irrigation	5,000	20	100,000	20	100,000	20	100,000	20	100,000	20	100,000	21	105,500
Koele PD-Commercial (Tennis & Stables)	incl	1											
Koele Single Family	600	14	8,400	52	31,200	152	91,200	200	120,000	255	153,000	365	219,000
Koele Multi-Family	560	27	15,120	51	28,560	90	50,400	90	50,400	90	50,400	156	87,360
Koele Common Areas Irrigation	5,000	10	50,000	10	50,000	10	50,000	10	50,000	10	50,000	26	130,000
Koele Parks (Future)	1,700	12	19,550	12	19,550	12	20,400	12	20,400	12	20,400	12	19,550
Cavendish Golf Course & Maintenance			14,286		20,000		20,000		20,000		20,000		20,000
KOELE PD/LANA`I CITY: WASTEWATER			**224,447**		**250,769**		**266,999**		**284,954**		**303,749**		**303,749**
Koele Golf Course Irrigation Effluent			224,447		250,769		266,999		284,954		303,749		303,749

FIGURE 4-74. Build-out Analysis By 5 Year Increments Continued

	Use Per Standards	Existing Units	Existing Resulting Flows	2015	2015 Resulting Flows	2020	2020 Resulting Flows	2025	2025 Resulting Flows	2030	2030 Resulting Flows	2030 Incl. Entitled	2030 Resulting Flows
D: POTABLE (Wells 2 & 4)			**519,241**		**645,644**		**749,716**		**1,130,932**		**1,252,267**		**1,711,268**
el	350	250	87,500	250	87,500	250	87,500	250	87,500	250	87,500	250	87,500
el Irrigation *	17,000	17	282,540	17	289,000	17	289,000	29	493,000	29	493,000	57	962,200
el (Future)	350	0	0	0	150	57	19,810	150	52,500	150	52,500	250	87,500
gle Family Homes	600	16	9,600	63	37,800	100	60,000	150	90,000	200	120,000	282	169,200
lti-Family	560	51	28,560	112	62,720	150	84,000	175	98,000	300	168,000	184	103,040
nmercial	6,000	5	31,500	5	30,000	7	42,000	9	54,000	10	61,500	5	31,500
ities (WWTP & Lift Stations)			6,812		8,045		8,838		9,745		10,724	0	10,724
nstruction/Development			29,900		31,000		31,000		31,000		31,000	0	31,000
ks (Domestic use and Irrigation)	1,700	2	3,400	20	34,000	22	37,400	66	112,200	66	112,200	66	112,761
blic Use			29,200		54,000	0	78,000	0	90,000		102,000	0	102,000
a Agriculture			10,229		11,429		12,168		12,987		13,843		13,843
D: NON-POTABLE WATER (Wells 1, 9 & 14)			**796,558**		**1,089,400**		**1,210,000**		**1,465,000**		**1,690,000**		**1,690,000**
gle Family-Irrigation	3,000	16	48,000	75	225,000	100	300,000	175	525,000	200	600,000	200	600,000
lti-Family-Irrigation	1,200	51	61,200	112	134,400	150	180,000	175	210,000	300	360,000	300	360,000
nmon Areas Irrigation	5,000	16	81,840	16	80,000	16	80,000	16	80,000	16	80,000	16	80,000
f Course Irrigation			605,518	650,000	650,000		650,000		650,000		650,000		650,000
D: WASTEWATER			**72,940**		**81,494**		**86,768**		**92,603**		**98,711**		**98,711**
f Course Irrigation Effluent		Current	72,940		81,494		86,768		92,603		98,711		98,711
E RESERVE			**600,000**		**600,000**		**600,000**		**600,000**		**600,000**		**600,000**
	Suggested		600,000		600,000		600,000		600,000		600,000		600,000
TOTAL			**3,465,489**		**4,271,597**		**4,858,942**		**5,669,497**		**6,201,376**		**6,921,764**
LESS EFFLUENT & RESERVES = PUMPED WATER			**2,068,102**		**3,339,334**		**3,905,175**		**4,691,940**		**5,198,916**		**5,919,304**
MPED WATER WITH ASSUMED 12% UAFW			**2,350,116**		**3,794,698**		**4,437,699**		**5,331,750**		**5,907,859**		**6,726,482**
				WELLS WITH LOSSES		WELLS WITH LOSSES		WELLS WITH LOSSES		WELLS WITH LOSSES		WELLS WITH LOSSES	
WELLS 2 & 4 SERVICE AREA			1,047,285	1,190,097	1,237,977	1,406,792	1,396,909	1,587,397	1,787,536	2,031,291	1,911,220	2,171,841	2,370,221
WELLS 6 & 8 SERVICE AREA			724,259	823,022	1,011,957	1,149,951	1,286,098	1,461,475	1,439,404	1,635,686	1,597,696	1,815,564	1,859,083
WELLS 1, 9 & 14 SERVICE AREA			796,558	905,180	1,089,400	1,237,955	1,210,000	1,375,000	1,465,000	1,664,773	1,690,000	1,920,455	1,690,000
WASTEWATER - using projection coefficients			**297,387**		**332,263**		**353,767**		**377,557**		**402,460**		**402,460**
WASTEWATER - using per-unit calculations (not used)			307,033		511,439		877,224		984,984		1,125,053		1,551,359
AGRICULTURAL RESERVE			500,000		500,000		500,000		500,000		500,000		500,000
RESOURCE RESERVE			600,000		600,000		600,000		600,000		600,000		600,000
- Pumped with UAFW, Plus Effluent and Reserves			2,647,503		4,126,961		4,791,466		5,709,307		6,310,319		7,128,942

FIGURE 4-75. Differences Between Proposal Build-out and Compiled Build-out

	2030	2030 Demand	2030 PD Not in Proposal	2030 Demand w/ PD Not in Proposal	Basis / Notes
LANA`I CITY RESIDENTIAL (Wells 3, 6 & 8)		**851,060**		**923,787**	
Lana`i City Residential - Existing	1,062	362,860		362,862	forecast coefficients using LCTY+KPAU res demand. elas. = 1
Lana`i City Residential -New/Future	712				already included in forecast coefficients above.
Country Lana`i City Recreation Area	8	13,600		13,600	1,700 is per unit standard, vs. 1,375/ac proposed by CCR.
Affordable Housing Property (Future)	292	175,200		257,025	per unit standards. staff planner estimate from updated submitt
DHHL Property	225	135,000		125,900	per unit standards staff est. was 125,900. close enough.
Kaumulapau Subdivision	45	27,000		27,000	per unit standards. however, CCR est of 1,000 per unit is probably closer at this elevation.
Lana`i City Redevelopment Project		137,400		137,400	Discrepancies btwn. County & CCR records could not be resolved as of this draft. Assumes 201 SF & 30 MF remain.
LANA`I CITY NON-RESIDENTIAL + CAVENDISH (Wells 3,6 & 8)		**163,336**		**163,336**	
Kaumulapau Harbor		21,119		21,119	forecast coefficient for non-res uses in KPAU.
Lana`i City Govt/Comm & Inst/ LtInd/ Airport/Lana`i WWTP/Lana`i…		110,198		110,198	forecast coefficient all LCTY except res. Kpau already above.
Lana`i City Area Agriculture		8179		8,179	forecast coefficients on existing ag metered amount
Lana`i City School Expansion	10	17,000		17,000	per-acre standards.
Future Commercial & BCT - All Other					included in forecast above, two lines up.
Airport Improvements		6,840		6,840	techincally incl. in forecast above, two lines up. exist=o not to double count. assumed continuous growth.
IRRIGATION GRID (Wells 2 & 4)		**658,953**		**658,953**	
Agriculture		37,953		37,953	forecast coefficent on existing ag use.
Agriculture Reserve		500,000		500,000	agricultural reserve approved by committee.
Other Ag or Commercial Uses					already included in forecasts above.
Miki Basin Heavy Industrial Baseyard (2009)	20	120,000		120,000	per acre standards. Outdoor uses may be met by reclaimed.
New Warehouse	1	1,000	1	1,000	lump sum per CCR proposal.
Future Use		0		0	not tallied here. included above.
KOELE PD: POTABLE (Wells 3, 6 & 8)		**583,300**		**771,960**	
Koele PD Redevelopment Portion	170	102,000	170	102,000	per unit standards. assumes this is part of PD SF allowance.
Koele PD-Hotel	102	35,700	102	35,700	per unit standards.
Koele PD-Hotel(Future)	148	51,800	151	52,850	per unit standards. PD allows 253 rooms. prop is for 250.
Koele PD-Hotel Irrigation	20	100,000	21	105,500	which is 51,800.
Koele PD-Commercial (Tennis & Stables)					not tallied seperately. should be included in above.
Koele Single Family	255	153,000	365	219,000	per unit standards. proposal totals 425 SF units. PD allows max of 535 SF units.
Koele Multi-Family	90	50,400	156	87,360	per unit standards. PD allows 156 MF units. Prop is for 90.
Koele Common Areas Irrigation	10	50,000	26	130,000	per acre standards.not clear why common area irrigation is needed in addition to MF, Hotel & SF irrigation. Should be included already. may be double-counting. this is true in both PDs.
Koele Parks (Future)	12	20,400	12	19,550	per acre standards. 11.5 ac park x 1,700 gp/ac.
Cavendish Golf Course & Maintenance		20,000		20,000	actual rounded up as per CCR proposal.
KOELE PD/LANA`I CITY: WASTEWATER		**303,749**		**303,749**	
Koele Golf Course Irrigation Effluent		303,749		303,749	Forecast coefficients on 2008 AWTF Production. (vs deliveries)

FIGURE 4-75. Differences Between Proposal Build-Out and Compiled Build-Out Continued

	2030	2030 Demand	2030 PD Not in Proposal	2030 Demand w/ PD Not in Proposal	Basis / Notes
MANELE PD: POTABLE (Wells 2 & 4)		**1,238,424**		**1,711,268**	
Manele Hotel	250	87,500	250	87,500	per unit standards. - in last column rooms included in per-acre
Manele Hotel Irrigation	29	493,000	57	962,200	normally exceeds actual use, and includes irrigation,
Manele Hotel (Future)	150	52,500	250	87,500	PD allows 500 HOT units. Note that per-acre hotel standard
Manele Single Family Homes	200	120,000	282	169,200	per unit standards. PD allows 282 SF units. Prop is for 200.
Manele Multi-Family	300	168,000	184	103,040	per unit standards. PD allows 184 MF units. Prop is for 300.
Manele Commercial	10	61,500	5	31,500	use. PD only has 5.25 acres of commercial.
Manele Utilities (WWTP & Lift Stations)		10,724	0	10,724	forecast coefficients on actual would run 6,812 existing to 10,7
Manele Construction/Development		31,000	0	31,000	lump sum estimate per CCR proposal.
Manele Parks (Domestic use and Irrigation)	66	112,200	66	112,761	per acre standards. PD ord. has 66.33 acres park.
Manele Public Use		102,000	0	102,000	lump sum estimate per CCR proposal. Included in park or PQP
					PQP (public-quasi public) only 2 acres in Project District.
Manele Area Agriculture		13,843		13,843	forecast coefficients on existing ag amount
MANELE PD: NON-POTABLE WATER (Wells 1, 9 & 14)		**1,690,000**		**1,690,000**	
Manele Single Family-Irrigation	200	600,000	200	600,000	one from the other. the proposal allows for both, double
Manele Multi-Family-Irrigation	300	360,000	300	360,000	within county per-acre standards. But proposal adds per-unit
Manele Common Areas Irrigation	16	80,000	16	80,000	needed in addition to MF, Hotel & SF irrigation. Should be
Manele Golf Course Irrigation		650,000		650,000	actual total pumpage and project condition restrictions.
					actual gc irrigation is 596,009. +9,509 for clbhs & maint. bldg.
MANELE PD: WASTEWATER		**98,711**		**98,711**	
Manele Golf Course Irrigation Effluent		98,711		98,711	
RESOURCE RESERVE		**600,000**		**600,000**	
		600,000		600,000	
TOTAL		**6,187,533**		**6,921,764**	
LESS EFFLUENT & RESOURCE RESERVE = PUMPED WATER		5,185,073		5,919,304	for all but present, ag reserve is assumed to be pumping
PUMPED WATER WITH ASSUMED 12% UAFW		**5,892,128**		**6,726,482**	**UNLESS WASTEWATER DID MEET STANDARDS**
			WELLS		WELLS
			WITH		WITH
			LOSSES		LOSSES
WELLS 2 & 4		1,897,377	2,156,110	2,356,378	2,677,702
WELLS 6 & 8		1,597,696	1,815,564	1,859,083	2,112,594
WELLS 1, 9 & 14		1,690,000	1,920,455	1,690,000	1,920,455
WASTEWATER		**402,460**		**402,460**	**uses forecast coefficients**
PER UNIT WASTEWATER ALTERNATIVE CALC		1,125,053		1,551,359	uses per-unit standards at proposed build-out rates.
AGRICULTURAL RESERVE		500,000		500,000	
RESOURCE RESERVE		600,000		600,000	
		6,294,588		7,128,942	

Build-Out Analysis

FIGURE 4-76. Phase II Approvals Build-out.

	Use Per Standards	Phase II Units	Forecast Growth Plus Phase II GPD	Forecast Growth Plus Phase II GPD with UAFW 12% LCTY,KOPD,KPAU 15% MNPD, IGGP
LANA`I CITY RESIDENTIAL (Wells 3, 6 & 8)			**923,427**	**1,049,349**
Lana`i City Residential - Existing	existing	1,062	268,127	304,690
Lana`i City Residential -New/Future	orecast add't'l	0	94,375	107,244
Country Lana`i City Recreation Area	1,700	8	13,600	15,455
Affordable Housing Property (Future)	600	0	257,025	292,074
DHHL Property	600	0	125,900	143,068
Kaumulapau Subdivision	600	0	27,000	30,682
Lana`i City Redevelopment Project			137,400	156,136
LANA`I CITY NON-RESIDENTIAL + CAVENDISH (Wells 3,6 & 8)			**163,336**	**185,609**
Kaumulapau Harbor		14,058	21,119	23,999
Lana`i City Govt/Comm & Inst/ LtInd/ Airport/Lana`i WWTP/Lana`i…			110,198	125,225
Lana`i City Area Agriculture			8179	9,294
Lana`i City School Expansion	1,700	10	17,000	19,318
Future Commercial & BCT - All Other				0
Airport Improvements			6,840	7,773
IRRIGATION GRID (Wells 2 & 4)			**658,953**	**809,671**
Agriculture			37,953	44,651
Agriculture Reserve	set	500,000	500,000	588,235
Other Ag or Commercial Uses				34,432
Miki Basin Heavy Industrial Baseyard (2009)	6,000	0	120,000	141,176
New Warehouse	1000	0	1,000	1,176
Future Use		0	0	0
Reclaimed Water from Lana`i City to Palawai Grid				
Reclaimed Water from Lana`i City to Palawai Grid			see below	see below
KOELE PD: POTABLE (Wells 3, 6 & 8)			**330,936**	**376,064**
Koele PD Redevelopment Portion	600	0	0	0
Koele PD-Hotel	350	102	35,700	40,568
Koele PD-Hotel(Future)	350	0	0	0
Koele PD-Hotel Irrigation	5,000	20	100,000	113,636
Koele PD-Commercial (Tennis & Stables)	incl	1		0
Koele Single Family	600	125	75,000	85,227
Koele Multi-Family	560	65	36,400	41,364
Koele Common Areas Irrigation *	5,000	10	50,000	56,818
Koele Parks (Future)	1,700	12	19,550	22,216
Cavendish Golf Course & Maintenance			14,286	16,234
KOELE PD/LANA`I CITY: WASTEWATER			**316,798**	**316,798**
Koele Golf Course Irrigation Effluent			316,798	316,798

FIGURE 4-77. Phase II Approvals Build-out Continued

	Use Per Standards	Phase II Units	Forecast Growth Plus Phase II GPD	Forecast Growth Plus Phase II GPD with UAFW 12% LCTY,KOPD,KPAU
MANELE PD: POTABLE (Wells 2 & 4)			**641,767**	**755,020**
Manele Hotel	350	250	87,500	102,941
Manele Hotel Irrigation *	17,000	17	282,540	332,400
Manele Hotel (Future)	350	0	0	0
Manele Single Family Homes	600	161	96,600	113,647
Manele Multi-Family	560	101	56,560	66,541
Manele Commercial	6,000	5	31,500	37,059
Manele Utilities (WWTP & Lift Stations)			10,724	12,616
Manele Construction/Development			29,900	35,176
Manele Parks (Domestic use and Irrigation)	1,700	2	3,400	4,000
Manele Public Use			29,200	34,353
Manele Area Agriculture			13,843	16,286
MANELE PD: BRACKISH WATER (Wells 1, 9 & 14) & RECLAIMED WATER			**1,336,040**	**1,571,812**
Manele Single Family-Irrigation*	3,000	161	483,000	568,235
Manele Multi-Family-Irrigation*	1,200	101	121,200	142,588
Manele Common Areas Irrigation*	5,000	16	81,840	96,282
Manele Golf Course Irrigation			650,000	764,706
Manele PD: Wastewater				
Manele Reclaimed Water			see below	see below
Lana`i City Reclaimed Water sent to Manele			see below	see below
RESOURCE RESERVE			**600,000**	**600,000**
	Suggested		600,000	600,000
TOTAL WATER DEMAND AND RESERVATION			4,971,257	5,664,322
LESS RESOURCE RESERVE ONLY			4,371,257	5,064,322
RECLAIMED WATER LANA`I CITY			501,464	501,464
RECLAIMED WATER MANELE			119,507	119,507
;S EFFLUENT & RESERVES = PUMPED BEFORE CONSRV.			3,750,286	4,443,351
CONSERVATION TARGET - FRESH			402,000	402,000
CONSERVATION TARGET - BRACKISH			83,000	83,000
PUMPED WATER WITH ASSUMED UAFW	**After Conservation**		**3,265,286**	**3,958,351**
WELLS 2 & 4			943,720	1,207,691
WELLS 6 & 8			995,901	1,506,022
WELLS 1, 9 & 14			**1,008,867**	**1,244,639**
* Further adjustments need to be made to bring pumpage in this well service area down				
check well subtotal			2,948,488	3,958,351
ESTIMATED RECLAIMED USE			620,971	620,971
FURTHER REDUCTION - DESALINIZATION				300,000
AGRICULTURAL RESERVE			500,000	588,235
RESOURCE RESERVE			600,000	600,000

Resource Development Strategy

A base case “resource development strategy” was developed to investigate and identify a viable approach to meet anticipated planning period water needs most economically within resource availability constraints. The strategy identifies new supply resources and conservation measures sufficient to provide for existing water needs as well as anticipated water needs for known new projects and projects with Phase II project district entitlements.

The resource development strategy serves as a planning and analysis tool to determine what new resources and conservation measures will be necessary and will most economically and effectively meet water demands that could develop during the planning period. In the context of Lana‘i’s limited water resources, the resource development strategy also serves to show what economic challenges can be expected in conjunction with build-out of entitled land developments.

Resource Strategy Demand Projections

The resource development strategy incorporates a projection of water demand through the year 2030 based on econometric analysis of the Socio-Economic forecast used in the current County general plan update. Projections beyond 2030 include estimate of water needs for build-out of known projects and projects with Phase II project district entitlements.

The tables below shows the projected water production broken down by water system and service area for five year increments to the year 2030. The rightmost column shows production requirements to meet the needs of build-out of known projects and projects with Phase II entitlements. The projections identify and include the impacts of the conservation and leak reduction measures identified below.

A 10% percent aquifer pumping reserve (to keep pumping below 90% of sustainable yield) is included in the projections. Totals are shown both including and excluding this pumping reserve. Production requirements in the year 2030 and for Phase II build-out exceed the pumpage sustainable yield of the Leeward aquifer (3 MGD) and would therefore require some contribution from resources developed in the Windward aquifer.

Details regarding the development of the resource develompent strategy water use tables are listed on the pages following the tables.

FIGURE 4-78. Base Case Resource Development Strategy Water Use Table (1 of 3)

RESOURCE DEVELOPMENT STRATEGY - SOURCE USE TO THE YEAR 2030

Land Use Category	Present Metered (2008)	Source Requirement with Target UAFW 12% in LCTY,KOPD,KPAU 15% in MNPD, IGGP	Pumped Water For Each Demand Stream Including UAFW 2010	2015	2020	2025	2030	Phase II Plus Other Known Projects
Koele PD - Fresh	149,128	169,464	185,149	157,403	185,909	206,816	229,426	335,507
Koele PD - Brackish	0	0	0	0	0	0	0	0
Koele PD - Reclaimed Water	234,093	234,093	258,235	261,552	278,477	297,204	316,798	316,798
Lana`i City & Related Areas - Residential - Fresh	268,127	304,690	333,374	287,071	348,037	379,530	421,030	367,508
Lana`i City & Related Areas - Other - Fresh	105,486	119,870	131,173	116,067	134,386	151,973	165,457	165,592
Lana`i City Housing Project				87,290	155,551	223,813	257,943	292,074
County Lana`i City Recreation Area				15,455	15,455	15,455	15,455	15,455
DHHL Project				11,591	112,386	115,114	129,091	143,068
Lana`i City Redevelopment Project				41,081	82,161	133,071	144,604	156,136
Kaumalapau Subdivision								30,682
Lana`i City & Kaumalapau - Conservation Target - Fresh			5,750	91,200	95,800	100,400	105,000	105,000
Potable Resource Reserve - 10% of Aquifer Sustainable Yield (300 KGal each)		600,000	600,000	600,000	600,000	600,000	600,000	600,000
Palawai IGGP - Agricultural - Fresh	28,044	32,993	35,590	19,616	22,707	28,074	28,524	28,067
Palawai IGGP - Agricultural - Reserve - Fresh			588,235	588,235	588,235	588,235	588,235	588,235
Palawai IGGP - Other - Fresh - incl. warehouse (total is offset by reclaimed)	24,461	28,778	30,755	17,109	16,712	21,544	29,267	23,523
Palawai IGGP - Miki Basin Industrial Park (120 Kgal total offset by reclaimed)							86,629	93,262
Palawai IGGP - Agricultural - Brackish	0	0	0	0	0	0	0	0
Palawai IGGP - Other - Brackish	0	0	0	0	0	0	0	0
Palawai IGGP - Reclaimed Water from Lana`i City							60,000	60,000
Manele PD - Potable	322,641	441,348	405,819	189,448	149,726	242,046	284,311	474,603
Manele PD - Brackish (2008 actual metered)	760,357	650,000	650,000	650,000	650,000	650,000	650,000	650,000
Manele PD - Brackish Water Over 650,000 (2008 pumpage was 943,776, w/19% UAFW & water levels declini		244,538	112,634	163,191	199,091	240,285	270,220	294,639
Manele PD - Reclaimed Water from Lana`i City								124,666
Seawater to Brackish Desalt or Other Approved Source								300,000
Manele PD & IGGP - Conservation Target - Fresh			15,400	250,800	266,200	291,600	297,000	297,000
Manele PD & IGGP - Conservation Target - Brackish			14,000	27,800	41,600	55,400	83,000	83,000
Manele PD - Reclaimed Water	72,940	72,940	80,462	81,496	86,769	92,605	98,711	119,507
TOTAL	1,965,277	2,898,713	3,446,576	3,656,405	4,029,203	4,433,164	4,860,700	5,664,322
including resource reserve								
TOTAL REMOVING RESOURCE RESERVE	1,965,277	2,298,713	2,846,576	3,056,405	3,429,203	3,833,164	4,260,700	5,064,322
(above i.e. POTENTIAL PUMPED Including System Losses WITHOUT Conservation, Reclaimed Water or Desalt)								
SUBTOTAL PUMPED FROM AQUIFER Incl System Losses WITH Conservation & Etc.	**1,658,244** (metered)	**1,991,680** a	**2,472,728** b	**2,343,557** c	**2,660,357** d	**2,995,955** e	**3,300,191** f	**3,658,351** g

Note: 500 Kgal Ag Reserve is assumed to be pumped in all but "present" years

FIGURE 4-79. Base Case Resource Development Strategy Water Use Table (2 of 3)

RESOURCE DEVELOPMENT STRATEGY - SOURCE USE TO THE YEAR 2030

	Present Metered (2008)	Source Requirement with Target UAFW 12% in LCTY,KOPD,KPAU 15% in MNPD, IGGP baseline existing	Pumped Water For Each Demand Stream Including UAFW 2010	2015	2020	2025	2030	Phase II Plus Other Known Projects
Total Needed from Conservation			35,150	369,800	403,600	447,400	485,000	485,000
Breakdown by Source of Water								
Subtotal Potable		1,097,143	1,710,094	1,530,366	1,811,265	2,105,671	2,379,971	2,713,712
Subtotal Brackish		894,538	762,634	813,191	849,091	890,285	920,220	944,639
Subtotal Reclaimed		307,033	338,697	343,048	365,246	389,809	475,509	620,971
Subtotal Conservation		0	35,150	369,800	403,600	447,400	485,000	485,000
Subtoal Desalt		0	0	0	0	0	0	300,000
Check - Subtotal Source Requirement		2,298,713	2,846,576	3,056,405	3,429,203	3,833,164	4,260,700	5,064,322
Resource Reserve		600,000	600,000	600,000	600,000	600,000	600,000	600,000
Subtotal All Including Reserves		2,898,713	3,446,576	3,656,405	4,029,203	4,433,164	4,860,700	5,664,322
Breakdown by Water District								
Koele PD		403,557	446,259	464,556	512,286	554,221	598,724	704,805
Lanai City & Related Areas		424,560	467,422	604,154	895,876	1,069,155	1,186,079	1,223,015
Irrigation Grid / Palawai		61,771	654,580	624,960	627,654	637,854	792,655	793,087
Manele PD		1,408,826	1,278,315	1,362,735	1,393,387	1,571,935	1,683,242	2,343,415
General Island - Potable Resource Reserve		600,000	600,000	600,000	600,000	600,000	600,000	600,000
Check - Total		2,898,713	3,446,576	3,656,405	4,029,203	4,433,164	4,860,700	5,664,322
PUMPED ONLY Breakdown by Well Service Area								
Wells 6 & 8 Service Area (LCTY, KPAU, KOPD)		594,024	649,696	715,958	1,033,885	1,225,771	1,363,005	1,506,022
Wells 2 & 4 Service Area (MNPD, IGGP)		503,145	1,060,424	814,435	777,406	879,926	1,016,966	1,207,690
Wells 1, 9 & 14 Service Area (Brackish MNPD)		894,538	762,634	813,191	849,091	890,285	920,220	944,639
SUBTOTAL PUMPED		**1,991,706**	**2,472,754**	**2,343,583**	**2,660,383**	**2,995,981**	**3,300,191**	**3,658,351**

FIGURE 4-80. Base Case Resource Development Strategy Water Use Table (3 of 3)

RESOURCE DEVELOPMENT STRATEGY - SOURCE USE TO THE YEAR 2030

Breakdown by Water District and Source of Water	Present Metered (2008)	Source Requirement with Target UAFW 12% in LCTY,KOPD,KPAU 15% in MNPD, IGGP	Pumped Water For Each Demand Stream Including UAFW 2010	2015	2020	2025	2030	Phase II Plus Other Known Projects
Koele PD		**403,557**	**446,259**	**464,556**	**512,286**	**554,221**	**598,724**	**704,805**
Potable		169,464	185,149	157,403	185,909	206,816	229,426	335,507
Brackish		234,093	258,235	261,552	278,477	297,204	316,798	316,798
Reclaimed								
Conservation			2875	45600	47900	50200	52500	52500
Koele PD - Check		*403,557*	*446,259*	*464,556*	*512,286*	*554,221*	*598,724*	*704,805*
Lana`i City & Related Areas		**424,560**	**467,422**	**604,154**	**895,876**	**1,069,155**	**1,186,079**	**1,223,015**
Potable		424,560	464,547	558,554	847,976	1,018,955	1,133,579	1,170,515
Brackish								
Reclaimed								
Conservation			2,875	45,600	47,900	50,200	52,500	52,500
Unidentified Alternate Source								
Lanai City Check		*424,560*	*467,422*	*604,154*	*895,876*	*1,069,155*	*1,186,079*	*1,223,015*
Irrigation Grid / Palawai		**61,771**	**654,580**	**624,960**	**627,654**	**637,854**	**792,655**	**793,087**
Potable		61,771	654,580	624,960	627,654	637,854	732,655	733,087
Brackish								
Reclaimed								60,000
Conservation								
Unidentified Alternate Source								
IGGP Check		*61,771*	*654,580*	*624,960*	*627,654*	*637,854*	*732,655*	*793,087*
Manele PD		**1,408,826**	**1,278,315**	**1,362,735**	**1,393,387**	**1,571,935**	**1,683,242**	**2,343,415**
Potable		441,348	405,819	189,448	149,726	242,046	284,311	474,603
Brackish		650,000	650,000	650,000	650,000	650,000	650,000	650,000
Brackish Beyond 650,000		244,538	112,634	163,191	199,091	240,285	270,220	294,639
Reclaimed from Manele Plant		72,940	80,462	81,496	86,769	92,605	98,711	119,507
Conservation		0	29,400	278,600	307,800	347,000	380,000	380,000
Reclaimed from Lana`i City Plant		0	0	0	0	0	0	124,666
Desalinization Plant								300,000
Manele Check		*1,408,826*	*1,278,315*	*1,362,735*	*1,393,387*	*1,571,935*	*1,683,242*	*2,343,415*
Potable Resource Reserve (half in each aquifer system)		**600,000**	**600,000**	**600,000**	**600,000**	**600,000**	**600,000**	**600,000**
Check Totals		**2,898,713**	**3,446,576**	**3,656,405**	**4,029,203**	**4,433,164**	**4,860,700**	**5,664,322**

Base Case Resource Development Strategy Water Use Table Footnotes

*** This method is adapted from the SES forecast analysis with base year 2008 at base case with elasticity of 1.5 forecast growth factors applied to present consumption.

** The last column totaling 5,664,332 corresponds to the last column in Figure 4-79, on pages 4-111 to 4-112. .

a . Present Source Requirement Although actual pumped is 2,241,222 this is due to high system losses, especially in the service areas of wells 2 and 4. For purposes of present source use with targeted capacity, 12% is seen as a realistic goal for the areas of Koele, Lana`i City and Kaumalapau, while 15% is seen as more realistic for the brackish system, and the service area of wells 2 & 4, which include potable Manele service and the Palawai Irrigation Grid

Estimated amounts use base case escalation factors with an elasticity of 1.5, except for brackish, which is targeted for reduction, and reclaimed as people are not likely to generate more waste.

Given that reduction of per-unit use in landscape irrigation is one goal of this plan, for brackish water, estimated demand is escalated using base case escalation factors with an elasticity of 1.

Reclaimed water is also escalated at an elasticity of 1, except in the last column, where it is estimated for build-out of Phase II.

b. 2010 Source use in 2010 reflects the following considerations:

Forecast used 2008 calendar year consumption, and escalated at elasticity of 1.5.

15% system losses were assumed for Manele and the Palawai Irrigation Grid. 12% system losses were assumed for Lana`i City and Koele.

Conservation measures assumed to be implemented during the 20+ year planning period include Palawai Grid Pipe Replacement; Toilet, fixture and appliance replacement program; Landscape Conservation; Cover on 15 MG brackish reservoir; Leak detection program and annual water audit; Hotel incentives program; Tiered rate structure, and other measures. Some of these measures are set for given dates, others are expected to roll in over the planning period, still others may be more effective if implemented early in one sweep, rather than roll-in, but are assumed to roll-in to allow some flexibility for implementation. In either case, the documented savings is intended to meet or exceed the target for that period.

Wherever conservation savings are anticipated, the total demand for fresh or brackish water, as indicated, is decreased by the amount shown.

Ultimate estimated conservation targets are as follows:

Lana`i City and Koele - Fresh - 80,000 + 11,000 + 12,000 + 2,000 = 105,000 reflecting fixture replacements, landscape conservation, leak detection and repair and hotel & landscape incentives programs

Manele and Palawai - Fresh - 200,000 + 50,000 + 20,000 + 15,000 + 12,000 = 297,000 reflecting Palawai Grid Pipe Replacement, landscape conservation, fixture replacement program, leak detection and repair, hotel & landscape incentives programs

Manele and Palawai - Brackish - 50,000 + 14,000 + 13,000+ 6000 = 83,000 reflecting landscape conservation, cover of brackish reservoir, leak detection and repair and landscape incentive programs

By the end of 2010, the following measures are assumed to have at least commenced - leak detection, water audit, and landscape conservation

Also within 2010, the hypalon cover for the brackish reservoir is assumed to have been installed.

c. 2015 Source use in 2015 reflects the following considerations:

By 2015, the Palawai Grid Pipe replacement is assumed to be installed. Estimated savings are 200,000 in the Palawai Grid/Manele area. Success can be evaluated by UAFW analysis.

By 2015, fixture replacement in the areas of Lana`i City and Koele is assumed to have been completed, whether or not all fixtures in Manele and Palawai are done at the same time, for a minimum savings of 100,000 GPD island wide.

Leak detection and repair, water audit, landscape conservation and incentive programs are assumed to be ongoing since 2010, and to roll in over the planning period.

d. 2020: Assumptions include:

By 2020 - plans to distribute withdrawals away from the leeward aquifer should be well along.

At this point - Palawai Grid Repair, 15 MG Reservoir Cover, Island-wide fixture and appliance replacement are in place. Leak detection and repair, landscape conservation and incentive programs are ongoing.

Conservation savings continue to roll in as more leaks are found or incentives offered, etc.

Management measures inside all Lana`i Hale fence increments should be resulting in lower animal head counts within the Hale. This can be measured by resuming regular survey of animal counts in the fenced area.

e. 2025: Assumptions include:

Before pumpage reaches 2.7 MGD, there must be a pumping well or wells in the windward aquifer

At this point - Palawai Grid Repair, 15 MG Reservoir Cover, Island-wide fixture and appliance replacement are in place. Leak detection and repair, landscape conservation and incentive programs are ongoing.

Conservation savings continue to roll in as more leaks are found or incentives offered, etc.

f. 2030: Assumptions include:

Landscape conservation implementation should have brought overall irrigation down by at least 111,000 gpd.

Incentive programs should have saved another 20,000 GPD at hotels, large landscapes and commercial properties.

Leak detection and repair should have saved another 40,000 GPD across the island.

CHAPTER 5

Supply Options

In This Chapter

Key Points

- This chapter discusses measures to provide for the range of projected demands identified in the *Demand Analysis* chapter. To meet reliability standards and serve the base case growth forecast, Lanaʻi would require about 2.93 MGD in additional capacity by 2030. To meet reliability standards for build-out plus entitlements, 12.15 MGD in new capacity would be required.

- A list of potential supply options sufficient to meet either the high or low end of the forecast ranges is delineated and characterized, with some analysis of life cycle resource costs. A rough estimate of cost recovery requirements is provided for each scenario.

  New source options considered include:
  - High level potable well near Well 5 in the Leeward Aquifer
  - Well 2-B at the site of Shaft 3 in the Leeward Aquifer
  - Recommissioning Well 7 in the Leeward Aquifer
  - New wells in the Windward Aquifer at Malaʻau
  - Recommissioning the Maunalei Shaft and Tunnels in the Windward Aquifer
  - New wells in the Windward Aquifer at or near the Maunalei Shaft and Tunnel sites
    - Two (2) new wells using existing transmission
    - Three (3) new wells using existing transmission
    - Three (3) new wells using new transmission
  - New wells in the Windward Aquifer at Kauiki
    - Assuming that these wells can tie into Maunalei Wells transmission

    - Assuming new transmission had to be constructed
- New wells in the Windward Aquifer at Kehewai Ridge
    - at 2,250’ elevation
    - at 2,750’ elevation
- New Brackish Well 15 in the Leeward Aquifer
    - Used without additional desalinization
    - Used with desalinization
- “General” Desalinization Options
    - Brackish to potable
    - Seawater to potable
    - Seawater to brackish for irrigation

Supply and Demand Side Efficiency Options include:

- Loss Reduction - Repair of Palawai Grid Pipes
- Loss Reduction - Cover for the 15 MG Brackish Reservoir
    - Floating Cover
    - Aluminum Cover
    - Hypalon Balls
- Expanded use of Lana‘i City Reclaimed Water
    - Lana‘i City to Miki Basin
    - Lana‘i City to Manele
    - Lana‘i City to Manele via Miki Basin
- Various General Demand Side Management (DSM) Programs
    - Fixture replacements of toilets, showerheads, faucets, etc.
    - Replacements of appliances such as dishwashers, clothes washers, etc.
    - Landscape efficiency items: climate adapted-plants, moisture sensors, rain shut-offs, etc.

- A number of conservation options targeted to the largest user types on Lana‘i are discussed in the text.
- A list of system needs is developed costed and characterized, including source development, pipe replacements, storage improvements, pump improvements, needs for monitoring and telemetry, etc. These total roughly $100 million dollars for build-out or $10.4 million to meet base case forecasts.
- The proposed capital plan includes funds for approximately 485,00 GPD in potential efficiency savings, which are identified throughout the text and compiled in Figure 5-55 on page 5-85.
- Capital needs are converted to rough carrying costs, and added to annual revenues and revenue losses as reported to the PUC and to anticipated increased costs in labor and facilities identified by Brown & Caldwell in the May 2009 draft and March, 2010 *Lana‘i Water System Acquisition Appraisal.*
- To meet these capital needs, bi-monthly charges, water rates and new meter fees are developed and presented. Several potential rate designs are included. All have been tested against 2008 billing data.
- A basic source plan is presented on page 5-85. This plan is tied to demand triggers, rather than dates.

Installed Capacity Requirements

Source requirements were discussed in the *Demand Analysis* chapter of this document. Source requirements refer to the amount of water needed to meet demands plus seasonal and diurnal fluctuations, accounting for anticipated system losses.

For developing a capital plan, not only source requirements, but also installed capacity requirements must be considered. Installed capacity requirements are essentially source requirements plus sufficient additional capacity to meet infrastructure standards for redundancy and reliability.

According to *System Standards (Water System Standards*, State of Hawaii, 2002), wells should be designed to be able to meet maximum day demand (defined as 1.5 times average demand), in 16 hours pumping, with the largest pump out of service. In effect, this means that sufficient capacity should be installed to meet about 225% of average day withdrawals, or that any given installed source or set of sources should be assumed to utilize roughly 45% of its total installed capacity. In addition, the count of wells available to serve each area should be sufficient that wells can meet these requirements with the largest one out of service.

To derive installed capacity requirements, the starting source requirements selected were based upon actual metered demands plus an “industry-standard” assumed percent for system losses, as escalated either in the base case forecast scenario or the build-out scenario. To start, these demands were broken down by the three well service areas on the island, i.e. into: demands for the area served by Wells 6 & 8; demands for the area served by Wells 2 & 4; and demands for the area served by Wells 1, 9 & 14. Beginning installed capacity requirements used were derived as follows:

FIGURE 5-1. Starting Source Requirements for Capacity Requirement Calculation

Well Service Area	2008 Metered Demand	Assumed Losses For Projection	Equation	Starting Source Requirements
6 & 8	522,742	12%	x / 1-.12	594,025
2 & 4	375,146	15%	x / 1-.15	441,348
1, 9 & 14	760,357	15%	x / 1-.15	894,538

One fact that will jump out at some readers in the tables above is that for all wells, starting source requirements are lower than actual pumped demand. Current losses in all systems are higher than target losses used in the projection. This is a policy statement. Targets are lower than current unaccounted-for water (UAFW) of 45% for Wells 2 & 4 and 19% for Wells 1, 9 & 14. Rather than include such losses in projected needs, measures are identified as part of the plan to reduce them. CCR proposals assume 12% UAFW, so this is reasonably consistent.

FIGURE 5-2. Source Capacity Requirements By Well Service Area

Source Requirements for Base Case - Elasticity = 1

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	594,025	441,348	894,538	1,929,911
2009	603,307	448,245	908,515	1,960,067
2010	612,589	455,141	922,493	1,990,223
2011	622,809	462,734	937,883	2,023,427
2012	633,029	470,328	953,274	2,056,631
2013	643,249	477,921	968,664	2,089,835
2014	653,469	485,514	984,055	2,123,038
2015	663,690	493,108	999,445	2,156,242
2016	672,280	499,490	1,012,382	2,184,153
2017	680,871	505,873	1,025,319	2,212,063
2018	689,462	512,256	1,038,255	2,239,973
2019	698,053	518,639	1,051,192	2,267,884
2020	706,644	525,022	1,064,129	2,295,794
2021	716,148	532,083	1,078,441	2,326,672
2022	725,652	539,144	1,092,754	2,357,550
2023	735,156	546,206	1,107,066	2,388,428
2024	744,660	553,267	1,121,378	2,419,306
2025	754,165	560,329	1,135,691	2,450,184
2026	764,113	567,720	1,150,672	2,482,506
2027	774,062	575,112	1,165,654	2,514,827
2028	784,010	582,503	1,180,635	2,547,149
2029	793,959	589,895	1,195,616	2,579,470
2030	803,907	597,287	1,210,598	2,611,792

Installed Capacity Less Largest Pump Requirements for Base Case - Elasticity = 1

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	1,336,556	993,034	2,012,710	4,342,299
2009	1,357,441	1,008,550	2,044,160	4,410,151
2010	1,378,325	1,024,067	2,075,609	4,478,002
2011	1,401,321	1,041,152	2,110,238	4,552,711
2012	1,424,316	1,058,237	2,144,866	4,627,419
2013	1,447,311	1,075,322	2,179,495	4,702,128
2014	1,470,306	1,092,407	2,214,123	4,776,836
2015	1,493,302	1,109,492	2,248,751	4,851,545
2016	1,512,631	1,123,853	2,277,859	4,914,343
2017	1,531,960	1,138,215	2,306,967	4,977,142
2018	1,551,290	1,152,576	2,336,075	5,039,940
2019	1,570,619	1,166,937	2,365,183	5,102,739
2020	1,589,948	1,181,298	2,394,291	5,165,537
2021	1,611,333	1,197,187	2,426,493	5,235,013
2022	1,632,717	1,213,075	2,458,696	5,304,488
2023	1,654,102	1,228,963	2,490,899	5,373,963
2024	1,675,486	1,244,851	2,523,101	5,443,439
2025	1,696,870	1,260,739	2,555,304	5,512,914
2026	1,719,255	1,277,371	2,589,012	5,585,638
2027	1,741,639	1,294,002	2,622,721	5,658,361
2028	1,764,023	1,310,633	2,656,429	5,731,085
2029	1,786,407	1,327,264	2,690,137	5,803,808
2030	1,808,792	1,343,895	2,723,845	5,876,532

Source Requirements for Proposals Plus Entitlements

	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
Now	823,022	1,178,473	905,180	2,906,674
2015	1,149,951	1,393,805	1,237,955	3,781,710
2020	1,461,475	1,587,397	1,375,000	4,423,872
2025	1,635,686	2,016,533	1,664,773	5,316,992
2030	1,815,561	2,156,110	1,920,455	5,892,126
+Entitlements	2,112,592	2,677,702	1,920,455	6,710,749

Installed Capacity Less Largest Pump Requirements for Proposals Plus Entitlements

	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
Now	1,851,799	2,651,564	2,036,654	6,540,016
2015	2,587,390	3,136,060	2,785,398	8,508,848
2020	3,288,319	3,571,642	3,093,750	9,953,711
2025	3,680,294	4,537,199	3,745,739	11,963,232
2030	4,085,013	4,851,248	4,321,023	13,257,284
+Entitlements	4,753,332	6,024,830	4,321,023	15,099,185

“Installed Capacity Less Largest Pump Requirements” refers to the amount of capacity that would be required by this standard, assuming that an additional pump was out of service. The numbers here do not reflect the capacity of that additional pump. Rather, they reflect the amount of capacity required after a hypothetical pump is out of service.

Installed Capacity Requirements

Based upon total installed capacity requirements shown in Table 5-2, requirements for new capacity only, i.e. only the portion of capacity above and beyond that at present, are presented in Table 5-3.

FIGURE 5-3. Required Additions to Installed Capacity

Required Addition to Installed Capacity Less Largest Pump Requirements for Base Case - Elasticity = 1

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
2008	544,556	-302,966	1,148,710	1,390,299
2009	565,441	-287,450	1,180,160	1,458,151
2010	586,325	-271,933	1,211,609	1,526,002
2011	609,321	-254,848	1,246,238	1,600,711
2012	632,316	-237,763	1,280,866	1,675,419
2013	655,311	-220,678	1,315,495	1,750,128
2014	678,306	-203,593	1,350,123	1,824,836
2015	701,302	-186,508	1,384,751	1,899,545
2016	720,631	-172,147	1,413,859	1,962,343
2017	739,960	-157,785	1,442,967	2,025,142
2018	759,290	-143,424	1,472,075	2,087,940
2019	778,619	-129,063	1,501,183	2,150,739
2020	797,948	-114,702	1,530,291	2,213,537
2021	819,333	-98,813	1,562,493	2,283,013
2022	840,717	-82,925	1,594,696	2,352,488
2023	862,102	-67,037	1,626,899	2,421,963
2024	883,486	-51,149	1,659,101	2,491,439
2025	904,870	-35,261	1,691,304	2,560,914
2026	927,255	-18,629	1,725,012	2,633,638
2027	949,639	-1,998	1,758,721	2,706,361
2028	972,023	14,633	1,792,429	2,779,085
2029	994,407	31,264	1,826,137	2,851,808
2030	1,016,792	47,895	1,859,845	2,924,532

Required Addition to Installed Capacity Less Largest Pump Requirements for Proposals Plus Entitlements

	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
Now	544,556	-302,966	1,148,710	1,390,299
2015	1,795,390	1,840,060	1,921,398	5,556,848
2020	2,496,319	2,779,642	2,301,750	7,001,711
2025	2,888,294	3,745,199	2,953,739	9,011,232
2030	3,293,013	4,059,248	3,529,023	10,305,284
+Entitlements	3,961,332	5,232,830	3,529,023	12,147,185

Projected installed capacity requirements are shown in Figure 5-4. Installed capacity requirements increase five times as much in the build-out scenario as in the base case forecast.

Forecast capacity requirements rise more slowly than may be expected at first glance, because after the existing year, unaccounted-forwater is assumed to drop from current levels to 12% for Lana‘i City and Kaumalapau, and 15% for the other service districts. While this may not occur by year two, it is the target over the planning period.

System Standards refer only to systems utilized for drinking water by either humans or livestock. Since neither humans nor livestock are served with drinking water from the brackish systems, the standards do not apply to them at this time. However, this provides information the margin of reliability of these systems.

Lanaʻi City, Koele & Kaumalapau - Wells 6 & 8 Service Area

Supply Objectives and General Alternatives

Lanaʻi City, the Koele Project District and Kaumalapau are served by Wells 6 and 8. Well 3 once provided back-up for this area, but is currently out of service. Well 7 is not in use.

Based upon pumped demand, with Well 3 out of service, the system does not currently meet standards for installed capacity. 2/3 of the capacity of the smaller pump is only 528,000 GPD, while 1.5 x metered demand is 783,113 GPD.

Depending upon whether growth occurs at the forecasted rate, or at the build-out pace proposed, the Lanaʻi City system could require between 0.47 and 2.76 MGD in additional installed capacity over the planning period. Assuming an average productivity of 300,000 GPD per well, this means that anywhere from 2 to 9 additional wells could be required to meet capacity standards.

Existing plans for this service area include the replacement of Well 3 and bringing Well 7 on line. The addition of these two wells would be adequate to meet base case forecasted demands, assuming both could deliver the estimated 300,000 GPD. The sum of proposed withdrawals from wells proposed in the Leeward aquifer is greater than the aquifer's sustainable yield. One or more wells may be developed purely for distribution of withdrawals, or a well in the Windward aquifer may be required instead.

Potential well sites for the build-out scenario are identified and characterized later in this chapter. Options considered for the service area of Wells 6 & 8 include recommissioning of Maunalei Shaft 2, drilling wells at or near the old Maunalei sources, drilling a well at Malau, wells in the Kauiki or watershed. Other options include desalinization, loss reduction and other measures listed above.

Supply side measures that would reduce losses specifically in this service area include replacement of substandard lines, including the line to Kaumalapau, old asbestos transmission lines above the city, and old steel lines within Lanaʻi City. Supply and demand side conservation measures that would affect all service areas, including this one, are discussed later in this chapter.

Manele & Palawai Irrigation Grid - Wells 2 & 4 Service Area

Supply Objectives and General Alternatives

Manele and the Palawai Irrigation Grid are supplied primarily by Well 4. Well 2 is rarely used at this time, because it is necessary to take a cable car down to the well to start and stop it. The defunct Well 3 once served as a backup to this system, although there is no dedicated storage for this set-up.

Well 4 has the smallest total capacity and is therefore the well which remains in service when the largest pump is assumed out of service for standards evaluaton. Well 4 has adequate capacity to meet max day demands. So this system technically meets standards for installed redundancy. However, with Well 2 rarely used due to logistical issues, one has to conclude that some work is needed to stabilize reliability.

This service area will require additional installed capacity of 0.35 MGD to 4.4 MGD to meet *System Standards* over the planning period, depending upon whether growth occurs at the forecasted rate, or at the build-out pace proposed.

Existing plans for this service area include the replacement of Well 2 and possible addition of a Well 2-B at the site of the old Shaft 3. In addition, the replacement of Well 3 will be able to make use of the old connection between these systems. These projects would be adequate to meet the base case forecasted requirements, but again, the sum of withdrawals from new wells proposed in the Leeward aquifer exceeds that aquifer's estimated yield. Here again, one or more wells may be developed purely for distribution of withdrawals or reliability.

Potential well sites for the build-out scenario are identified and characterized later in this chapter. Options considered for the service area of Wells 2 &4 include replacement of Well 5, new potable wells at the Well 5 site, or between Well 3 and the Hi‘i tank, or in the Windward aquifer. A well located along the existing water line between Well 3 and the Hi'i tank could provide production and backup to either the Lana‘i City system or the Manele / Palawai potable system.

Development of windward sources could also be used to supplement this service area. Windward source development options have been examined both along the old Maunalei transmission line, or in Kehewai Ridge with a new line that wraps from Kehewai Ridge around the Lana‘ihale to the south. In selecting windward well site and transmission route options, care has been taken to avoid work in the areas deemed by forestry experts to have the most valuable native habitat. In selecting sites in Maunalei and Kauiki, kuleana entitlements will have to be taken into account.

An expanded interconnection between the service areas of Wells 2 & 4 and Wells 3 & 6 could help to stabilize reliability in both areas. One item that is not included in the proposed capital plan that LWCI might wish to consider is a connection between Lana‘i City / Koele service area to the new Hi‘i storage when it is constructed. Expanded interconnection could allow unused capacity of the Lana‘i City / Koele system to be used to serve the Manele / Palawai system. In this case, additional production from Well 7 or from the Windward aquifer area could be used to provide backup or, to some extent, additional water to the Manele / Palawai system. If development proceeds according to the base case forecast, the replacement of Well 3 and Well 7, combined with such interconnection, would be enough to carry both systems beyond 2015.

Reduction of system losses could also go far toward firming capacities. Supply side measures that would reduce losses specifically in this service area include replacement of substandard lines, in particular the deteriorated lines in the Palawai Irrigation Grid. These lines are known to be leaking in several areas. If replacement of these lines could reduce losses from 44% to 15% as projected, this would save 202,000 GPD in pumped demand, and reduce the amount of installed capacity required by about 300,000 GPD. This measure compares favorably to new source development on a levelized cost basis.

Manele District Non-Potable System

Supply Objectives and General Alternatives

Water service for irrigation in the Manele Project District area currently consists of brackish water from Wells 1, 9 and 14, and 72,940 GPD of reclaimed water. Wells 1, 9 & 14 have some problems. Well 1 is pumping below design capacity to mitigate dropping water levels. Water levels in Wells 9 and 14 are also dropping. Well 10 and Well 12 appear to be non-productive.

Declining water levels indicate the need for increased distribution of withdrawals. Efforts are under way to develop a Well 15, in the hopes of providing additional capacity to this system.

Although *System Standards* do not apply to non-potable water service, it is still a good idea to plan for some redundancy. Some reliability is provided by the 15 MG brackish reservoir. The 15 MG brackish reservoir holds more than 13 times the current installed daily capacity requirement, and 7 times more than the build-out daily capacity requirement. Pumped water storage adds reliability, but it does not add source availability.

The service area of Wells 1, 9 and 14 would be expected to require an additional 0.7 MGD to 1.8 MGD in installed capacity depending upon whether growth occurs at the forecasted rate, or at the build-out pace proposed. However, this system is not required to meet *System Standards* for installed capacity. Source requirements based upon projected metered demand plus 15% range from 1.21 to 1.69 MGD, resulting in an increased source requirement of 0.316 to 0.795 MGD. According to the base case forecast, wastewater availability at Manele is expected to increase from 72,940 to 98,711 GPD, an increase of 25,771 GPD. This would not be adequate to meet even the base case projection of increased demand. Build-out of the CCR proposal plus entitlements could generate a total of 296,586 GPD in wastewater, or an increase of 223,646 GPD. After adjustments for treatment and low return rates discussed in the previous chapter, reclaimed water at Manele, even with buildout would be less than 150,000 GPD, an even greater shortfall.

If additional use of the brackish aquifer were an option, assuming that distribution of withdrawals could help to resolve dropping water levels, this would be met by three to seven new wells. However, the existing type and degree of use of brackish water from the high level aquifer is disputed, and significant increases in use are likely to be disputed as well. County Ordinance 2408 (1995), amending Chapter 19.70 of the Maui County Code stated that the total amount of non-potable water drawn from the high level aquifer that may be used for irrigation of the golf course, driving range or other associated landscaping should not exceed an average of 650,000 gallons per day. An issue remains unresolved as to whether “associated landscaping” is meant to include all non-potable irrigation at the Manele Project District, or only the Golf Course area itself. From a review of documents from 1989 through 1993 it appears that initial stipulations were that residential irrigation, would come from outside the High Level aquifer. (*Examples: Hearings Docket A89-649 re: Manele Golf Course, Table distributed by CCR to Maui Planning Commission 12/28/1992, showing 0.55 MGD of non-potable water from the high level aquifer for the Golf Course, and 0.4 MGD of irrigation water from sources outside the high level aquifer for irrigation of residential properties, October 12, 1995 letter from Department of Water Supply to Department of Planning regarding Manele Project District Residential and Multi-family Development, Increment I - Project District Phase 2 approval for 166 SF and 96 MF units, indicating their understanding that no water from the high level aquifer would be used for landscape irrigation pursuant to condition 7 of the District Boundary Amendment.*)

Options to meet increasing demand requirements for this service area include increased use of reclaimed water to the extent available, development of new brackish wells outside the high level aquifer to provide irrigation water or as feedstock for desalination, seawater desalination, irrigation efficiency improvements, covers to reduce evaporation from the 15 MG Brackish Reservoir, and a pipeline connecting Lanaʻi City Auxiliary Treatment Facility to the Manele Project District irrigation area. Even at full build-out, this last option would not be practical until toward the end of the planning period. If installed, it could provide up to about 0.5 MGD of reclaimed water to Manele, with the remainder of the available reclaimed water used in Lanaʻi City and Koele. However, it would require expanded treatment capacity in Lanaʻi City, which is unlikely to be funded by the County during the planning period. Althouth some delay and expense are involved, this option, combined with reductions in system losses and conservation measures, could meet projected source requirements for non-potable water in Manele. Much will depend on how new developments are landscaped and irrigated.

Koele Golf Course Non-Potable System

Supply Objectives and General Alternatives

This system provides non-potable water for irrigation purposes. Treated effluent from the Lanaʻi City Auxiliary Wastewater Treatment Facility is pumped to the *The Experience at Koele* Golf Course as its sole source of water for irrigation purposes. County Code 19.71.055, defines special situations and exceptions during which potable water may be used, as well as the approvals required for each.

Water demand for this system is characterized in the 2002 report, “Storage and Supply Master Plan for the Koele Golf Course” by R. M. Towill Corporation. (RMTC), and in related reports to CCR by RMTC. In normal rainfall conditions, demand averages 256,000 GPD, peaking in the summer at

486,000 GPD.

During 2008, the Auxiliary Water Treatment Facility provided 234,093 GPD to the golf course, indicating that current supply falls short of average needs by approximately 22,000 GPD. In drought conditions consumption is higher, averaging 346,000 GPD, with summer peaks of 511,000 GPD.

Anticipated reclaimed water generated by either the base case or build-out scenario is expected to resolve this shortfall for average periods. Reclaimed water estimates in the build-out scenario would cover current drought shortages, though these could also be met by additional use of storage. Although additional storage has not been evaluated in this document, storage systems could be evaluated further as necessary to enable increased use of effluent for the Golf Course. As suggested by RMTC (*2002*), such considerations should be kept in mind for coordination with Lana‘i City and Koele Project District drainage improvements as well.

Potential Supply Options

Development of New Wells

The following pages discuss new wells which could be developed to provide additional water supply for Lana‘i. Aside from additional supply, benefits provided by additional wells would include improved geographical distribution of well pumping, increased production redundancy for system reliability, and potentially increased flexibility of operations.

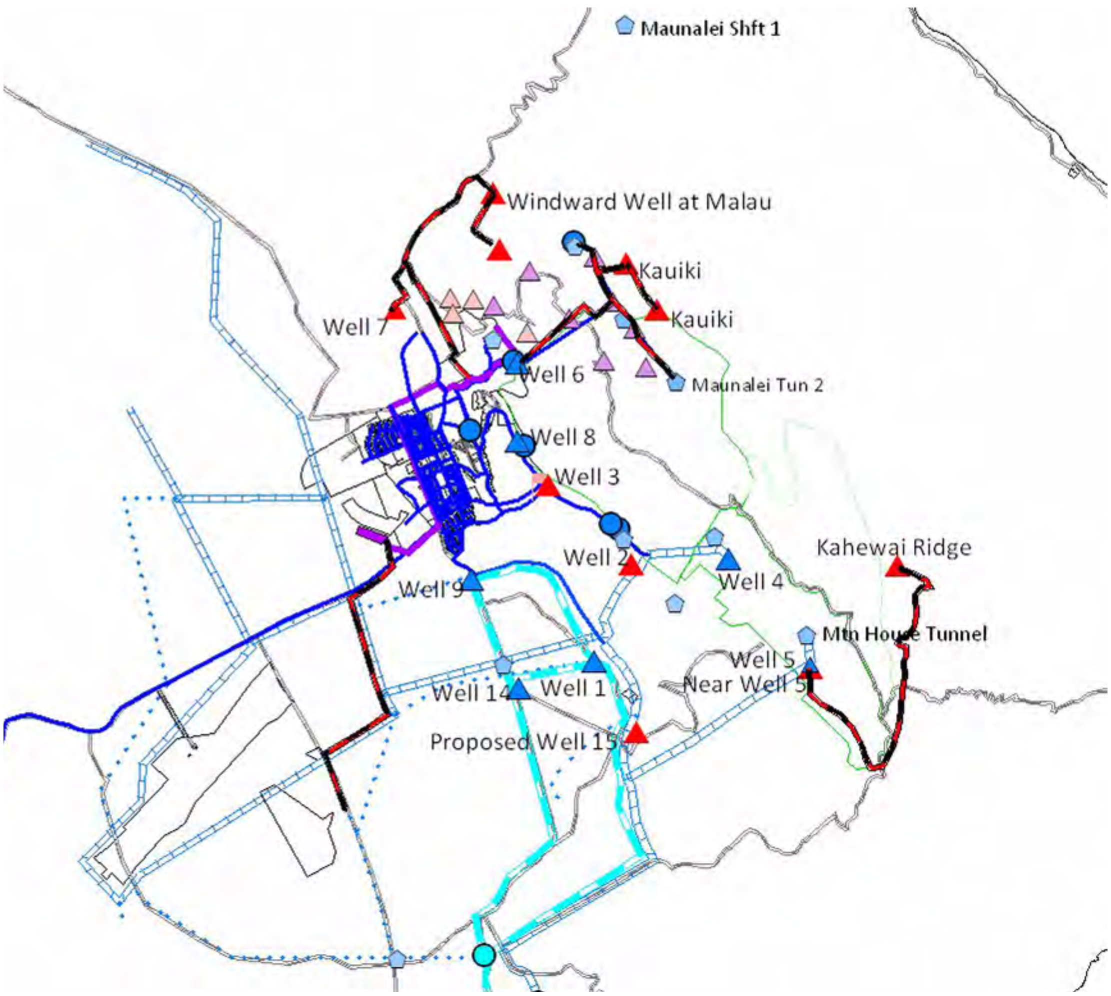
The potential magnitude of additional supply capacity that can be provided by new wells is limited by the sustainable recharge capacity of the source aquifers. Improvements in the distribution of pumping can increase the actual effective sustainable production. In order to fully develop the sustainable yield for high level potable water, it would be necessary to develop wells on the windward side of the Lana‘ihale. The need to distribute pumpage to the Windward Aquifer Sector becomes a mandate when pumpage in the Leeward Aquifer Sector approaches 2.7 MGD, or 90% of its sustainable yield. Included in the discussion of development of new wells is an option to recommission the existing Maunalei shaft and tunnels situated in the Windward Aquifer Sector.

Cost estimates for several new well development options are provided below. The costs of developing new wells include engineering, drilling, casing, pump equipment, and any necessary transmission or storage improvements, electrical supply extensions, and road improvements. Costs of operating wells include electricity for pumping, chemicals for disinfection treatment, well operation and maintenance.

Cost analyses are based on life cycle levelized costs based on the economic life of the project, assuming 6% cost of capital, 3% general annual inflation, 3% nominal fixed annual operating cost increase, 4% nominal electricity and variable cost annual increase and a 6% analysis discount rate. Variable operating costs include MECO electricity costs at $0.40 per KWH based on May 2008 prices (reflecting $125 per barrel crude oil price). Details regarding the assumptions in the characterization of project costs and cost analyses are documented in several tables including a summary table indicating the costs and unit life cycle costs for each project.

For new well development, the largest cost item over the life of the operation of the well is electricity for pumping. Levelized over the life of the well, electrical costs for some typical wells exceed capital costs by a factor of at least four. Life cycle electricity costs exceed capital costs even for options that include substantial transmission improvement capital costs.

FIGURE 5-4. Lana‘i Source Options Considered



Leeward High Level Potable Well Development (near Hi‘i Tank)

Cost analysis was performed for developing a new high level potable well near the existing water transmission line between Well 3 and the Hi‘i Tank. This location was selected considering proximity to existing transmission, distribution of leeward water pumping, probability of low-level chloride potable source water and capability to serve either or both of the island’s potable water systems.

The elevation of the well was assumed to be 1,800 ft. with a source water level of 1,100 ft. Well depth is assumed to be 1,200 ft. installed with a 0.864 MGD pump. Costs for hydrology and engineering to locate and design the well are included. Production is assumed to be 300,000 GPD. The capital cost, including engineering, drilling, development and ancillaries, water and power transmission connection and contingency, is $2.9 million. First year electrical energy cost is $1.41 per thousand gallons. The total thirty-year levelized costs are $4.49 per thousand gallons. This cost is comprised of $1.90 capital cost, $0.27 operating and maintenance cost and $2.32 electrical energy cost.

FIGURE 5-5. New High Level Well in Leeward Aquifer Near Hi‘i Tank

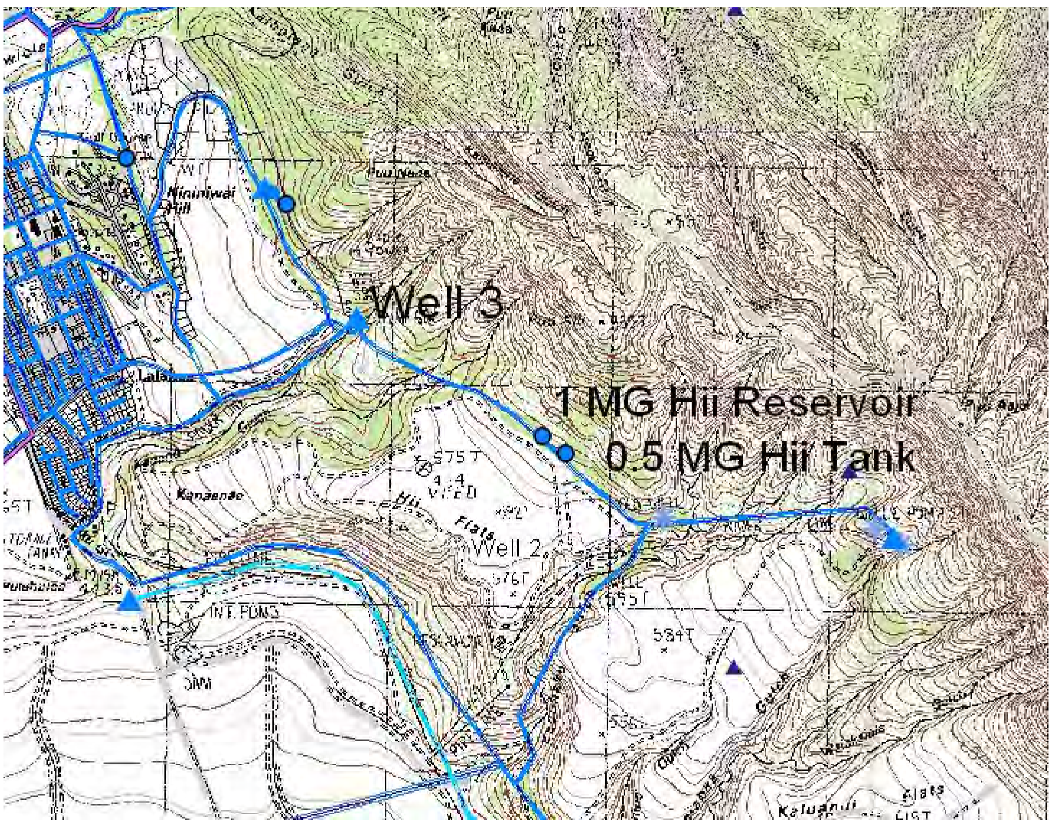


FIGURE 5-6. High Level Potable Well Near Hi'i Tank

Capacity (MGD)				
Installed Capacity		0.864		
Max. Day Capacity		0.864		
Effective Sustainable Capacity		0.300		
Facility Capacity Factor		100%		
Average Facility Output		0.300		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$30,000	$100,000	HDA Estimate	2500 ft power line to Hi'i Tank or alt. [illegible]
Drilling	$900,000	$3,000,000	HDA Estimate	(1) well 12" at 1200 ft @ $750 plf
Development	$1,159,000	$3,863,333	HDA Estimate	(1) pump 1 mgd @ $550k, SCADA, Ancillaries
Transmission Improvements	$150,000	$500,000		Feeder and connection to existing line
Storage Improvements	$0	$0		
Design / Engineering	$150,000	$500,000	HDA Estimate	Hydrology study for well location, well engineering
Contingencies	$477,800	$1,592,667	HDA Estimate	20%
Total Plant Cost (	$2,866,800	$9,556,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$2,866,800	$9,556,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$5,479	$18,263		$0.05 per kgal based on estimated Lanai average
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$15,120	$50,400		5 Kwh/kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$20,599	$68,663		
Variable Operating Costs ($)		Per kGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$1.400	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh. Vertical lift from el 1100' water level to el 1800' line grad
Chemicals/Materials		$0.008	HDA Estimate	100% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$1.408		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op Cost Disc Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op Cost Disc Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		$3.876		
Amortized Cap. Cost (Book Life)		$2.281		
Fixed Op. Cost		$0.188		
Varible Op. Cost		$1.408		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	19.055	$4.551		
Capital Cost (20 year Amort.)	9.556	$2.281		
Fixed Op. Cost	1.030	$0.246		
Varible Op. Cost	8.469	$2.021		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	22.554	$4.489		
Capital Cost (Amort. per Econ. Life)	9.556	$1.901		
Fixed Op. Cost	1.361	$0.271		
Varible Op. Cost	11.636	$2.315		

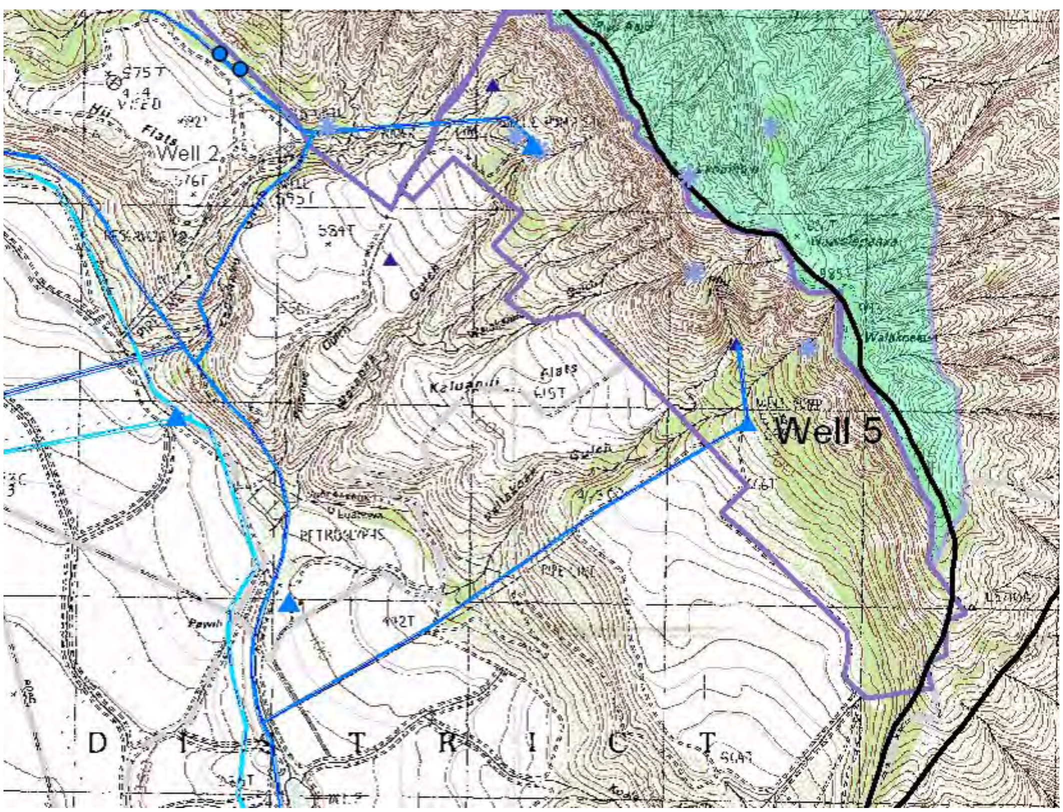
Leeward High Level Potable Well Development (near Well 5)

Existing Well 5 is in a promising location but has problems associated with its well and/or pump installation. An analysis of the feasibility of refurbishing this well or drilling an adjacent new well could provide an economical new source. If this option is selected, the highlighted bright (blue-ish) green area is an area to avoid, due to remaining high quality native habitat.

The costs of drilling a new well adjacent to Well 5 and using existing access, transmission and power supply improvements were estimated. The elevation of the well and the elevation of the aquifer water level were assumed to be the same as Well 5. The project includes the costs of engineering, well drilling, development including ancillaries, connection to adjacent power and water transmission lines and contingencies.

Production is assumed to average 300,000 GPD. Incremental capitalized costs are $3.0 million. First year electrical energy cost is $1.61 per thousand gallons. The total thirty-year levelized costs are $4.91 per thousand gallons. This cost is comprised of $1.96 capital cost, $0.30 fixed operating and maintenance cost and $2.64 electrical energy cost.

FIGURE 5-7. **High Level Potable Well Development Near Well 5**



Potential Supply Options

FIGURE 5-8. Leeward High Level Potable Well Development (near Well 5)

Capacity (MGD)				
Installed Capacity		0.864		
Max. Day Capacity		0.864		
Effective Sustainable Capacity		0.300		
Facility Capacity Factor		100%		
Average Facility Output		0.300		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$5,000	$16,667	HDA Estimate	Connection to existing power line
Drilling	$900,000	$3,000,000	HDA Estimate	(1) well 12" at 1200 ft @ $750 plf
Development	$1,159,000	$3,863,333	HDA Estimate	(1) pump 1 mgd @ $550K, SCADA, ancillaries
Transmission Improvements	$100,000	$333,333		Feeder and connection to existing line
Storage Improvements	$250,000	$833,333		50Kgal contact tank, chlorinator
Design / Engineering	$50,000	$166,667	HDA Estimate	Well engineering
Contingencies	$492,800	$1,642,667	HDA Estimate	20%
Total Plant Cost (	$2,956,800	$9,856,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$2,956,800	$9,856,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$5,479	$18,263		$0.05 per kgal based on estimated Lanai average
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$17,280	$57,600		5 kwh/kgal/kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$22,759	$75,863		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$1.600	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 1500' water level to el 2300' tank
Chemicals/Materials		$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$1.608		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op Cost Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		$4.168		
Amortized Cap. Cost (Book Life)		$2.353		
Fixed Op. Cost		$0.208		
Varible Op. Cost		$1.608		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	20.666	$4.936		
Capital Cost (20 year Amort.)	9.856	$2.353		
Fixed Op. Cost	1.138	$0.272		
Varible Op. Cost	9.672	$2.309		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	24.650	$4.906		
Capital Cost (Amort. per Econ. Life)	9.856	$1.960		
Fixed Op. Cost	1.504	$0.299		
Varible Op. Cost	13.290	$2.643		

Well 2 - B at Shaft 3 Site

Well 2 Shaft 3 is rarely operated for various reasons. LWCI intends to replace Well 2. In addition, a well at the site of Shaft 3 is considered. Some LWCI staff have posited that the behavior of water levels at the two sites indicate that these facilities may tap different dike compartments. Additional studies are planned to examine this hypothesis. If it proves to be the case, then in addition to replacing Well 2, an additional well, Well 2-B is intended.

The costs of drilling a new well at the Shaft 3 site and using existing access, transmission and power supply improvements were estimated. The elevation of the well and the elevation of the aquifer water level were assumed to be the same as Well 2/Shaft 3. The project includes the costs of engineering, well drilling, development including ancillaries, connection to adjacent power and water transmission lines and contingencies.

Production is assumed to average 300,000 GPD. Incremental capitalized costs are $1.9 million. First year electrical energy cost is $0.92 per thousand gallons. The total thirty-year levelized costs are $2.97 per thousand gallons. This cost is comprised of $1.25 capital cost, $0.20 fixed operating and maintenance cost and $1.51 electrical energy cost.

FIGURE 5-9. Well 2-B

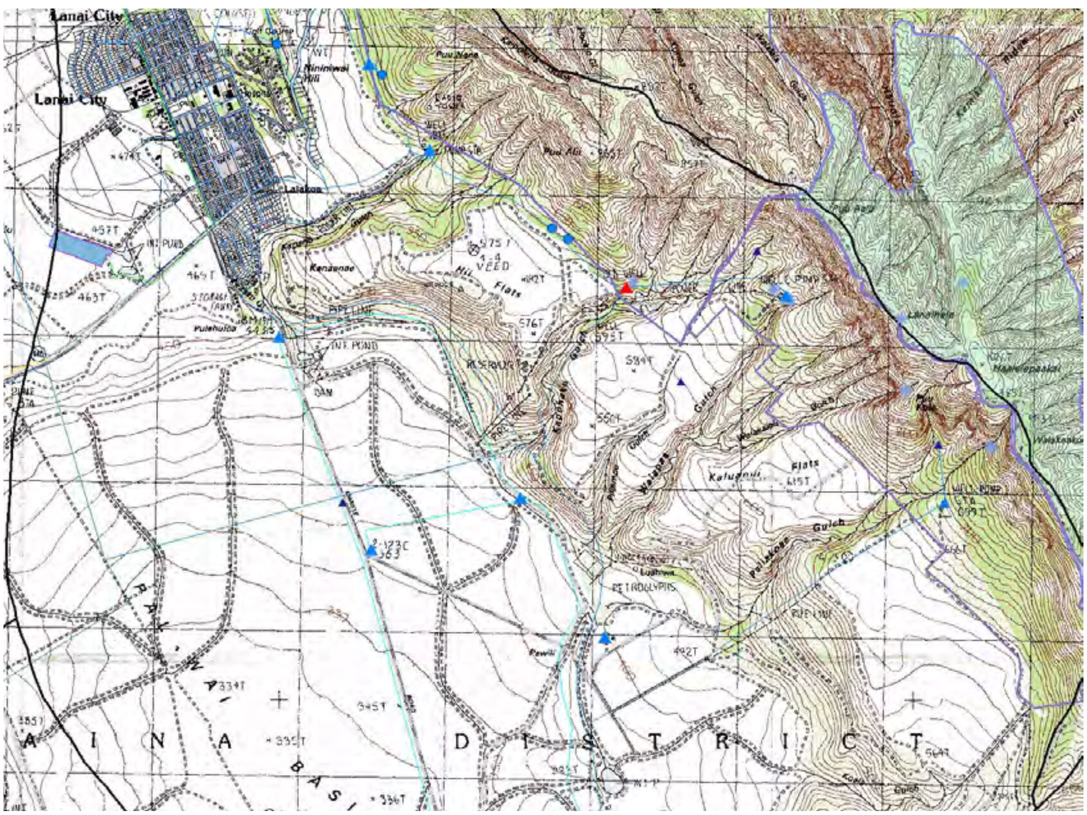


FIGURE 5-10. Well 2-B at Shaft 3 Site

Capacity (MGD)				
Installed Capacity		0.864		
Max. Day Capacity		0.864		
Effective Sustainable Capacity		0.300		
Facility Capacity Factor		100%		
Average Facility Output		0.300		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$5,000	$16,667	HDA Estimate	Connection to existing power line
Drilling	$255,000	$850,000	HDA Estimate	(1) well 12" at 300 ft @ $850 plf
Development	$1,159,000	$3,863,333	HDA Estimate	(1) pump 1 mgd @ $550k, SCADA, ancillaries
Transmission Improvements	$100,000	$333,333		Feeder and connection to existing line
Storage Improvements	$0	$0		
Design / Engineering	$50,000	$166,667	HDA Estimate	Well engineering
Contingencies	$313,800	$1,046,000	HDA Estimate	20%
Total Plant Cost (	$1,882,800	$6,276,000		
Expenditure Pattern Year	Nom	Normalized		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$1,882,800	$6,276,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$5,479	$18,263		$0.05 per kgal based on estimated Lanai average
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$9,936	$33,120		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrica energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$15,415	$51,383		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$0.920	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 1350' water level to el 1810' tank el
Chemicals/Materials		$0.000		
Maintenance Expenses				
Total Variable Op. Costs		$0.920		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	30			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$2.309**		
Amortized Cap. Cost (Book Life)		$1.248		
Fixed Op. Cost		$0.141		
Varible Op. Cost		$0.920		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**12.582**	**$3.005**		
Capital Cost (20 year Amort.)	6.276	$1.498		
Fixed Op. Cost	0.771	$0.184		
Varible Op. Cost	5.536	$1.321		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**14.901**	**$2.966**		
Capital Cost (Amort. per Econ. Life)	6.276	$1.248		
Fixed Op. Cost	1.019	$0.203		
Varible Op. Cost	7.606	$1.513		

Recommission Well 7

Well 7 is not presently in use. Although initial water levels appear to have been lower than those in many of the pumping wells, it offers some advantages. The fact that the well has already been drilled would help to keep costs of development down. Well 7 could readily be tied in to both the City system and the west end of the Palawai Irrigation Grid, offering operational flexibility. Well 7 could serve as a backup well to enhance system reliability.

The costs of bringing Well 7 on line were estimated assuming new transmission, storage and pump facilities. The well is at 1,775' elevation with a water level of 650'. The project includes the costs of engineering, refurbishing the pump site, development including ancillaries, connection to adjacent power and water transmission lines and contingencies.

Production is assumed to average 300,000 GPD. Capital costs are $2.7 million. First year electrical energy cost is $2.39 per thousand gallons. The total thirty-year levelized costs are $6.02 per thousand gallons. This cost is comprised of $1.78 capital cost, $0.35 fixed operating and maintenance cost and $3.89 electrical energy cost.

FIGURE 5-11. Recommission Well 7

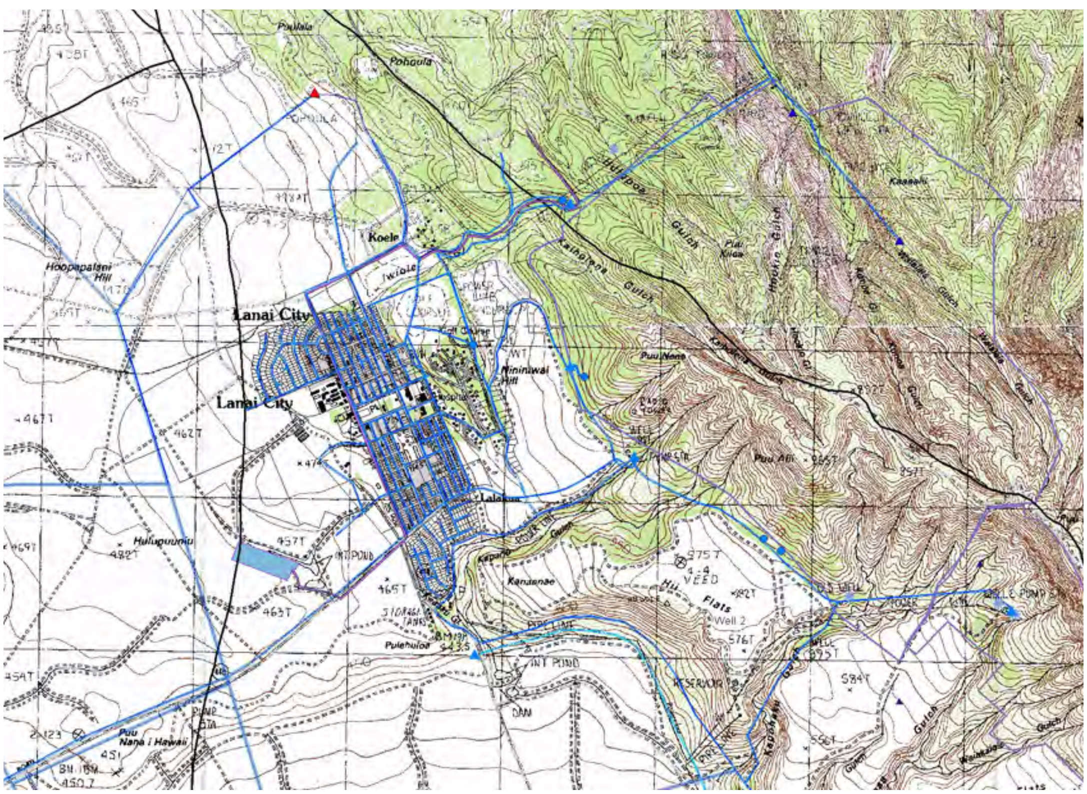


FIGURE 5-12. Recommission Well 7

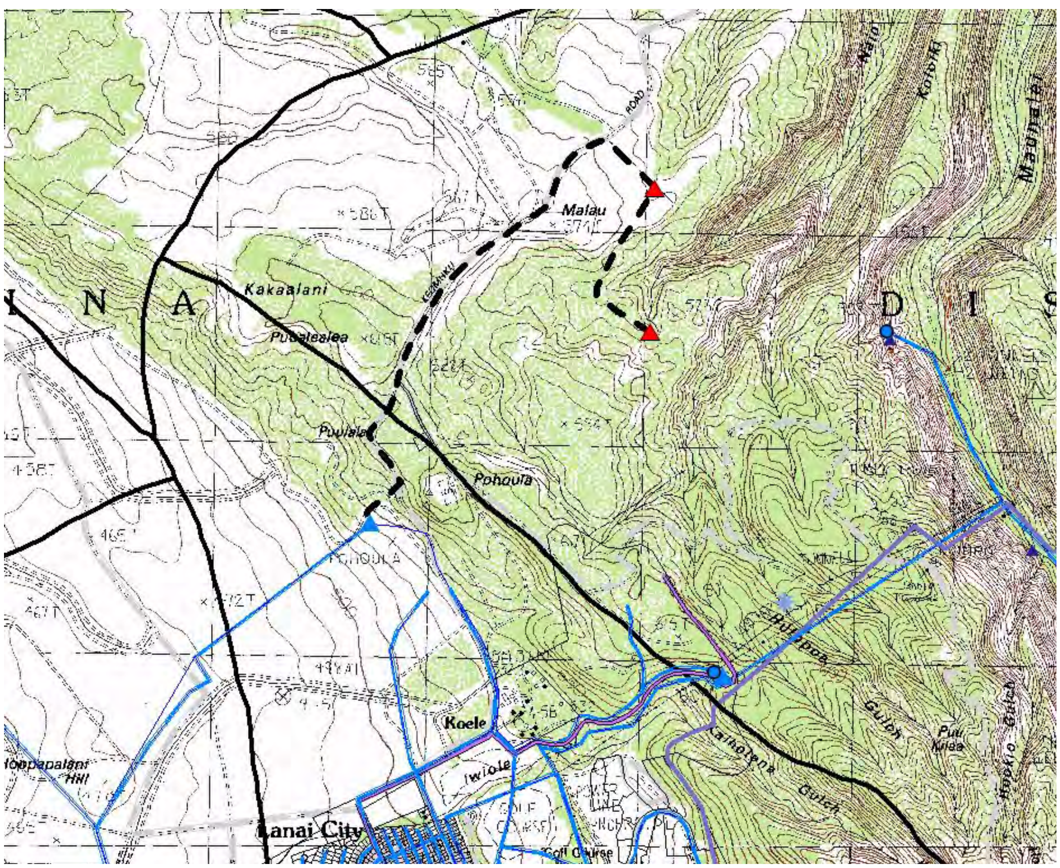
Capacity (MGD)				
Installed Capacity		0.720		
Max. Day Capacity		0.720		
Effective Sustainable Capacity		0.300		
Facility Capacity Factor		100%		
Average Facility Output		0.300		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$0	$0	HDA Estimate	Existing well site
Refurbish well site	$50,000	$166,667	HDA Estimate	Refurbish well site
Development	$1,159,000	$3,863,333	HDA Estimate	(1) pump 1 mgd @ $550k, SCADA, ancillaries
Transmission Improvements	$697,842	$2,326,140		2900 ft 8" line @ $200 plf to L.C Tank
Storage Improvements	$250,000	$833,333		50Kgal contact tank; chlorinator
Design / Engineering	$75,000	$250,000	HDA Estimate	Hydrology, siting, well engineering
Contingencies	$446,368	$1,487,895	HDA Estimate	20%
Total Plant Cost (	$2,678,210	$8,927,368		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$2,678,210	$8,927,368		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$5,479	$18,263		$0.05 per kgal based on estimated Lanai average
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$21,240	$70,800		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$26,719	$89,062		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$2.360	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 1000' water level to el 1850' tank
Chemicals/Materials		$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$2.368		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$4.742**		
Amortized Cap. Cost (Book Life)		$2.131		
Fixed Op. Cost		$0.244		
Varible Op. Cost		$2.368		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**24.508**	**$5.854**		
Capital Cost (20 year Amort.)	8.927	$2.131		
Fixed Op. Cost	1.336	$0.319		
Varible Op. Cost	14.245	$3.400		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**30.266**	**$6.024**		
Capital Cost (Amort. per Econ. Life)	8.927	$1.776		
Fixed Op. Cost	1.766	$0.351		
Varible Op. Cost	19.573	$3.893		

Windward Wells at Malau

The area north of Lana‘i City along Commode Road near the ridge is in the northwest portion of the Windward aquifer. There are several possible well site locations in this area. This area is approximately one mile north of Well 6. This area is reasonably close to existing power and water transmission lines and would have economical road access.

Costs for a new potable well at this location were analyzed assuming a wellhead ground elevation of 1810 feet pumping from a water level of 1000 ft. to the Lana‘i City tank elevation of 1850 feet. Production is assumed to be 300,000 GPD with a 0.864 MGD pump. Capital costs include engineering, drilling, well development and ancillaries, contact tank with chlorination, new 8" water transmission line to Lana‘i City tank and contingency. First year electricity cost is $1.71 per thousand gallons. The total thirty-year levelized costs are $7.35 per thousand gallons. This cost is comprised of $4.23 capital cost, $0.31 fixed operating and maintenance cost and $2.81 electrical energy cost.

FIGURE 5-13. Windward Wells at Malau



Potential Supply Options

FIGURE 5-14. Windward Wells at Malau

Capacity (MGD)				
Installed Capacity		0.864		
Max. Day Capacity		0.864		
Effective Sustainable Capacity		0.300		
Facility Capacity Factor		100%		
Average Facility Output		0.300		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$5,000	$16,667	HDA Estimate	Connection to existing power line
Drilling	$750,000	$2,500,000	HDA Estimate	(1) well 12" at 1000 ft @ $750 plf
Development	$1,159,000	$3,863,333	HDA Estimate	(1) pump 1 mgd @ $550k, SCADA, ancillaries
Transmission Improvements	$3,000,000	$10,000,000		15,000 ft 8" line @ $200 plf to L.C.Tank
Storage Improvements	$250,000	$833,333		50Kgal contact tank; chlorinator
Design / Engineering	$150,000	$500,000	HDA Estimate	Hydrology, siting, well engineering
Contingencies	$1,062,800	$3,542,667	HDA Estimate	20%
Total Plant Cost (	$6,376,800	$21,256,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$6,376,800	$21,256,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$5,479	$18,263		$0.05 per kgal based on estimated Lanai average
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$18,360	$61,200		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$23,839	$79,463		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$1.700	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 1000' water level to el 1850' tank
Chemicals/Materials		$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$1.708		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$6.999**		
Amortized Cap. Cost (Book Life)		$5.074		
Fixed Op. Cost		$0.218		
Varible Op. Cost		$1.708		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**32.722**	**$7.816**		
Capital Cost (20 year Amort.)	21.256	$5.074		
Fixed Op. Cost	1.192	$0.284		
Varible Op. Cost	10.274	$2.452		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**36.948**	**$7.354**		
Capital Cost (Amort. per Econ. Life)	21.256	$4.228		
Fixed Op. Cost	1.575	$0.313		
Varible Op. Cost	14.117	$2.808		

Recommission Windward Maunalei Shaft and Tunnels

The Maunalei Shaft #2 and the Maunalei Tunnels #1 and #2 are located two miles northeast of Lana'i City in Maunalei gulch. Shaft #2 is located at the 850' elevation. The tunnels are located at the 1,100' and 1500' elevation respectively. These windward aquifer sources draw water at approximately the same elevation as the water levels in the leeward high level potable aquifer sources. These were once major developed sources of water for the island. Existing but old high pressure water transmission lines connect these sources with one another and up the side of the gulch to the location of Well 6.

The cost of using Maunalei sources was evaluated with four assumptions. In this option, existing sources could be refurbished, but transmission would need replacement. Although this scenario is unlikely, it is examined here for the benefit of cost comparison. It assumes the need for source improvements, a booster pump station and control tank. The feasibility of recommissioning these water sources would have to be determined by further study. Cost estimates include hydrology and feasibility study, engineering, new power and water transmission lines, source improvements, SCADA and ancillaries, booster station, control and contact storage tank and contingency.

Two principal cost elements for this project are the capital cost of the transmission improvements and electrical costs to pump water from the sources in the gulch up to the 2,060 foot hydraulic elevation at the ridge. Capitalized costs total $10.1 million in this scenario. First year electricity cost is $2.43 per thousand gallons. The total thirty-year levelized costs are $8.40 per thousand gallons. This cost is comprised of $4.02 capital cost, $0.38 fixed operating and maintenance cost and $3.99 electrical energy cost.

FIGURE 5-15. Recommission Windward Maunalei Shaft and Tunnels

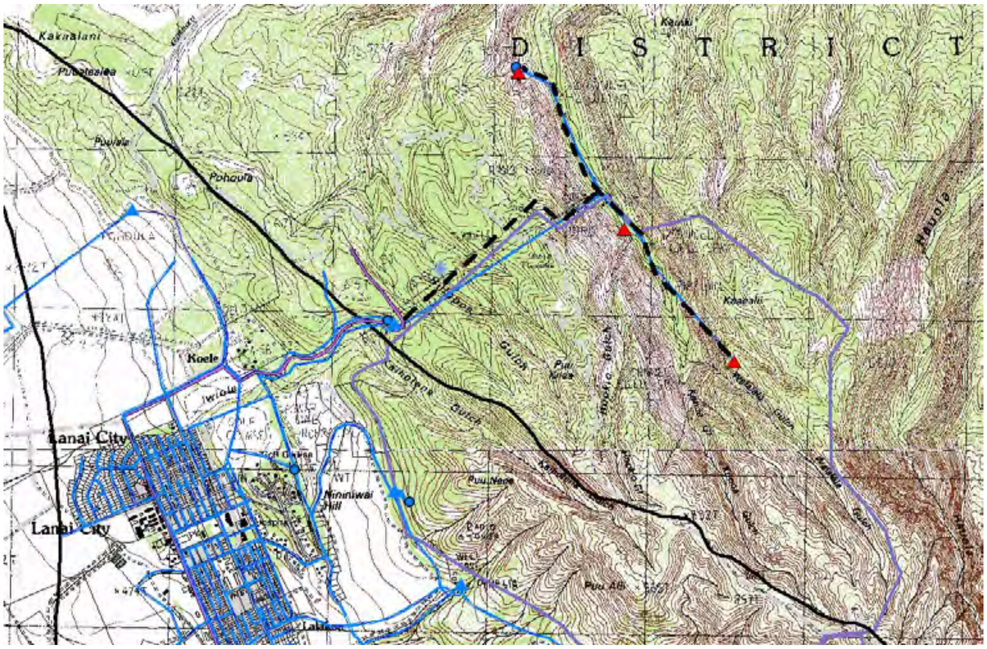


FIGURE 5-16. Recommissioning Windward Maunalei Shaft and Tunnels

Capacity (MGD)				
Installed Capacity		1.000		
Max. Day Capacity		0.750		
Effective Sustainable Capacity		0.500		
Facility Capacity Factor		100%		
Average Facility Output		0.500		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$175,000	$350,000	HDA Estimate	Electrical controls, water utility power transmission ext. share Road improvements
Shaft / Tunnel Improvements	$750,000	$1,500,000	HDA Estimate	
Development / Booster Station	$1,500,000	$3,000,000	HDA Estimate	SCADA, ancillaries, booster station w/intake sump structure
Transmission Improvements	$5,500,000	$11,000,000	HDA Estimate	4500 ft 8" line @ $200 plf feeds to lift 4750 ft 10" hp line @ $500 plf Maunalei to ridge to Well #6 5000 ft 12" line @ $445 plf Well#6 to Lanai City Tank
Storage Improvements	$250,000	$500,000		50kgal contact/control tank
Design / Engineering	$250,000	$500,000	HDA Estimate	Hydrology study, engineering
Contingencies	$1,685,000	$3,370,000	HDA Estimate	20%
Total Plant Cost (	$10,110,000	$20,220,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$10,110,000	$20,220,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$18,263	$36,525		$0.10 per kgal based on two times average due to remote location
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$30,250	$60,500		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$48,513	$97,025		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$2.420	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 850' water level to el 2060' hydraulic line at ridge"
Chemicals/Materials		$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$2.428		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$7.520**		
Amortized Cap. Cost (Book Life)		$4.826		
Fixed Op. Cost		$0.266		
Varible Op. Cost		$2.428		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**36.281**	**$8.666**		
Capital Cost (20 year Amort.)	20.220	$4.826		
Fixed Op. Cost	1.455	$0.347		
Varible Op. Cost	14.606	$3.486		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**42.213**	**$8.402**		
Capital Cost (Amort. per Econ. Life)	20.220	$4.022		
Fixed Op. Cost	1.923	$0.383		
Varible Op. Cost	20.069	$3.992		

Windward Wells at Maunalei Shaft and Tunnel Sites

Wells could be developed in the bottom of Maunalei gulch. This would require similar improvements as recommissioning the Maunalei #2 Shaft and tunnels described above, including new or repaired transmission lines and a new booster station.

Cost analysis was performed for several scenarios. Two scenarios assume that the existing transmission pipes, right of way and electrical lines to the Maunalei sources could be used with some improvements. Booster station construction and other improvements in these scenarios are similar to the recommissioning scenario described above. Costs were derived for approaches that include development of two and three wells, respectively.   A third scenario assumes that construction of new high pressure transmission lines will be necessary.

In all three scenarios it is assumed that the new wells would be in the vicinity of the Maunalei 2 Shaft and/or Maunalei Tunnels along the existing collector line that serves these sources. Costs of hydrology and engineering studies to locate and design the wells is included. The wells are assumed to be at an elevation of 850 to 1100 ft. pumping from a water level of 800 to 1,000 ft. Pumping costs are estimated based on pumping water over the ridge at the location of the existing line at an elevation of 2,060 ft. Wells are assumed to be 500 ft. deep installed with 1 MG pumps.

For two wells relying on improvements to existing transmission with a total average output of 500,000 GPD. the capital cost is $6.8 million. First year electrical energy cost is $2.43 per thousand gallons. The total thirty-year levelized costs are $7.31 per thousand gallons. This cost is comprised of $2.69 capital cost, $0.62 fixed operating and maintenance cost and $3.99 electrical energy cost.

For three wells using existing transmission, the total average output is assumed to be 750,000 GPD. The capitalized cost is $8.0 million. First year electrical energy cost is $2.43 per thousand gallons. The total thirty-year levelized costs are $6.73 per thousand gallons. This cost is comprised of $2.12 capital cost, $0.62 fixed operating and maintenance cost and $3.99 electrical energy cost.

For three wells with new transmission pipe installed from the wells to the Lana‘i City tank the capital cost is $6.5 million. First year electrical energy cost is $2.43 per thousand gallons. The thirty-year levelized costs are $8.49 per thousand gallons. This cost is comprised of $3.87 capital cost, $0.62 fixed operating and maintenance cost and $3.99 electrical energy cost.

No picture is provided as these would be in the same area indicated on the previous page.

FIGURE 5-17. Two New Wells at Maunalei Shaft and Tunnel Sites Existing Transmission

Capacity (MGD)				
Installed Capacity		2.000		
Max. Day Capacity		1.000		
Effective Sustainable Capacity		0.500		
Facility Capacity Factor		100%		
Average Facility Output		0.500		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$20,000	$40,000	HDA Estimate	Connection to existing power line
Drilling	$750,000	$1,500,000	HDA Estimate	(2) wells 12" 500ft deep @ $750/ft.
Development	$3,318,000	$6,636,000	HDA Estimate	(2) 1 MGD pumps@$500k", SCADA, Ancillaries Booster Pump Station, Intake sump well
Transmission	$1,200,000	$2,400,000	HDA Estimate	Repairs, improvements and connection to existing transmission line
Storage Improvements	$250,000	$500,000		50Kgal contact/control tank
Design / Engineering	$100,000	$200,000	HDA Estimate	Hydrolgy study for well location, well engineering
Contingencies	$1,127,600	$2,255,200	HDA Estimate	20%
Total Plant Cost (	$6,765,600	$13,531,200		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$6,765,600	$13,531,200		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$18,263	$36,525		$0.10 per kgal based on two times average due to remote location
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$60,500	$121,000		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$78,763	$157,525		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$2.420	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 850' water level to el 2060' hydraulic line at ridge"
Chemicals/Materials		$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$2.428		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$6.089**		
Amortized Cap. Cost (Book Life)		$3.230		
Fixed Op. Cost		$0.431		
Varible Op. Cost		$2.428		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**30.500**	**$7.285**		
Capital Cost (20 year Amort.)	13.531	$3.230		
Fixed Op. Cost	2.363	$0.564		
Varible Op. Cost	14.606	$3.486		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**36.723**	**$7.309**		
Capital Cost (Amort. per Econ. Life)	13.531	$2.691		
Fixed Op. Cost	3.123	$0.621		
Varible Op. Cost	20.069	$3.992		

Supply Options

FIGURE 5-18. Three New Wells at Maunalei Shaft and Tunnel Sites - Existing Transmission

Capacity (MGD)				
Installed Capacity		2.000		
Max. Day Capacity		1.000		
Effective Sustainable Capacity		0.500		
Facility Capacity Factor		100%		
Average Facility Output		0.500		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$20,000	$40,000	HDA Estimate	Connection to existing power line
Drilling	$750,000	$1,500,000	HDA Estimate	(2) wells 12" 500ft deep @ $750/ft.
Development	$3,318,000	$6,636,000	HDA Estimate	(2) 1 MGD pumps@$500k", SCADA, Ancillaries Booster Pump Station, Intake sump well
Transmission	$1,200,000	$2,400,000	HDA Estimate	Repairs, improvements and connection to existing transmission line
Storage Improvements	$250,000	$500,000		50Kgal contact/control tank
Design / Engineering	$100,000	$200,000	HDA Estimate	Hydrolgy study for well location, well engineering
Contingencies	$1,127,600	$2,255,200	HDA Estimate	20%
Total Plant Cost (	$6,765,600	$13,531,200		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$6,765,600	$13,531,200		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$18,263	$36,525		$0.10 per kgal based on two times average due to remote location
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$60,500	$121,000		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$78,763	$157,525		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$2.420	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 850' water level to el 2060' hydraulic line at ridge"
Chemicals/Materials		$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$2.428		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$6.089**		
Amortized Cap. Cost (Book Life)		$3.230		
Fixed Op. Cost		$0.431		
Varible Op. Cost		$2.428		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**30.500**	**$7.285**		
Capital Cost (20 year Amort.)	13.531	$3.230		
Fixed Op. Cost	2.363	$0.564		
Varible Op. Cost	14.606	$3.486		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**36.723**	**$7.309**		
Capital Cost (Amort. per Econ. Life)	13.531	$2.691		
Fixed Op. Cost	3.123	$0.621		
Varible Op. Cost	20.069	$3.992		

FIGURE 5-19. Three New Wells at Maunalei Shaft and Tunnel Sites - New Transmission

Capacity (MGD)				
Installed Capacity		3.000		
Max. Day Capacity		2.000		
Effective Sustainable Capacity		0.750		
Facility Capacity Factor		100%		
Average Facility Output		0.750		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$25,000	$33,333	HDA Estimate	Connection to existing power line
Drilling	$2,250,000	$3,000,000	HDA Estimate	(3) wells 12" 500ft deep @ $750/ft.
Development	$3,897,500	$5,196,667	HDA Estimate	(3) 1 MGD pumps@$500k*, SCADA, Ancillaries
Transmission Improvements	$5,500,000	$7,333,333	HDA Estimate	4500 ft 8" line @ $200 plf Well feeds to lift
Storage Improvements	$250,000	$333,333		50kgal contact/control tank
Design / Engineering	$250,000	$333,333	HDA Estimate	Hydrolgy study for well location, well engineering
Contingencies	$2,434,500	$3,246,000	HDA Estimate	20%
Total Plant Cost (	$14,607,000	$19,476,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$14,607,000	$19,476,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$27,394	$36,525		$0.10 per kgal based on two times average due to remote location
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$90,750	$121,000		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$118,144	$157,525		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$2.420	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 850' water level to el 2060' hydraulic line at ridge"
Chemicals/Materials		$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$2.428		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$7.508**		
Amortized Cap. Cost (Book Life)		$4.649		
Fixed Op. Cost		$0.431		
Varible Op. Cost		$2.428		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**36.445**	**$8.705**		
Capital Cost (20 year Amort.)	19.476	$4.649		
Fixed Op. Cost	2.363	$0.564		
Varible Op. Cost	14.606	$3.486		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**42.668**	**$8.493**		
Capital Cost (Amort. per Econ. Life)	19.476	$3.874		
Fixed Op. Cost	3.123	$0.621		
Varible Op. Cost	20.069	$3.992		

Windward Wells at Kauiki

In order to explore the costs of developing wells further east in the Windward aquifer the costs of drilling and operating a well on the east side of Maunalei gulch were estimated. A site at Kauiki east and above the Maunalei gulch at 1750 feet elevation was characterized. Well drilling and development costs are assumed to be higher than other areas because of the remote location of the well site. Project costs include hydrology and engineering studies, well drilling, development including pump and ancillaries, power transmission (water utility share), high pressure water transmission line and contingencies.

Two scenarios were characterized. The first scenario includes the costs of developing new transmission lines from the wellhead, through Maunalei Gulch to the existing transmission line at Well 6. The second scenario assumes that this project would be incremental to previous development of transmission and booster station improvements to transmit water from sources in Maunalei Gulch. In this case transmission improvements would include high pressure transmission lines from the wellhead down into Maunalei gulch and connection with the existing transmission system at the booster station. Both scenarios assume installed well capacity of 1 MGD and average production of 300,000 GPD.

Assuming that the project includes construction of new transmission to the connection to the existing water system at Well 6, the capitalized costs are $10.9 million. First year electrical energy cost is $2.73 per thousand gallons. The total thirty-year levelized costs are $12.27 per thousand gallons. This cost is comprised of $7.24 capital cost, $0.53 fixed operating and maintenance cost and $4.49 electrical energy cost.

If the project is built after transmission and booster station improvements are developed for Mauanalei Gulch sources, the incremental capitalized costs would be $4.9 million. First year electrical energy cost would be $2.73 per thousand gallons. The total thirty-year levelized costs are $8.25 per thousand gallons. This cost is comprised of $3.23 capital cost, $0.53 fixed operating and maintenance cost and $4.49 electrical energy cost.

FIGURE 5-20. Windward Wells at Kauiki

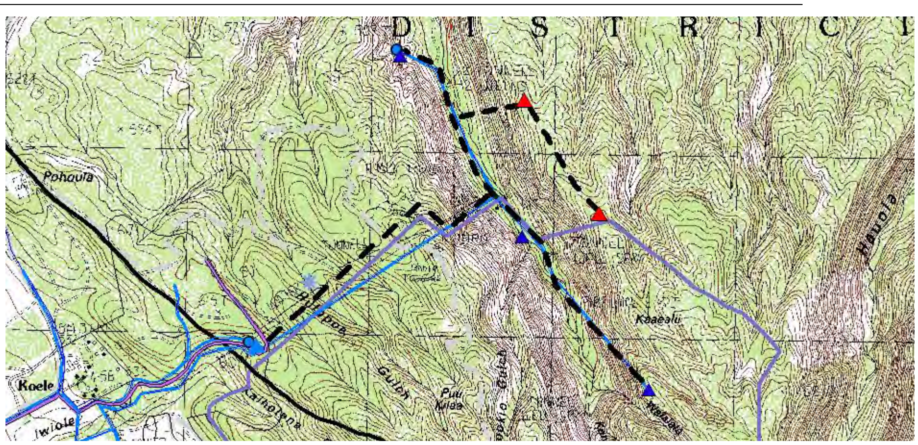


FIGURE 5-21. Windward Wells at Kauiki - New Transmission

Capacity (MGD)				
Installed Capacity		0.864		
Max. Day Capacity		0.648		
Effective Sustainable Capacity		0.300		
Facility Capacity Factor		100%		
Average Facility Output		0.300		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$300,000	$1,000,000	HDA Estimate	Electrical controls, water utility power transmission ext. share Road improvements
Drilling	$1,020,000	$3,400,000	HDA Estimate	Drilling 12" well 1200 ft depth @ $850/ft
Development	$1,159,000	$3,863,333	HDA Estimate	(1) pump 1 mgd @ $550k, SCADA, ancillaries
Transmission Improvements	$6,125,000	$20,416,667	HDA Estimate	7800 ft 10" hp line @ $500 plf Kauiki thru Maunalei to Well #6 5000 ft 12" line @ $445 plf Well#6 to Lanai City Tank
Storage Improvements	$250,000	$833,333		50kgal contact/control tank
Design / Engineering	$250,000	$833,333	HDA Estimate	Hydrology study, engineering
Contingencies	$1,820,800	$6,069,333	HDA Estimate	20%
Total Plant Cost (	$10,924,800	$36,416,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$10,924,800	$36,416,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$10,958	$36,525		$0.10 per kgal based on two times average due to remote location
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$29,376	$97,920		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$40,334	$134,445		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$2.720	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 700' water level to el 2060' hydraulic line at ridge"
Chemicals/Materials		$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$2.728		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$11.788**		
Amortized Cap. Cost (Book Life)		$8.692		
Fixed Op. Cost		$0.368		
Varible Op. Cost		$2.728		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**54.844**	**$13.100**		
Capital Cost (20 year Amort.)	36.416	$8.692		
Fixed Op. Cost	2.016	$0.481		
Varible Op. Cost	16.411	$3.917		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**61.631**	**$12.267**		
Capital Cost (Amort. per Econ. Life)	36.416	$7.243		
Fixed Op. Cost	2.665	$0.530		
Varible Op. Cost	22.550	$4.485		

FIGURE 5-22. Windward Wells at Kauiki - Incremental Cost

Capacity (MGD)				
Installed Capacity		0.864		
Max. Day Capacity		0.648		
Effective Sustainable Capacity		0.300		
Facility Capacity Factor		100%		
Average Facility Output		0.300		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$275,000	$916,667	HDA Estimate	Electrical controls, water utility power transmission ext. share Road improvements
Drilling	$1,020,000	$3,400,000	HDA Estimate	Drilling 12" well 1200 ft depth @ $850/ft
Development	$1,159,000	$3,863,333	HDA Estimate	(1) pump 1 mgd @ $550k, SCADA, ancillaries
Transmission Improvements	$1,350,000	$4,500,000	HDA Estimate	2600 ft 10" hp line @ $500 plf Kauiki to Maunalei boosters Check valve at Maunalei transmission connection
Storage Improvements	$0	$0		
Design / Engineering	$250,000	$833,333	HDA Estimate	Hydrology study, engineering
Contingencies	$810,800	$2,702,667	HDA Estimate	20%
Total Plant Cost (	$4,864,800	$16,216,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$4,864,800	$16,216,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$10,958	$36,525		$0.10 per kgal based on two times average due to remote location
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$29,376	$97,920		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$40,334	$134,445		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$2.720	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 700' water level to el 2060' hydraulic line at ridge*
Chemicals/Materials		$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$2.728		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$6.966**		
Amortized Cap. Cost (Book Life)		$3.871		
Fixed Op. Cost		$0.368		
Varible Op. Cost		$2.728		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**34.644**	**$8.275**		
Capital Cost (20 year Amort.)	16.216	$3.871		
Fixed Op. Cost	2.016	$0.481		
Varible Op. Cost	16.411	$3.917		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**41.431**	**$8.246**		
Capital Cost (Amort. per Econ. Life)	16.216	$3.225		
Fixed Op. Cost	2.665	$0.530		
Varible Op. Cost	22.550	$4.485		

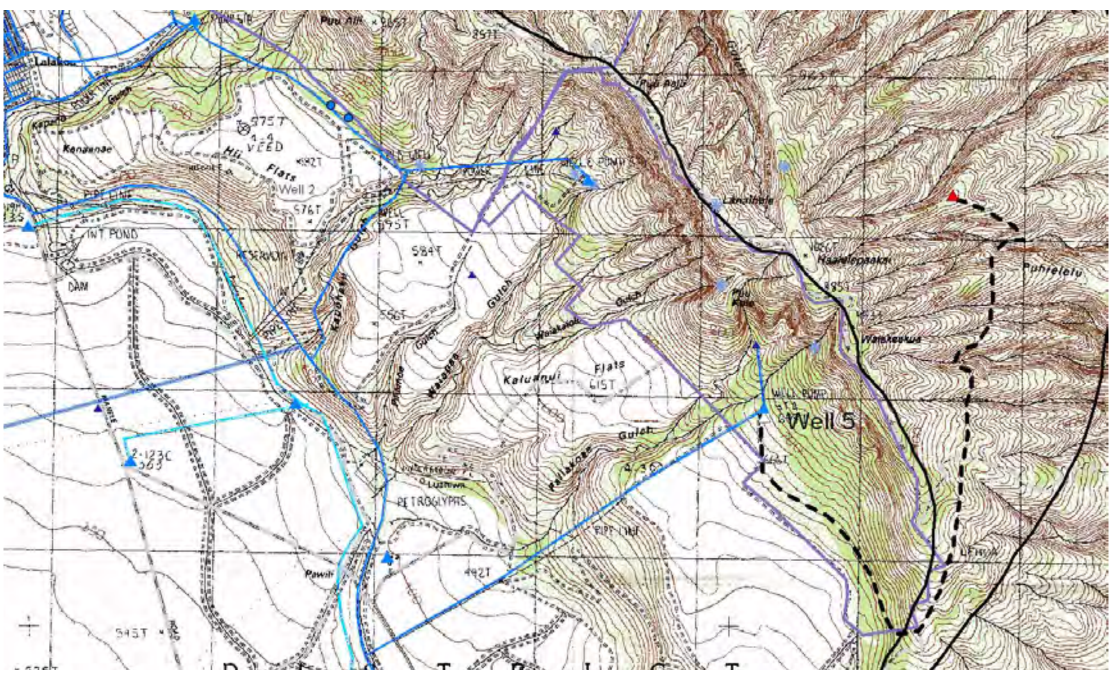
Windward Well at Kehewai Ridge

In order to explore the cost of developing a ground water source in the south portion of the Windward aquifer, sites were located at Kehewai Ridge at 2,250 feet and 2,750 feet elevations. There are no previous wells in this immediate area and success of drilling a well in this area is uncertain. A lower elevation well site in this area might provide more economy in terms of water pumping costs but a higher elevation site might be more likely to hit high level aquifer water and/or draw from a higher elevation dike compartment. Road access, power transmission and water transmission to this area would have to be developed. Well drilling and development costs for this project are assumed to be higher than other areas due to the remote location. Project costs include hydrology and engineering studies, road development, well drilling, development including ancillaries, power line and water transmission line, control and contact storage tank and contingencies.

For the 2,250 foot elevation site, production is assumed to be 300,000 GPD. Capitalized costs are $9.3 million. First year electrical energy cost is $2.11 per thousand gallons. The total thirty-year levelized costs are $9.99 per thousand gallons. This cost is comprised of $6.15 capital cost, $0.37 fixed operating and maintenance cost and $3.47 electrical energy cost.

For the 2,750 foot elevation site costs are slightly higher. Production is also assumed to be 300,000 GPD. Capitalized costs are $9.7 million. First year electrical energy cost is $2.51 per thousand gallons. The total thirty-year levelized costs are $10.96 per thousand gallons. This cost is comprised of $6.40 capital cost, $0.43 fixed operating and maintenance cost and $4.12 electrical energy cost.

FIGURE 5-23. Windward Well at Kehewai Ridge



Supply Options

FIGURE 5-24. Windward Well at Kehewai Ridge - 2,250' Elevation

Capacity (MGD)				
Installed Capacity		0.864		
Max. Day Capacity		0.864		
Effective Sustainable Capacity		0.300		
Facility Capacity Factor		100%		
Average Facility Output		0.300		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$100,000	$333,333	HDA Estimate	Water utility share line extension, electrical controls
Drilling	$1,120,000	$3,733,333	HDA Estimate	(1) well 12" at 1400 ft @ $800 plf
Development	$1,159,000	$3,863,333	HDA Estimate	(1) pump 1 mgd @ $550k, SCADA, ancillaries
Transmission Improvements	$4,950,000	$16,500,000		21,000 ft 8" line @ $200 plf to Well#5 15,000 ft. access road @ $50
Storage Improvements	$250,000	$833,333		50Kgal contact tank; chlorinator
Design / Engineering	$150,000	$500,000	HDA Estimate	Hydrology, siting, well engineering
Contingencies	$1,545,800	$5,152,667	HDA Estimate	20%
Total Plant Cost (	$9,274,800	$30,916,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$9,274,800	$30,916,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$5,479	$18,263		$0.05 per kgal based on estimated Lanai average
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$22,680	$75,600		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$28,159	$93,863		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$2.100	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 1200' water level to el 2250' wellhead
Chemicals/Materials		$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$2.108		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$9.744**		
Amortized Cap. Cost (Book Life)		$7.380		
Fixed Op. Cost		$0.257		
Varible Op. Cost		$2.108		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**45.004**	**$10.750**		
Capital Cost (20 year Amort.)	30.916	$7.380		
Fixed Op. Cost	1.408	$0.336		
Varible Op. Cost	12.681	$3.027		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**50.200**	**$9.992**		
Capital Cost (Amort. per Econ. Life)	30.916	$6.149		
Fixed Op. Cost	1.861	$0.370		
Varible Op. Cost	17.424	$3.466		

Potential Supply Options

FIGURE 5-25. Windward Well at Kehewai Ridge - 2,750' Elevation

Capacity (MGD)				
Installed Capacity		0.864		
Max. Day Capacity		0.864		
Effective Sustainable Capacity		0.300		
Facility Capacity Factor		100%		
Average Facility Output		0.300		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$100,000	$333,333	HDA Estimate	Water utility share line extension, electrical controls
Drilling	$1,440,000	$4,800,000	HDA Estimate	(1) well 12" at 1800 ft @ $800 plf
Development	$1,159,000	$3,863,333	HDA Estimate	(1) pump 1 mgd @ $550k, SCADA, ancillaries
Transmission Improvements	$4,950,000	$16,500,000		21,000 ft 8" line @ $200 plf to Well#5 15,000 ft. access road @ $50
Storage Improvements	$250,000	$833,333		50Kgal contact tank; chlorinator
Design / Engineering	$150,000	$500,000	HDA Estimate	Hydrology, siting, well engineering
Contingencies	$1,609,800	$5,366,000	HDA Estimate	20%
Total Plant Cost (	$9,658,800	$32,196,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$9,658,800	$32,196,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$5,479	$18,263		$0.05 per kgal based on estimated Lanai average
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$27,000	$90,000		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$32,479	$108,263		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$2.500	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 1500' water level to el 2750' wellhead
Chemicals/Materials		$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		$2.508		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$10.489**		
Amortized Cap. Cost (Book Life)		$7.685		
Fixed Op. Cost		$0.296		
Varible Op. Cost		$2.508		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**48.907**	**$11.682**		
Capital Cost (20 year Amort.)	32.196	$7.685		
Fixed Op. Cost	1.624	$0.388		
Varible Op. Cost	15.087	$3.601		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**55.073**	**$10.962**		
Capital Cost (Amort. per Econ. Life)	32.196	$6.404		
Fixed Op. Cost	2.146	$0.427		
Varible Op. Cost	20.731	$4.123		

New Brackish Wells with Mixing to Provide Additional Potable Supply

New wells that provide water with chloride levels marginally below water drinking standards could be mixed with fresher water to increase total potable water supply. This would require sufficient transmission, storage and control infrastructure to guarantee adequate mixing of brackish and potable water sources.

The costs of implementing this approach would include the same components as new potable wells with the addition of any necessary improvements required to assure adequate mixing.

New Brackish Well for Irrigation Use Without Treatment

For non-potable water needs a well could be developed in the leeward lower level aquifer area. There are existing plans to drill a well (proposed Well 15) about 4000 feet southeast of Well 1 at an elevation of 1350 feet. It is expected that the aquifer water elevation will be about 700 feet.

The costs of developing the proposed Well 15 were estimated for purposes of comparison with other potential water sources. The project includes engineering, well drilling, development including ancillaries, connection with existing adjacent transmission and contingency. Production was assumed to be 300,000 GPD. Capitalized costs are $2.7 million. First year electrical energy cost is $1.30 per thousand gallons. The total thirty-year levelized costs are $4.16 per thousand gallons. This cost is comprised of $1.76 capital cost, $0.26 fixed operating and maintenance cost and $2.14 electrical energy cost.

FIGURE 5-26. Proposed Brackish Well 15

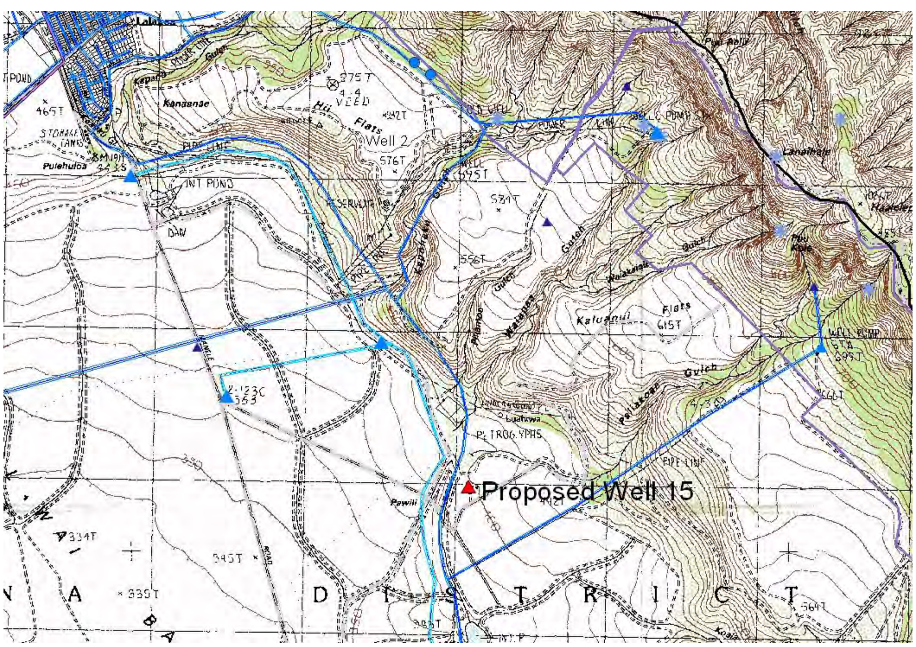


FIGURE 5-27. Proposed Brackish Well 15

Capacity (MGD)				
Installed Capacity		0.864		
Max. Day Capacity		0.864		
Effective Sustainable Capacity		0.300		
Facility Capacity Factor		100%		
Average Facility Output		0.300		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$5,000	$16,667	HDA Estimate	Connection to existing power line
Drilling	$900,000	$3,000,000	HDA Estimate	(1) well 12" at 1200 ft @ $750 plf
Development	$1,159,000	$3,863,333	HDA Estimate	(1) pump 1 mgd @ $550k, SCADA, ancillaries
Transmission Improvements	$100,000	$333,333		Feeder and connection to existing line
Storage Improvements	$0	$0		
Design / Engineering	$50,000	$166,667	HDA Estimate	Well engineering
Contingencies	$442,800	$1,476,000	HDA Estimate	20%
Total Plant Cost (	$2,656,800	$8,856,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$2,656,800	$8,856,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$5,479	$18,263		$0.05 per kgal based on estimated Lanai average
Apportioned Operating Labor		$0	HDA Estimate	
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$14,040	$46,800		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$19,519	$65,063		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$1.300	HDA calculation	5 kwh per kgal per thousand feet vertical lift @ $.40 per kwh Vertical lift from el 700' water level to el 1350' line hyd. hd.
Chemicals/Materials		$0.000		
Maintenance Expenses				
Total Variable Op. Costs		$1.300		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$3.592**		
Amortized Cap. Cost (Book Life)		$2.114		
Fixed Op. Cost		$0.178		
Varible Op. Cost		$1.300		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**17.654**	**$4.217**		
Capital Cost (20 year Amort.)	8.856	$2.114		
Fixed Op. Cost	0.976	$0.233		
Varible Op. Cost	7.822	$1.867		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**20.894**	**$4.159**		
Capital Cost (Amort. per Econ. Life)	8.856	$1.761		
Fixed Op. Cost	1.290	$0.257		
Varible Op. Cost	10.748	$2.138		

New Brackish Wells with Desalination

Desalination facilities can reduce the chloride level of brackish water to potable drinking standards. The cost of desalination is very dependent on the amount of required reduction in chloride level. Desalinating a brackish water source that is close to potable standards is much less expensive than desalination of seawater.

Cost estimates are documented below for desalination of seawater and 50% seawater to potable standards. Costs for desalination of 50% seawater are about 25% lower than costs for desalination of pure seawater. The cost of desalination of slightly brackish water would be substantially less but cost estimates are not currently available. Costs for this approach would include not only the costs of desalination but also the costs of new well development including the components identified above for new potable well development.

Potential Supply Options

FIGURE 5-28. Desalination of Brackish Water to Potable Quality

Capacity (MGD)				
Installed Capacity		0.250	Towill	
Max. Day Capacity		0.250		
Effective Sustainable Capacity		0.250		
Facility Capacity Factor		100%		
Average Facility Output		0.250		
Capital Costs ($)	Total	Per MGD		
Basic Plant Cost	$3,271,500	$13,086,000	Towill	$2003 Towill estimate escalated to $2007 at 3%
Site Improvements		$0		
Transmission Improvements		$0		
Treatment Improvements		$0		
Storage Improvements		$0		
Engineering Costs		$0		
Contingencies	$0	$0	Towill	Included in capital cost estimate
Total Plant Cost (	$3,271,500	$13,086,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$3,271,500	$13,086,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$80,438	$321,750	Towill	O&M. Annual silica cleaning, equipment. escalated to $2007
Apportioned Operating Labor		$0		
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$31,160	$124,640	HDA Calculation	5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electric energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$111,598	$446,390		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$9.971	Towill / HDA	Towill estimate of energy consumption with HDA estimate of power cost at $0.40 per Kwh
Chemicals/Materials				
Maintenance Expenses				
Total Variable Op. Costs		$9.971		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$14.317**		
Amortized Cap. Cost (Book Life)		$3.124		
Fixed Op. Cost		$1.222		
Varible Op. Cost		$9.971		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**79.777**	**$19.056**		
Capital Cost (20 year Amort.)	13.086	$3.124		
Fixed Op. Cost	6.695	$1.598		
Varible Op. Cost	59.996	$14.321		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**104.372**	**$20.774**		
Capital Cost (Amort. per Econ. Life)	13.086	$2.603		
Fixed Op. Cost	8.849	$1.760		
Varible Op. Cost	82.437	$16.397		

Desalination of Seawater

Desalination of seawater offers essentially unlimited ultimate source capacity but is more expensive than other available options. Cost estimates for a 250,000 GPD desalination facility are provided below for producing potable water from seawater, producing potable water from 50% seawater and producing slightly brackish water (for irrigation purposes) from seawater.

For a 250,000 GPD facility on Lanaʻi to desalinate seawater to 225 PM chlorides (potable water) the capital cost is estimated to be $3.4 million. First year electrical energy cost is $13.17 per thousand gallons. The total thirty-year levelized costs are $26.29 per thousand gallons. This cost is comprised of $2.69 capital cost, $1.92 operating and maintenance cost and $21.66 electrical energy cost.

For a 250,000 GPD facility on Lanaʻi to desalinate seawater to 400 PM chlorides (non-potable irrigation water) the capital cost is estimated to be $3.3 million. First year electrical energy cost is $6.37 per thousand gallons. The total thirty-year levelized costs are $14.72 per thousand gallons. This cost is comprised of $2.65 capital cost, $1.58 operating and maintenance cost and $10.48 electrical energy cost.

For a 250,000 GPD facility on Lanaʻi to desalinate 50% seawater to 225 PM chlorides (potable water) the capital cost is estimated to be $3.3 million. First year electrical energy cost is $9.97 per thousand gallons. The total thirty-year levelized costs are $20.77 per thousand gallons. This cost is comprised of $2.60 capital cost, $1.76 operating and maintenance cost and $16.40 electrical energy cost.

FIGURE 5-29. Desalination of Seawater to Potable Quality

Capacity (MGD)				
Installed Capacity		0.250	Towill	
Max. Day Capacity		0.250		
Effective Sustainable Capacity		0.250		
Facility Capacity Factor		100%		
Average Facility Output		0.250		
Capital Costs ($)	Total	Per MGD		
Basic Plant Cost	$3,381,750	$13,527,000	Towill	$2003 Towill estimate escalated to $2007 at 3%
Site Improvements		$0		
Transmission Improvements		$0		
Treatment Improvements		$0		
Storage Improvements		$0		
Engineering Costs		$0		
Contingencies	$0	$0	Towill	Included in capital cost estimate
Total Plant Cost (	$3,381,750	$13,527,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$3,381,750	$13,527,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$80,438	$321,750	Towill	O&M, Annual silica cleaning, equipment; escalated to $2007
Apportioned Operating Labor		$0		
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$41,160	$164,640	HDA Calculation	5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$121,598	$486,390		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$13.171	Towill / HDA	Towill estimate of energy consumption with HDA estimate of power cost at $0.40 per Kwh
Chemicals/Materials				
Maintenance Expenses				
Total Variable Op. Costs		$13.171		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$17.732**		
Amortized Cap. Cost (Book Life)		$3.229		
Fixed Op. Cost		$1.332		
Varible Op. Cost		$13.171		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**100.072**	**$23.903**		
Capital Cost (20 year Amort.)	13.527	$3.229		
Fixed Op. Cost	7.295	$1.741		
Varible Op. Cost	79.250	$18.917		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**132.062**	**$26.285**		
Capital Cost (Amort. per Econ. Life)	13.527	$2.691		
Fixed Op. Cost	9.642	$1.918		
Varible Op. Cost	108.893	$21.659		

FIGURE 5-30. Desalination of Seawater to Brackish Quality Suitable for Irrigation Use

Capacity (MGD)				
Installed Capacity		0.250	Towill	
Max. Day Capacity		0.250		
Effective Sustainable Capacity		0.250		
Facility Capacity Factor		100%		
Average Facility Output		0.250		
Capital Costs ($)	Total	Per MGD		
Basic Plant Cost	$3,334,500	$13,338,000	Towill	$2,964,000 Towill estimate escalated to $2007 at 3%
Site Improvements		$0		
Transmission Improvements		$0		
Treatment Improvements		$0		
Storage Improvements		$0		
Engineering Costs		$0		
Contingencies	$0	$0	Towill	Included in capital cost estimate
Total Plant Cost (	$3,334,500	$13,338,000		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$3,334,500	$13,338,000		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor	$80,438	$321,750	Towill	O&M; Annual silica cleaning, equipment: escalated to $2007
Apportioned Operating Labor		$0		
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	$19,910	$79,640	HDA Calculation	5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$100,348	$401,390		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		$6.371	Towill / HDA	Towill estimate of energy consumption with HDA estimate of power cost at $0.40 per Kwh
Chemicals/Materials				
Maintenance Expenses				
Total Variable Op. Costs		$6.371		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$10.654**		
Amortized Cap. Cost (Book Life)		$3.184		
Fixed Op. Cost		$1.099		
Varible Op. Cost		$6.371		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**57.693**	**$13.781**		
Capital Cost (20 year Amort.)	13.338	$3.184		
Fixed Op. Cost	6.020	$1.437		
Varible Op. Cost	38.335	$9.151		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**73.969**	**$14.723**		
Capital Cost (Amort. per Econ. Life)	13.338	$2.653		
Fixed Op. Cost	7.957	$1.583		
Varible Op. Cost	52.674	$10.477		

Supply and Demand Side Efficiency Options

Total water system demand needs can be met by supply side efficiency options or measures, such as increasing supply, or reducing losses; or by demand-side measures, aimed at reducing water needs. These options are sometimes called Demand Side Measures (DSM) and Supply Side Measures (SSM).

Leak Detection and Repair

Leak detection programs can reduce water system losses. Reducing losses reduces water system operating expenses and expands available deliverable production capacity. Leak detection efforts are effective on both the customer and the utility "side of the meter." Leak detection efforts on the customer premises can be implemented as a DSM program. Leak detection efforts for the water supply system can be implemented as an ongoing maintenance program or as a specifically commissioned project.

Unaccounted-for Water Auditing

Unaccounted-for water analysis is good utility practice. Whether such unaccounted-for water represents actual system losses or merely un-metered uses, a regular audit and examination of unaccounted-for water can help to identify problem areas. Regular unaccounted-for water auditing could be made easier by certain changes to the Periodic Water Report. In order to arrive at unccounted-for water, meter pumpage and consumption meter read dates had to be reconciled. These could both be reported on a monthly basis. This was the practice prior to 1981. In addition, summarized subtotals, rather than being reported by "Lana'i City", "Manele, Aoki Diversified Agriculture and Ag Activities Near the Airport", and Kaumalapau, could be reported by the 5 districts noted in this document, which represent distinct sets of sources and pressure zones. These are Lana'i City and surrounding areas (LCTY); Koele Project District area (KOPD), Palawai Irrigation Grid (IGGP), Manele Project District area (MNPD), and Kaumalapau (KPAU). Sources for each of these areas should be noted in the reports in such a way that these can be distinguished. It would also be useful to regularly subtotal estimated irrigation use in each district and from each set of sources, versus domestic use.

Pipe Replacement

In the course of seeking the causes of unaccounted-for water described in the previous chapter, several old and leaking pipes were identified. Some of these may create significant system loss. The most dramatic example of such potential is the Palawai Grid line. Repair of this line is estimated to result in over 200,000 GPD in savings. A list of pipe repair priorities totalling roughly twelve million was generated and is included in the capital program and discussion later in this chapter.

Use of Reclaimed Water

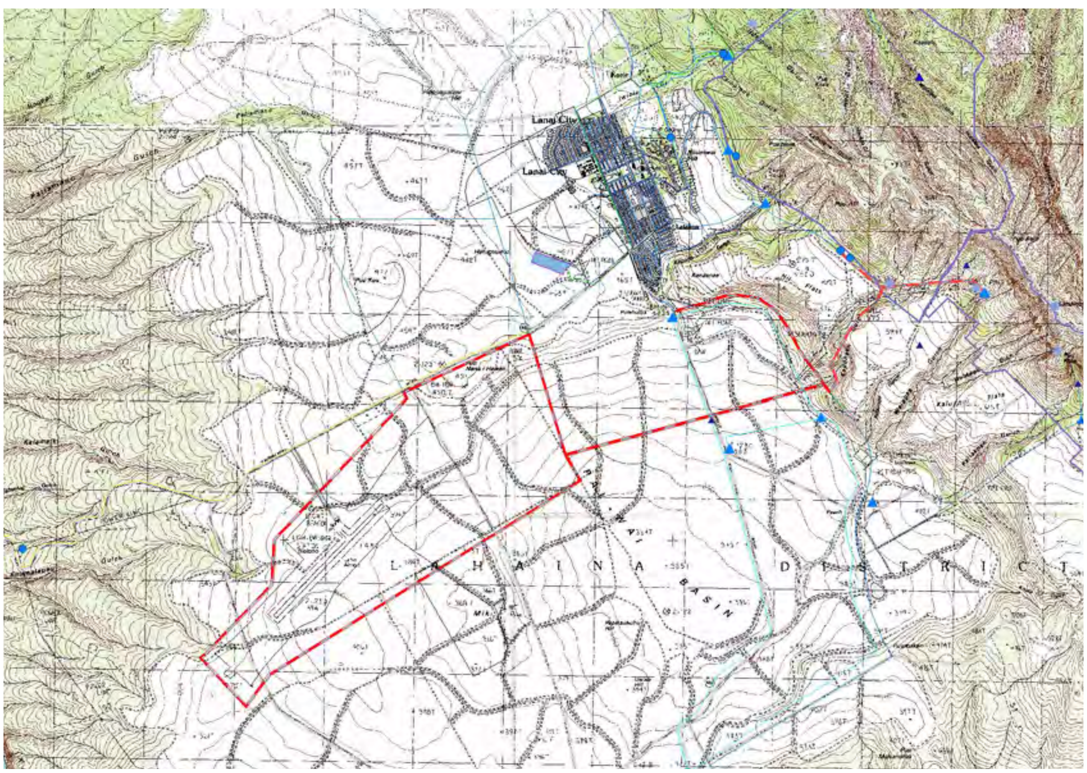
As discussed previously, sufficient reclaimed water availability to offset between 400,000 and 600,000 GPD or more of potable or brackish use is seen as likely during the planning period. A number of options for reclaimed use are considered in the section to follow, ranging from use of 60,000 GPD to 500,000 GPD.

Pipe Replacement to Reduce System Losses

Unaccounted-for water analysis in the previous chapter led to examination of the source value of pipe replacements in the Palawai Grid. Unaccounted-for water in this area was 44.61% in 2008. To the extent that this represents losses rather than un-metered uses, this represents substantial and expensive operating loss for this service area.

Several options were considered for repairs in this area. For evaluation on a levelized cost basis, the capital cost of this replacement is estimated at about $3.8 million dollars. Water savings are estimated at 202,000 GPD. First year electrical energy savings are $1.49 per thousand gallons. The total thirty-year levelized costs are $2.34 per thousand gallons. This cost is comprised of $4.54 in capital costs, a savings of $.07 in operating and maintenance cost and a savings of $2.14 in electrical energy cost.

FIGURE 5-31. Palawai Grid Pipe Replacement



Supply and Demand Side Efficiency Options

FIGURE 5-32. Palawai Grid Pipe Replacement

Capacity (MGD)				
Installed Capacity		0.202		
Max. Day Capacity		0.202		
Effective Sustainable Capacity		0.202		
Facility Capacity Factor		100%		
Average Facility Output		0.202		
Capital Costs ($)	Total	Per MGD		
Exploration/Land/Power	$0	$0		
Refurbish well site	$0	$0		
Development	$0	$0		
Transmission Improvements	$3,200,000	$15,841,584		Per CIP Pipe Replacement Estimate
Storage Improvements	$0	$0		
Design / Engineering	$0	$0		
Contingencies	$640,000	$3,168,317		20%
Total Plant Cost (	$3,840,000	$19,009,901		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$3,840,000	$19,009,901		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor		$0		$0.05 per kgal based on estimated Lanai average
Apportioned Operating Labor		$0		
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand	-$3,737	-$18,500		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	-$3,737	-$18,500		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy		-$1.480	HDA calculation	Per Well Production Cost Spreadsheet
Chemicals/Materials		-$0.008	HDA Estimate	150% Maui system average cost
Maintenance Expenses				
Total Variable Op. Costs		-$1.488		
Plant Life (Years)				
Functional Life	20			
Economic/Analysis Life	20			
Book Life	20			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$2.999**		
Amortized Cap. Cost (Book Life)		$4.538		
Fixed Op. Cost		-$0.051		
Varible Op. Cost		-$1.488		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**9.782**	**$2.337**		
Capital Cost (20 year Amort.)	19.010	$4.538		
Fixed Op. Cost	-0.277	-$0.066		
Varible Op. Cost	-8.950	-$2.136		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**9.782**	**$2.337**		
Capital Cost (Amort. per Econ. Life)	19.010	$4.538		
Fixed Op. Cost	-0.277	-$0.066		
Varible Op. Cost	-8.950	-$2.136		

Covering Open Reservoirs to Reduce Evaporative Losses

Open reservoirs lose water due to evaporation. Estimates for evaporative losses for reservoirs in Hawaii are typically 1/4” per day. Several types of reservoir covers are available. Floating covers are less expensive than structural “roof” covers but require more maintenance and more frequent replacement.

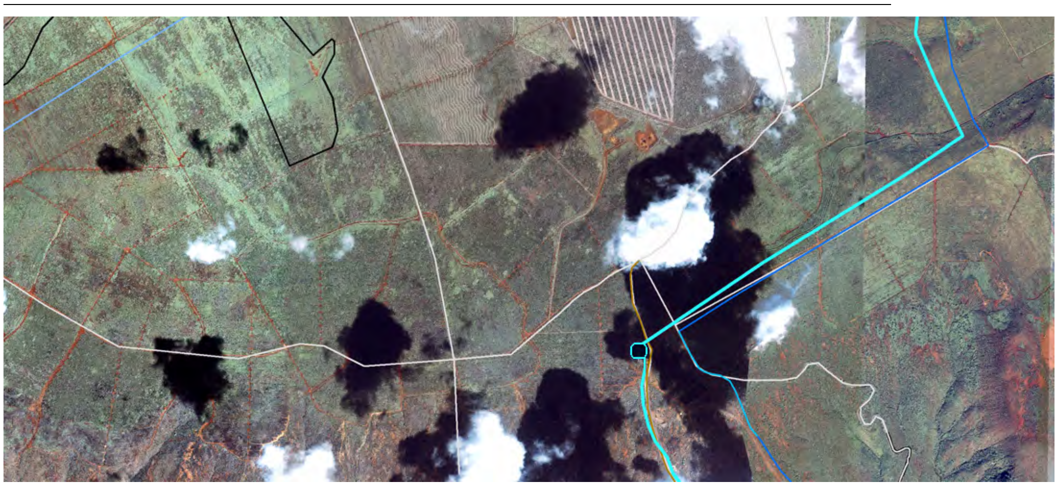
Life cycle costs were estimated for both floating and structural aluminum covers for the 15 MG Manele Reservoir. Cost estimates for installation on Lana’i were obtained from suppliers and Hawaii installers. The Manele Reservoir loses about 17,000 GPDGPD to evaporation. The analysis assumes that covering the reservoir would completely eliminate evaporative losses and would allow precipitation to continue to enter the reservoir.

For a floating reservoir installed costs, including engineering, site and foundation work, materials, installation and contingency, would be about $366,000. The cover is assumed to have a functional life of 10 years. No fixed operating or variable costs are assumed. The total ten-year levelized unit costs would be $10.31 per thousand gallons of reduced losses.

For a structural aluminum roof cover, installed costs, including engineering, site and foundation work, materials, installation and contingency, would be about $4.0 million. The cover is assumed to have a functional life of 30 years. No fixed operating or variable costs are assumed. The total thirty-year levelized unit costs would be $60.67 per thousand gallons of reduced losses.

An additional option evaluated involved the use of Hypalon balls to form a non-structural floating cover. This project was evaluated at roughly $450,000 for materials and an additional $45,000 for contingencies, for a total of $495,000. This cover was somewhat more cost-effective than other cover options. The total lifetime levelized cost of this option would be $13.14 per thousand gallons of reduced losses.

FIGURE 5-33. Hi‘i Reservoir Cover



Supply and Demand Side Efficiency Options

FIGURE 5-34. Floating Cover For Hi‘i Reservoir

Capacity (MGD)				
Installed Capacity		0.017		Avoided evaporative losses for 10,000 sq meters @ 1/4"/day
Max. Day Capacity		0.017		
Effective Sustainable Capacity		0.013		80% average reservoir surface area
Facility Capacity Factor		100%		
Average Facility Output		0.013		
Capital Costs ($)	Total	Per MGD		
Design / Engineering	$5,000	$378,788	HDA Estimate	
Cover and anchoring system	$317,308	$24,038,462	Quote from Lemna	Lump sum estimate from manufacturer; 10,000 sq. meters cover adjusted from quote on 13,000 sp. meter cover @
Site Improvements and Installation	$10,000	$757,576	HDA Estimate	
		$0		
		$0		
		$0		
Contingencies	$33,231	$2,517,483	HDA Estimate	10%
Total Plant Cost (	$365,538	$27,692,308		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$365,538	$27,692,308		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor		$0		
Apportioned Operating Labor		$0		
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand		$0		
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$0	$0		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy				
Chemicals/Materials				
Maintenance Expenses				
Total Variable Op. Costs		$0.000		
Plant Life (Years)				
Functional Life	10			
Economic/Analysis Life	10			
Book Life	10			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost. Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost. Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$10.301**		
Amortized Cap. Cost (Book Life)		$10.301		
Fixed Op. Cost		$0.000		
Varible Op. Cost		$0.000		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**27.692**	**$6.615**		
Capital Cost (20 year Amort.)	27.692	$6.610		
Fixed Op. Cost	0.000	$0.000		
Varible Op. Cost	0.000	$0.000		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**27.692**	**$10.308**		
Capital Cost (Amort. per Econ. Life)	27.692	$10.301		
Fixed Op. Cost	0.000	$0.000		
Varible Op. Cost	0.000	$0.000		

FIGURE 5-35. Aluminum Cover for Hi‘i Reservoir

Capacity (MGD)				
Installed Capacity		0.017		Avoided evaporative losses for 10,000 sq meters @ 1/4"/day
Max. Day Capacity		0.017		
Effective Sustainable Capacity		0.013		80% average reservoir surface area
Facility Capacity Factor		100%		
Average Facility Output		0.013		
Capital Costs ($)	Total	Per MGD		
Lump Sum Project Estimate	$3,657,856	$277,110,303	Quote from Temcor and Hawaii Rep.	Lump sum estimate from manufacturer; 10,000 sq. meters area covered by aluminum low dome structure
		$0		
		$0		
		$0		
Contingencies	$365,786	$27,711,030	HDA Estimate	10%
Total Plant Cost (	$4,023,642	$304,821,333		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$4,023,642	$304,821,333		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor		$0		
Apportioned Operating Labor		$0		
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand		$0		
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$0	$0		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy				
Chemicals/Materials				
Maintenance Expenses				
Total Variable Op. Costs		$0.000		
Plant Life (Years)				
Functional Life	30			
Economic/Analysis Life	30			
Book Life	30			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op Cost Disc Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op Cost Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$60.630**		
Amortized Cap. Cost (Book Life)		$60.630		
Fixed Op. Cost		$0.000		
Varible Op. Cost		$0.000		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**304.821**	**$72.810**		
Capital Cost (20 year Amort.)	304.821	$72.760		
Fixed Op. Cost	0.000	$0.000		
Varible Op. Cost	0.000	$0.000		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**304.821**	**$60.671**		
Capital Cost (Amort. per Econ. Life)	304.821	$60.630		
Fixed Op. Cost	0.000	$0.000		
Varible Op. Cost	0.000	$0.000		

FIGURE 5-36. Hypalon Balls - Cover for Hi‘i Reservoir

Capacity (MGD)				
Installed Capacity		0.017		Avoided evaporative losses for 10,000 sq.meters @ 1/4"/day
Max. Day Capacity		0.017		
Effective Sustainable Capacity		0.014		85% reduction in evaporative losses
Facility Capacity Factor		100%		
Average Facility Output		0.014		
Capital Costs ($)	Total	Per MGD		
Lump Sum Project Estimate	$450,000	$32,085,561	Lump Sum Quote	Lump Sum Quote for materials delivered to site per LWCI
		$0		
		$0		
		$0		
Contingencies	$45,000	$3,208,556	HDA Estimate	10%
Total Plant Cost (	$495,000	$35,294,118		
Const. Per. Esc. Rate (Nom.)	3.00%			
AFUDC Interest Rate (Nom.)	6.00%			
AFUDC Factor		1.000		
	Total	Per MGD		
Total Capitalized Cost	$495,000	$35,294,118		
Fixed Operating Costs ($)	Per Year	Per Y/MGD		
Dedicated Operating Labor		$0		
Apportioned Operating Labor		$0		
Maintenance Labor		$0		
Fixed Operating Costs				
Electrical Demand		$0		
Chemicals/Materials		$0		
Maintenance Expenses		$0		
Amort. of Capitalized Rebuild Costs		$0		
Total Fixed Op. Costs	$0	$0		
Variable Operating Costs ($)		Per KGal		
Operating Labor				
Maintenance Labor				
Electrical Energy				
Chemicals/Materials				
Maintenance Expenses				
Total Variable Op. Costs		$0.000		
Plant Life (Years)				
Functional Life	10			
Economic/Analysis Life	10			
Book Life	10			
Levelized Production Costs ($)				
Cost of Capital	6.00%			
Discount Rate (Nom.)	6.00%			
Fixed Op.Cost Esc. Rate (Nom.)	3.00%			
Effective Fixed Op.Cost Disc. Rate	2.91%			
Var. Op.Cost Esc. Rate (Nom.)	4.00%			
Effective Var. Op.Cost Disc. Rate	1.92%			
		$/kgal		
First Year Cost w/Amortized Capital		**$13.129**		
Amortized Cap. Cost (Book Life)		$13.129		
Fixed Op. Cost		$0.000		
Varible Op. Cost		$0.000		
	NPV $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost	**35.294**	**$8.430**		
Capital Cost (20 year Amort.)	35.294	$8.425		
Fixed Op. Cost	0.000	$0.000		
Varible Op. Cost	0.000	$0.000		
	NPV $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost	**35.294**	**$13.138**		
Capital Cost (Amort. per Econ. Life)	35.294	$13.129		
Fixed Op. Cost	0.000	$0.000		
Varible Op. Cost	0.000	$0.000		

Reclaimed Water Use

Three options were examined for utilization of “excess” reclaimed water from Lana‘i City to offset potable or brackish irrigation use. These were: utilizing reclaimed water for irrigation of the planned Miki Industrial Park; sending “excess” reclaimed water from Lana‘i City directly to Manele for irrigation use; and a two-stage project in which reclaimed water is piped to Miki Basin in Phase I and from Miki onward to Manele in Phase II.

Estimated costs for a recycled line to Miki Basin, included transmission and contingency in the amount of $1,536,000 for an assumed use of about 60,000 GPD, and a thirty year functional life. First year energy costs are approximately $0.40 per thousand gallons. For 60,000 GPD of reclaimed water, the total thirty-year levelized cost is $5.77 per thousand gallons. This cost is comprised of $5.09 in capital cost, $0.02 operating and maintenance cost and about $0.66 in energy costs per thousand gallons.

The cost of a recycled water line to Manele was estimated at $16,896,000, comprised of $10,000,000 in treatment plant upgrade, $4.08 million in transmission and $2.82 million in contingencies. The functional life of this project is estimated at thirty years. First year energy costs are estimated at about $0.40 per thousand gallons. For an assumed 500,000 GPD, the total costs per thousand gallons are $7.40, comprised of $6.72 in capital costs, $0.02 in operating and maintenance and about $0.66 in energy costs per thousand gallons.

A Phase I line to Miki Basin, to be followed by connection to Manele is slightly more expensive to install, due to the extra size. The estimated capital costs is $2,304,000 including transmission and contingencies. The amount of production is still assumed to be about 60,000 GPD. The functional life of the project is estimated at thirty years. First year energy costs are estimated at about $0.40 per thousand gallons. For an assumed 60,000 GPD, the total costs per thousand gallons are $8.32, comprised of $7.64 in capital costs, $0.02 in operating and maintenance and about $0.66 in energy costs per thousand gallons.

Phase II of this project, from Miki Basin to Manele would cost an estimated $15,456,000, including $10,000,000 in treatment plant upgrade, $2,880,000 in transmission and $2,576,000 in contingencies. The project is presumed to send 440,000 GPD to Manele, with a functional life of thirty years. First year energy costs are estimated at about $0.40 per thousand gallons. The total costs per thousand gallons is $7.66, comprised of $6.99 in capital costs, $0.02 in operating and maintenance and about $0.66 in energy costs per thousand gallons.

FIGURE 5-37. Reclaimed Water Line from Lana'i City to Miki Basin

Capacity (MGD)					
Installed Capacity			0.060		
Max. Day Capacity			0.060		
Effective Sustainable Capacity			0.060		
Facility Capacity Factor			100%		
Average Facility Output			0.060		
Capital Costs ($2002)		Total	Per MGD		
WWTP R-1 Upgrade		$0	$0		
			$0		
			$0		
Transmission		$1,280,000	$21,333,333	HDA Estimate	16000lf@$80plf for transmission, assumes no marginal distribution cost at Miki Basin (new project area)
			$0		
			$0		
Contingencies		$256,000	$4,266,667	HDA Estimate	20%
Total Plant Cost (		$1,536,000	$25,600,000		
Expenditure Pattern	Year	Nom	Normalized		
	Serv Date	1	100.0%		
	-1	0	0.0%		
	-2	0	0.0%		
	-3	0	0.0%		
	-4	0	0.0%		
	-5	0	0.0%		
	-6	0	0.0%		
	-7	0	0.0%		
	-8	0	0.0%		
Const. Per. Esc. Rate (Nom.)		3.00%			
AFUDC Interest Rate (Nom.)		6.00%			
AFUDC Factor			1.000		
		Total	Per MGD		
Total Capitalized Cost		$1,536,000	$25,600,000		
Fixed Operating Costs ($2002)		Per Year	Per Y/MGD		
Dedicated Operating Labor		$0	$0		
Apportioned Operating Labor			$0		
Maintenance Labor			$0		
Fixed Operating Costs					
Electrical Demand		$248	$4,140		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials			$0		
Maintenance Expenses			$0		
Amort. of Capitalized Rebuild Costs			$0		
Total Fixed Op. Costs		$248	$4,140		
Variable Operating Costs ($2002)			Per KGal		
Operating Labor					
Maintenance Labor					
Electrical Energy			$0.331	HDA per DEM	FY04 Reuse Elec Cost $123,110 for 536,003 Kgal Increased by 45% to reflect $2008 $0.34/KWH de-escalated to $2004
Chemicals/Materials			$0.050	HDA per DEM	FY04 UV Bulbs and Muriatic Acid
Maintenance Expenses			$0.017	HDA per DEM	FY04 Expenses $9,674 for 536,003 Kgal
Total Variable Op. Costs			$0.398		
Plant Life (Years)					
Functional Life		30			
Economic/Analysis Life		30			
Book Life		20			
Levelized Production Costs ($2002)					
Cost of Capital		6.00%			
Discount Rate (Nom.)		6.00%			
Fixed Op.Cost Esc. Rate (Nom.)		3.00%			
Effective Fixed Op.Cost. Disc. Rate		2.91%			
Var. Op.Cost Esc. Rate (Nom.)		4.00%			
Effective Var. Op.Cost. Disc. Rate		1.92%			
			$/kgal		
First Year Cost w/Amortized Capital			**$6.520**		
Amortized Cap. Cost (Book Life)			$6.111		
Fixed Op. Cost			$0.011		
Varible Op. Cost			$0.398		
		NPV2002 $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost		**28.058**	**$6.702**		
Capital Cost (20 year Amort.)		25.600	$6.111		
Fixed Op. Cost		0.062	$0.015		
Varible Op. Cost		2.395	$0.572		
		NPV2002 $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost		**28.974**	**$5.767**		
Capital Cost (Amort. per Econ. Life)		25.600	$5.092		
Fixed Op. Cost		0.082	$0.016		
Varible Op. Cost		3.291	$0.655		

FIGURE 5-38. Reclaimed Water Line to Manele

Capacity (MGD)					
Installed Capacity			0.500		
Max. Day Capacity			0.500		
Effective Sustainable Capacity			0.500		
Facility Capacity Factor			100%		
Average Facility Output			0.500		
Capital Costs ($2002)		Total	Per MGD		
WWTP R-1 Upgrade		$10,000,000	$20,000,000	DEM Rough Estimate	
			$0		
			$0		
Transmission		$4,080,000	$8,160,000	HDA Estimate	34000lf@$120plf for transmission, assumes no marginal distribution cost at Manele (new project area)
			$0		
			$0		
Contingencies		$2,816,000	$5,632,000	HDA Estimate	20%
Total Plant Cost (		$16,896,000	$33,792,000		
Expenditure Pattern	Year	Nom	Normalized		
	Serv Date	1	100.0%		
	-1	0	0.0%		
	-2	0	0.0%		
	-3	0	0.0%		
	-4	0	0.0%		
	-5	0	0.0%		
	-6	0	0.0%		
	-7	0	0.0%		
	-8	0	0.0%		
Const. Per. Esc. Rate (Nom.)		3.00%			
AFUDC Interest Rate (Nom.)		6.00%			
AFUDC Factor			1.000		
		Total	Per MGD		
Total Capitalized Cost		$16,896,000	$33,792,000		
Fixed Operating Costs ($2002)		Per Year	Per Y/MGD		
Dedicated Operating Labor		$0	$0		
Apportioned Operating Labor			$0		
Maintenance Labor			$0		
Fixed Operating Costs					
Electrical Demand		$2,070	$4,140		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials			$0		
Maintenance Expenses			$0		
Amort. of Capitalized Rebuild Costs			$0		
Total Fixed Op. Costs		$2,070	$4,140		
Variable Operating Costs ($2002)			Per KGal		
Operating Labor					
Maintenance Labor					
Electrical Energy			$0.331	HDA per DEM	FY04 Reuse Elec Cost $123,110 for 536,003 Kgal Increased by 45% to reflect $2008 $0.34/KWH de-escalated to $2004
Chemicals/Materials			$0.050	HDA per DEM	FY04 UV Bulbs and Muriatic Acid
Maintenance Expenses			$0.017	HDA per DEM	FY04 Expenses $9,674 for 536,003 Kgal
Total Variable Op. Costs			$0.398		
Plant Life (Years)					
Functional Life		30			
Economic/Analysis Life		30			
Book Life		20			
Levelized Production Costs ($2002)					
Cost of Capital		6.00%			
Discount Rate (Nom.)		6.00%			
Fixed Op.Cost Esc. Rate (Nom.)		3.00%			
Effective Fixed Op.Cost. Disc. Rate		2.91%			
Var. Op.Cost Esc. Rate (Nom.)		4.00%			
Effective Var. Op.Cost. Disc. Rate		1.92%			
			$/kgal		
First Year Cost w/Amortized Capital			**$8.476**		
Amortized Cap. Cost (Book Life)			$8.066		
Fixed Op. Cost			$0.011		
Varible Op. Cost			$0.398		
		NPV2002 $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost		**36.250**	**$8.659**		
Capital Cost (20 year Amort.)		33.792	$8.066		
Fixed Op. Cost		0.062	$0.015		
Varible Op. Cost		2.395	$0.572		
		NPV2002 $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost		**37.166**	**$7.397**		
Capital Cost (Amort. per Econ. Life)		33.792	$6.721		
Fixed Op. Cost		0.082	$0.016		
Varible Op. Cost		3.291	$0.655		

Supply and Demand Side Efficiency Options

FIGURE 5-39. Reclaimed Water Line to Miki as Phase I of Project to Manele

Capacity (MGD)					
Installed Capacity			0.060		
Max. Day Capacity			0.060		
Effective Sustainable Capacity			0.060		
Facility Capacity Factor			100%		
Average Facility Output			0.060		
Capital Costs ($2002)		Total	Per MGD		
WWTP R-1 Upgrade		$0	$0		
			$0		
			$0		
Transmission		$1,920,000	$32,000,000	HDA Estimate	16000lf@$120plf for transmission, assumes no marginal distribution cost at Miki Basin (new project area)
			$0		
			$0		
Contingencies		$384,000	$6,400,000	HDA Estimate	20%
Total Plant Cost (		$2,304,000	$38,400,000		
Expenditure Pattern	Year	Nom	Normalized		
	Serv Date	1	100.0%		
	-1	0	0.0%		
	-2	0	0.0%		
	-3	0	0.0%		
	-4	0	0.0%		
	-5	0	0.0%		
	-6	0	0.0%		
	-7	0	0.0%		
	-8	0	0.0%		
Const. Per. Esc. Rate (Nom.)		3.00%			
AFUDC Interest Rate (Nom.)		6.00%			
AFUDC Factor			1.000		
		Total	Per MGD		
Total Capitalized Cost		$2,304,000	$38,400,000		
Fixed Operating Costs ($2002)		Per Year	Per Y/MGD		
Dedicated Operating Labor		$0	$0		
Apportioned Operating Labor			$0		
Maintenance Labor			$0		
Fixed Operating Costs					
Electrical Demand		$248	$4,140		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials			$0		
Maintenance Expenses			$0		
Amort. of Capitalized Rebuild Costs			$0		
Total Fixed Op. Costs		$248	$4,140		
Variable Operating Costs ($2002)			Per KGal		
Operating Labor					
Maintenance Labor					
Electrical Energy			$0.331	HDA per DEM	FY04 Reuse Elec Cost $123,110 for 536,003 Kgal Increased by 45% to reflect $2008 $0.34/KWH de-escalated to $2004
Chemicals/Materials			$0.050	HDA per DEM	FY04 UV Bulbs and Muriatic Acid
Maintenance Expenses			$0.017	HDA per DEM	FY04 Expenses $9,674 for 536,003 Kgal
Total Variable Op. Costs			$0.398		
Plant Life (Years)					
Functional Life		30			
Economic/Analysis Life		30			
Book Life		20			
Levelized Production Costs ($2002)					
Cost of Capital		6.00%			
Discount Rate (Nom.)		6.00%			
Fixed Op.Cost Esc. Rate (Nom.)		3.00%			
Effective Fixed Op.Cost. Disc. Rate		2.91%			
Var. Op.Cost Esc. Rate (Nom.)		4.00%			
Effective Var. Op.Cost. Disc. Rate		1.92%			
			$/kgal		
First Year Cost w/Amortized Capital			**$9.575**		
Amortized Cap. Cost (Book Life)			$9.166		
Fixed Op. Cost			$0.011		
Varible Op. Cost			$0.398		
		NPV2002 $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost		**40.858**	**$9.759**		
Capital Cost (20 year Amort.)		38.400	$9.166		
Fixed Op. Cost		0.062	$0.015		
Varible Op. Cost		2.395	$0.572		
		NPV2002 $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost		**41.774**	**$8.315**		
Capital Cost (Amort. per Econ. Life)		38.400	$7.638		
Fixed Op. Cost		0.082	$0.016		
Varible Op. Cost		3.291	$0.655		

FIGURE 5-40. Reclaimed Water Line as Phase II from Miki to Manele

Capacity (MGD)					
Installed Capacity			0.440		
Max. Day Capacity			0.440		
Effective Sustainable Capacity			0.440		
Facility Capacity Factor			100%		
Average Facility Output			0.440		
Capital Costs ($2002)		Total	Per MGD		
WWTP R-1 Upgrade		$10,000,000	$22,727,273	DEM Rough Estimate	
			$0		
			$0		
Transmission		$2,880,000	$6,545,455	HDA Estimate	24000lf@$120plf for transmission, assumes no marginal distribution cost at Manele (new project area)
			$0		
			$0		
Contingencies		$2,576,000	$5,854,545	HDA Estimate	20%
Total Plant Cost (		$15,456,000	$35,127,273		
Expenditure Pattern	Year	Nom	Normalized		
	Serv Date	1	100.0%		
	-1	0	0.0%		
	-2	0	0.0%		
	-3	0	0.0%		
	-4	0	0.0%		
	-5	0	0.0%		
	-6	0	0.0%		
	-7	0	0.0%		
	-8	0	0.0%		
Const. Per. Esc. Rate (Nom.)		3.00%			
AFUDC Interest Rate (Nom.)		6.00%			
AFUDC Factor			1.000		
		Total	Per MGD		
Total Capitalized Cost		$15,456,000	$35,127,273		
Fixed Operating Costs ($2002)		Per Year	Per Y/MGD		
Dedicated Operating Labor		$0	$0		
Apportioned Operating Labor			$0		
Maintenance Labor			$0		
Fixed Operating Costs					
Electrical Demand		$1,822	$4,140		5 Kwh/Kgal/Kft lift efficiency*derived sys demand cost factor*electrical energy cost*installed capacity
Chemicals/Materials			$0		
Maintenance Expenses			$0		
Amort. of Capitalized Rebuild Costs			$0		
Total Fixed Op. Costs		$1,822	$4,140		
Variable Operating Costs ($2002)			Per KGal		
Operating Labor					
Maintenance Labor					
Electrical Energy			$0.331	HDA per DEM	FY04 Reuse Elec Cost $123,110 for 536,003 Kgal Increased by 45% to reflect $2008 $0.34/KWH de-escalated to $2004
Chemicals/Materials			$0.050	HDA per DEM	FY04 UV Bulbs and Muriatic Acid
Maintenance Expenses			$0.017	HDA per DEM	FY04 Expenses $9,674 for 536,003 Kgal
Total Variable Op. Costs			$0.398		
Plant Life (Years)					
Functional Life		30			
Economic/Analysis Life		30			
Book Life		20			
Levelized Production Costs ($2002)					
Cost of Capital		6.00%			
Discount Rate (Nom.)		6.00%			
Fixed Op.Cost Esc. Rate (Nom.)		3.00%			
Effective Fixed Op.Cost. Disc. Rate		2.91%			
Var. Op.Cost Esc. Rate (Nom.)		4.00%			
Effective Var. Op.Cost. Disc. Rate		1.92%			
			$/kgal		
First Year Cost w/Amortized Capital			**$8.794**		
Amortized Cap. Cost (Book Life)			$8.385		
Fixed Op. Cost			$0.011		
Varible Op. Cost			$0.398		
		NPV2002 $M/MGD	Levelized $/kgal		
Twenty-year Total NPV Cost		**37.585**	**$8.978**		
Capital Cost (20 year Amort.)		35.127	$8.385		
Fixed Op. Cost		0.062	$0.015		
Varible Op. Cost		2.395	$0.572		
		NPV2002 $M/MGD	Levelized $/kgal		
Economic Life Total NPV Cost		**38.501**	**$7.663**		
Capital Cost (Amort. per Econ. Life)		35.127	$6.987		
Fixed Op. Cost		0.082	$0.016		
Varible Op. Cost		3.291	$0.655		

Demand-Side Measures

Demand-Side measures refer to actions taken on the "customer's side of the water meter." These include reducing water use by using more efficient appliances or changing water use patterns.

Many water utilities encourage conservation and water use efficiency by implementing demand-side-management (DSM) programs. These programs use a variety of methods to promote efficiency including incentives to customers, provision of free or low-cost efficient fixtures or appliances, direct installations or conservation rate designs.

Landscape Conservation Measures

Nationwide, estimated outdoor use per-capita is 31.7 GPD.   Outdoor use per household varies from 10% to 75% of household consumption. However, even in hot dry areas such as Phoenix, Scottsdale and Tempe Arizona, outdoor use per household is estimated at under 200 GPD on average. A typical 18 hole golf course in Pima County, Arizona uses about 500,000 GPD. (Source: *Water Use and Conservation*, Amy Vickers, WaterPlow Press, Amherst, Massachusetts, 2001).

An area such as Manele is expected to have higher than average water consumption, due to the hot, dry nature of its climate. Residential per unit consumption in Manele is considerably higher than that in high-use communities in South Maui, such as Maui Meadows.   This need not be the case. A relatively lush appearance can be attained without creating desert-scapes or replacing foliage with cacti and pebbles. The high level of outdoor consumption on Lana‘i presents an opportunity for demand side savings.

Reduction in water consumption for landscapes can have several benefits. Such reductions can lower system peaking factors, reduce draft from sensitive aquifers, and lower both utility and customer facility costs, to name a few. Even a 10% reduction in irrigation water use could save over 110,000 GPD. Greater savings could quite possibly be attainable.

Landscape conservation begins with a thorough landscape water audit.   An inventory should be made delineating the following items as a minimum:

- Irrigated acreage, soils and soil infiltration rates,
- Plant materials,
- Size and irrigation demands of watering zones, weather station or evapotranspiration data (ET data),
- Irrigation equipment and controllers in each zone,
- Watering times, settings, operating pressures and gallons per minute of each zone,
- Condition of equipment, overspray areas, tilted heads, missing heads, etc.,
- Distribution uniformity of equipment,
- Condition of plant materials.

The principles of landscape conservation are well known and will not be iterated in detail here. A draft conservation ordinance, including landscape conservation measures is provided in Appendix E of this plan. Also attached in Appendix I are checklists for landscape conservation, golf courses and hotels. Some general "bullet points" include:

- Turf should be limited to active play or picnic areas.
- Where turf is used, mower blades should be set high.
- Mulching mowers should be used where possible. These return grass clippings to the lawn. Grass clippings contain about 85% water and 5% nitrogen. Leaving them on the lawn helps hold in moisture, reduce evaporation and keep grass cool.
- The majority of landscaped areas should be planted with native species that are adapted to the natural rainfall in the area, or with drought tolerant non-invasive non-native species. In Manele, plant species which are salt tolerant would also be appropriate.
- Thirsty plants should be limited to showcase areas. Plants in these areas can be planted in low areas or small basin-like forms to encourage water to pool.
- Mulches should be used both for decorative value and to reduce evaporative losses, cool soil and control weeds. Mulches can also slow erosion and reduce soil compaction. Plants with similar water requirements should be grouped so that irrigation circuits can be controlled more effectively.
- Irrigation circuits should be designed, timed and operated to prevent overspray or watering of non-planted areas.
- Watering should not occur in the heat of the day, nor during rainfall or other periods when soil moisture may already be adequate.
- Automated irrigation systems should be equipped with controllers capable of multiple programming for different zones, equipped with rain shut-off devices, and smart controllers capable of responding appropriately to either soil moisture or evapotranspiration conditions.
- Maintenance should include frequent leak detection efforts and rapid repairs.
- Distribution uniformities should be at least 85% for drip, 70% for rotors and 60% for spray heads.Discharge limitations for various types of irrigation emitters, as well as other measures, are included in the draft conservation ordinance attached as Appendix E.
- Design planted areas, particularly grassed areas to utilize natural runoff, and position plants in such a way that they receive runoff. A series of swales, basins, berms or microberms to direct flows toward planted areas can help to make use of whatever natural rainfall is present on site. Recessed or concave planting areas receive and retain rainfall better than raised beds.

Nationwide, one of the most effective conservation measures has been the low-tech option of limiting the number of times a week that watering can occur. Conventional wisdom is also that one should prune sparingly, to avoid growth accelerations that can increase water requirements. On Lana‘i, there is an example of a landscape that reduced consumption by allowing a very short bursts of light water spray a few times during the heat of the day to keep plants cool, but reserved deep watering for infrequent evenings. This is not the generally encouraged practice. In fact oscillating sprinklers and other sprinkler heads that produce fine mists or sprays are generally discouraged. However, it may merit further study. It should be noted that this practice was combined with very active pruning, which is also not a generally recommended practice for water conservation as noted above. The intense care taken on the property may mean that the method is not adaptable to those with less intensive maintenance. Nor is it clear how much of the reduced irrigation use came from these techniques versus more intensive monitoring and management of irrigation equipment. The reduction in water use achieved brought overall consumption more in line with that in Maui Meadows, one of Maui's highest per-unit use areas. Although the reduction in consumption achieved was laudable, it is not clear whether these techniques can or ought to be broadly replicated in Manele.

Landscape conservation measures that have been used with some success in South Maui hotels in recent years include:

- Installation of high-end smart controller systems,
- Installation and use of on-site weather stations,
- Replacement of irrigation nozzles,
- Installation of sub-surface drip systems under sod,
- Installation of drip irrigation under shrubs,
- Replacement of decorative plantings with drought tolerant natives, and installation of high-efficiency re-circulating water purification systems in water features.

The Grand Wailea Resort reported a 37% drop in irrigation consumption through the use of such measures.

Hotel Conservation

The hotels on Lana'i are the largest customers of Lana'i's water utility. Much of hotel use is irrigation use, but even leaving irrigation use aside, hotels are large customers. As such, an effort should be made by the water utility to partner with the hotel properties to achieve conservation both in the landscape and throughout hotel facilities.

An axiom in water conservation field is that "you can't save what you don't measure". As with irrigation, conservation at the hotels should begin with a detailed inventory of existing and proposed water uses at the hotels. The inventory should detail fixture units and counts, water uses and water using appliances and equipment in spas, restaurants, guest rooms, landscapes, laundries, cooling and other areas throughout the facility, locations and purposes of controls, sub-meters, water filters or recycling systems, locations and amounts of irrigated acreage, irrigation system elements, controllers, circuits and settings, acreage and volume of pools, filtration equipment, etc.

The hotels could benefit by being registering with the Green Building Certification Institute for LEED credits. The focused attention on conservation that comes with such an effort can result, not only in cost and resource savings, but also in an advertising boost, as "green" design and operation become increasingly marketable. In designing a conservation program, the hotels could aim to obtain 7 out of 10 water efficiency credits as a target. Certainly the future hotels should be designed built and commissioned in a manner that qualifies for a minimum of 7 out of 10 Water Efficiency credits.

Fixture replacements can save on electricity as well as water. A list of WaterSense certified high-efficiency toilets and other fixtures may be found at http://www.epa.gov/WaterSense/pp/index.htm. Fixture retrofits to consider include:

- Retrofit toilets with high efficiency models that use 1.28 gallons per flush or less
- Retrofit urinals with high efficiency models that use 0.5 gallons per flush or less.
- Install showerheads with a flow rate of 2 gpm at 60 psi or less in all units.
- Retrofit bathroom sink faucets with fixtures that do not exceed 1 gpm at 60 psi. (even more efficient models are available)

Cooling / HVAC systems should be reviewed. New systems should be constructed, commissioned and operated in a manner that conserves water as well as energy. Single pass cooling should not be permitted. Recent data indicate that increasing energy efficiency in coolers can also increase water efficiency. Cooling systems should be specified to qualify for LEED certification for energy efficiency and controllability, as well as the specific water conservation measures listed below for multi-pass systems:

- Installation of control systems and sub-metering to monitor and manage water quality and other parameters in make-up water and blow-down.
- Installation of appropriate treatment systems to manage water quality in cooling tower make-up water.
- Operation of cooling towers with greater than 5 cycles of concentration.
- Minimization of drift losses with baffles or drift eliminators.
- Establishment of a proactive cooling system maintenance and monitoring program.

Around the hotel, in kitchens, restaurants, snack shops and other areas, ice making, cooking and washing can be made more efficient with the following measures:

- Ice machines which use water for cooling should be replaced with efficient air-cooled models.
- Refrigeration systems should be air-cooled or closed-system recirculating systems.
- Pre-rinse spray valves on dishwashers shall have a flow rate equal to or less than 1.6 gpm at 60 psi.
- Food steamers should be self-contained "boilerless" or "connectionless" models.
- Wok stoves should be "waterless woks".
- Ware washing units should have flow rates of less than 1 gallon per rack.
- If tunnel washers or multi-load washer extractors are used, they should utilize no more than 2 gallons of water per pound of laundry.
- If regular commercial clothes washers are used, install washers that are *Energy Star* and *WaterSense* certified, or have a water factor (gallons/cubic foot of laundry) of not more than 6.

Guests should be encouraged to conserve. This can be done in a manner that actually enlaces the guest experience. For instance, guided and interpreted, or self-guided “tours” or walks to native plantings, educational materials and displays explaining local resources, even interactive experiences teaching about traditional uses of plants and guiding guests in small projects can create a sense of appreciation for the value and beauty of local resources.

As a minimum, guests should be encouraged to conserve by

- Placing tent cards in rooms to encourage guests to re-use sheets and towels.
- Ensuring adequate towel rack space to enable & encourage guests to hang towels neatly. This will also help encourage them not to require daily washing.
- Placing tent cards in restaurants informing guests that water is available upon request, rather than automatically.

Landscape conservation has been discussed above. In general,

- All irrigated areas shall be equipped with smart controllers capable of self-adjusting to account for moisture conditions, and of multiple programming for separation of turf and non-turf areas.
- Irrigation valves and circuits should be arranged such that plants with different water requirements are watered separately and appropriately (hydrozones).
- Landscaping should be designed and / or renovated so as to qualify for LEED credit WEc1.1 as a minimum.
- To the extent possible in landscaping, select native plant species that are adapted to the natural rainfall and salt conditions in the area. The project is located in Plant Zones 3 and 5. The use of climate-adapted native plants conserves water and protects watersheds from the spread of invasive plant species.

Even water features can be made more efficient. High efficiency filtration systems are available for pools and fountains.

For the new hotels, and in the event that the existing hotels are renovated, wastewater systems should be designed or renovated to qualify for LEED credit WEc2.

Once an inventory of water uses and conservation opportunities has been made, and measures undertaken, it is important to take stock of the actual performance of conserving measures. A useful tool is an annual tally of what has been done, the goal of each measure taken, and how the results panned out. Document the recorded savings or reductions in peak factors, to assist in fine-tuning facility management for conservation as time goes on. An annual inventory of uses, performance, and changes made to fixtures or processes such as treatment, recycling, or other measures to conserve, as well as water use impacts of each, should become a regular practice.

New hotels or expanded facilities should be conditioned upon implementation of such measures. Existing hotels should be encouraged in these directions with incentives such as rebates, as well as pricing signals. Some funds were budgeted to support this in the capital plan discussed in this chapter.

A variety of potential programs were characterized in terms of costs per thousand gallons saved. These included toilet replacement rebate and direct installations, leak detection audits, faucet and fixture giveaway programs, and various outdoor irrigation efficiency and control measures. Several of these programs appear to be cost effective measures in comparison with new source development.

Growth Management

One approach to meeting water demand is to manage the amount of growth and land development by general land use planning procedures. Decisions regarding where growth is allowed to occur and what types of developments are permitted are within the scope of land use planning. However, these decisions are informed by the status of both infrastructure and resources of many sorts, water among them. In the case of water, a unique situation exists, in that the State Water Code HRS §174C-31(a)(2) states that the Water Use and Development plans shall set forth the allocation of water to land use in each county. The Lanaʻi Water Advisory Committee discussed allocations at length. These discussions included review of project proposals discussed in the *Demand* chapter of this document, as well as resource issues discussed in the *Existing Resources and Systems* and *Source Water Protection* chapters of this document. The results of these discussions, along with some recommendations, are presented in the *Policy Issues* chapter of this document.

Water Source Protection

Water source protection is an important component of any water system management plan. For the Island of Lanaʻi water source protection has been identified as an especially important component because of the importance of vegetation in maintaining the amount of total effective precipitation. The importance and impacts of water source protection measures are discussed the next chapter, on *Source Water Protection*.

Summary of Levelized Costs

Several measures to increase available source have been discussed. Some of these measures include high capital investments up front, but low operating costs. Others include low initial investments, but high operating costs. Some measures create large additional capacity, while other measures create only a little. In order to develop a meaningful comparison of the value of these projects, total costs over the economic life of each project, including inflation and cost of capital where applicable, are derived and levelized to costs per 1,000 gallons of water produced.

In the tables on the following three pages, a summary of costs of new source development, supply side measures and demand side measures are presented in terms of cost per thousand gallons. Figure 5-42 examines new and replacement source options. Figure 5-43 examines loss reduction options, and Figure 5-44 examines demand side management options. In all cases measures are presented in order of least to most expensive on a life time basis.

Some explanation of the column headings may be of use. For the new and replacement source projects and loss reduction projects in Figure 5-42 and 5-43, respectively, installed capacity refers to the capacity of the equipment installed, whereas effective capacity refers to the average day yield anticipated accounting for limitations. Average output is the amount of water assumed in the economic analysis. For the purposes of comparison, this is assumed to be the same thing. The capital cost is the total cost in millions of dollars. The unit cost is millions of dollars per millions of gallons per day, or dollars per gallon per day. Variable costs are principally the costs of electricity and chemicals, or amortized filter costs for treatment plants. These costs are proportional to the amount of production. Economic plant life is assumed to be 30 years for new sources. It is the estimated life of the project before additional major expenditures would be anticipated, recognizing that some portions of projects have longer lives than others. The Unit NPV, or net present value is the capital fixed operating and variable operating cost in terms of $per gallon per day of operating the facility over 30 years expressed in current dollars. The levelized cost is the cost over thirty years in terms of thousands of gallons. Capital, Fixed and Variable operating costs are expressed in terms of levelized dollars per thousand gallons. Capital costs refer to the up-front investment to construct or install a facility. Fixed operating costs refer to expense to operate that are present in the same amount regardless of how much water is being produced, such as labor for metering and maintenance and fixed demand charges for electricity. Variable operating costs are those which increase with increased production such as electrical charges, chemicals or, in the case of treatment, amortized filter costs.

Supply Options

FIGURE 5-41. Summary of New and Replacement Source Options Levelized Costs

Option Name	Plant Capacity		Average Output	Capital Cost		Fixed Operating		Variable Operating Cost	Plant Life Economic	Economic Life Total Discounted Cost				
	Installed	Effective		Cost	Unit Cost	Cost	Unit Cost			Total Unit NPV	Total Levelized	Capital Levelized	Fixed Op. Levelized	Var. Op. Levelized
	MGD	MGD	MGD	$M	$M/MGD	$/Year	$/Year/MGD	$/kgal	Years	NPV $2007 $M /MGD	Levelized $ / kgal	Levelized $ / kgal	Levelized $ / kgal	Levelized $ / kgal
Proposed New Well #2B @ Shaft 3 Site	0.864	0.300	0.300	$1.883	$6.276	$15,415	$51,383	$0.92	30	$14.901	**$2.97**	$1.25	$0.20	$1.51
Proposed New Brackish Well #15	0.864	0.300	0.300	$2.657	$8.856	$19,519	$65,063	$1.30	30	$20.894	**$4.16**	$1.76	$0.26	$2.14
Well - High Level Potable (1) 1mgd near Hi`i Tank	0.864	0.300	0.300	$2.867	$9.556	$20,599	$68,663	$1.41	30	$22.554	**$4.49**	$1.90	$0.27	$2.31
Well - High Level Potable (1) 1MGD near Well #5	0.864	0.300	0.300	$2.957	$9.856	$22,759	$75,863	$1.61	30	$24.650	**$4.91**	$1.96	$0.30	$2.64
Recommission Well#7	0.720	0.300	0.300	$2.678	$8.927	$26,719	$89,062	$2.37	30	$30.266	**$6.02**	$1.78	$0.35	$3.89
Wells - Windward (3)1MGD at Maunalei w/Existing Transmission	3.000	0.750	0.750	$8.001	$10.668	$118,144	$157,525	$2.43	30	$33.860	**$6.74**	$2.12	$0.62	$3.99
Wells - Windward (2) 1 MGD Maunalei w/Existing Transmission	2.000	0.500	0.500	$6.766	$13.531	$78,763	$157,525	$2.43	30	$36.723	**$7.31**	$2.69	$0.62	$3.99
Windward Well at Malau	0.864	0.300	0.300	$6.377	$21.256	$23,839	$79,463	$1.71	30	$36.946	**$7.35**	$4.23	$0.31	$2.81
Windward Well at Kauiki (Incremental)	0.864	0.300	0.300	$4.865	$16.216	$40,334	$134,445	$2.73	30	$41.431	**$8.25**	$3.23	$0.53	$4.49
Recommission Maunalei Shaft/Tunnels	1.000	0.500	0.500	$10.110	$20.220	$48,513	$97,025	$2.43	30	$42.213	**$8.40**	$4.02	$0.38	$3.99
Wells - Windward (3)1MGD at Maunalei w/New Transmission	3.000	0.750	0.750	$14.607	$19.476	$118,144	$157,525	$2.43	30	$42.668	**$8.49**	$3.87	$0.62	$3.99
Windward Well at Kehewai Ridge 2250ft.	0.864	0.300	0.300	$9.275	$30.916	$28,159	$93,863	$2.11	30	$50.200	**$9.99**	$6.15	$0.37	$3.47
Windward Well at Kehewai Ridge 2750ft.	0.864	0.300	0.300	$9.659	$32.196	$32,479	$108,263	$2.51	30	$55.073	**$10.96**	$6.40	$0.43	$4.12
Windward Well at Kauiki	0.864	0.300	0.300	$10.925	$36.416	$40,334	$134,445	$2.73	30	$61.631	**$12.27**	$7.24	$0.53	$4.49
Desalination - Seawater to 400 ppm Chlorides	0.250	0.250	0.250	$3.335	$13.338	$100,348	$401,390	$6.37	30	$73.969	**$14.72**	$2.65	$1.58	$10.48
Desalination - 50% Seawater to 225 ppm Chlorides	0.250	0.250	0.250	$3.272	$13.066	$111,598	$446,390	$9.97	30	$104.372	**$20.77**	$2.60	$1.76	$16.40
Desalination - Seawater to 225 ppm Chlorides	0.250	0.250	0.250	$3.382	$13.527	$121,598	$486,390	$13.17	30	$132.062	**$26.29**	$2.69	$1.92	$21.66

Levelized costs are calculated based on 3.0% inflation, 6.0% cost of capital and 6.0% discount rate. Operating costs are estimates of Haiku Design & Analysis.
Electricity costs included in Variable Operating Costs are $0.40 per KWH (= $125/bbl crude oil price) escalated at 4.0% for levelization.
All engineering assumptions, estimated costs and impacts are planning projections that will need to be verified by specific studies prior to implementation.
NPV = net present value MGD = millions of gallons per day kgal = one thousand gallons $2007 = constant (real) dollars

FIGURE 5-42. Summary of Loss Reduction Options - Levelized Costs

Option Name	Plant Capacity			Capital Cost		Fixed Operating		Variable Operating Cost	Plant Life	Economic Life Total Discounted Cost				
	Installed	Effective	Average Output	Cost	Unit Cost	Cost	Unit Cost		Economic	Total Unit NPV	Total Levelized	Capital Levelized	Fixed Op. Levelized	Var. Op. Levelized
	MGD	MGD	MGD	$M	$M/MGD	$/Year	$/Year/MGD	$/kgal	Years	NPV $2007 $M /MGD	**Levelized $ / kgal**	Levelized $ / kgal	Levelized $ / kgal	Levelized $ / kgal
Pipe Replacement / Loss Reduction IGGP	0.202	0.202	0.202	$3.840	$19.010	-$3,737	-$18,500	-$1.49	20	$9.782	**$2.34**	$4.54	-$0.07	-$2.14
Recycled Water Line to Miki Basin Industrial Prk	0.060	0.060	0.060	$1.536	$25.600	$248	$4,140	$0.40	30	$28.974	**$5.77**	$5.09	$0.02	$0.65
Recycled Water Line to Manele (2030)	0.500	0.500	0.500	$16.896	$33.792	$2,070	$4,140	$0.40	30	$37.166	**$7.40**	$6.72	$0.02	$0.65
Phase II Recycled Water Line Miki Basin to Manele	0.440	0.440	0.440	$15.456	$35.127	$1,822	$4,140	$0.40	30	$38.501	**$7.66**	$6.99	$0.02	$0.65
Phase I Recycled Water Line to Miki Basin Industrial Park	0.060	0.060	0.060	$2.304	$38.400	$248	$4,140	$0.40	30	$41.774	**$8.31**	$7.64	$0.02	$0.65
Floating Cover on 15 MG Reservoir	0.017	0.013	0.013	$0.366	$27.692	$0	$0	$0.00	10	$27.692	**$10.31**	$10.30	$0.00	$0.00
Hypalon Balls on 15 MG Reservoir	0.017	0.014	0.014	$0.495	$35.294	$0	$0	$0.00	10	$35.294	**$13.14**	$13.13	$0.00	$0.00
Aluminum cover on 15 MG Reservoir	0.017	0.013	0.013	$4.024	$304.821	$0	$0	$0.00	30	$304.821	**$60.67**	$60.63	$0.00	$0.00

Notes: Levelized costs are calculated based on 3.0% inflation, 6.0% cost of capital and 6.0% discount rate. Operating costs are HDA estimates.
Electricity costs included in Variable Operating Costs are $0.40 per KWH (= $125/bbl crude oil price) escalated at 4.0% for levelization.
All engineering assumptions, estimated costs and impacts are planning projections that will need to be verified by specific studies prior to implementatic

Abbreviations: NPV = net present value MGD = millions of gallons per day kgal = one thousand gallons $2007 = constant (real) dollars

FIGURE 5-43. Summary of Demand Side Management Options - Levelized Costs

Candidate DSM Program Characterization

Program Name	Delivery Mechanism	Measure Cost: Equip Cost	Measure Cost: Instal Cost	Measure Cost: Total per unit	Utility Cost: Rebate per unit	Utility Cost: Admin per unit	Utility Cost: Total per unit	Program Cost: Participant per unit	Program Cost: Utility per unit	Program Cost: TRC per unit	Savings Efficacy gpdpf	Measure Life Years	Levelized Unit Cost: Participant $ / kgal	Levelized Unit Cost: Utility $ / kgal	Levelized Unit Cost: TRC $ / kgal
Toilet Flapper Install	Per SPU CPA	$8	$0	$8	$8	$12	$20	$0	$20	$20	9.25	10	$0.000	$0.804	**$0.804**
Toilet Targeted Retro	Direct installation of fixtures in targeted buildings with existing 5-7 gpf fixtures	$80	$100	$180	$180	$75	$255	$0	$255	$255	50.00	15	$0.000	$1.438	**$1.438**
Urinal Retro Rebate	Rebate Application similar to Honolulu toile rebate program	$250	$100	$350	$150	$50	$200	$200	$200	$400	55.55	15	$1.015	$1.015	**$2.031**
Toilet Retro Rebate	Bounty for old fixtures brought to depo (dumpster) and destroyed	$80	$100	$180	$100	$50	$150	$80	$150	$230	30.00	15	$0.752	$1.410	**$2.162**
Toilet Retro Rebate	Rebate Application based on Honolulu program	$80	$100	$180	$100	$50	$150	$80	$150	$230	30.00	15	$0.752	$1.410	**$2.162**
Shwrhd Direct Install	Showerheads installed by trained technicians				$0	$30	$30	$0	$30	$30	7.29	10	$0.000	$1.531	**$1.531**
Shwrhd Canvass	Showerheads distributed by door to door canvase with choice of type				$0	$20	$20	$0	$20	$20	4.86	10	$0.000	$1.531	**$1.531**
Showerhead Giveaway	Showerheads distributed at public events or by request				$0	$10	$10	$0	$10	$10	1.62	10	$0.000	$2.296	**$2.296**
Shwrhd Mass Mail	Showerheads mailed to all customers				$0	$15	$15	$0	$15	$15	1.62	10	$0.000	$3.444	**$3.444**
Water Eff Clothes Wash	Rebate Application with purchase documentation	$350	$0	$350	$150	$70	$220	$200	$220	$420	16.91	10	$4.400	$4.840	**$9.240**
Water Eff Dish Washer	Rebate Application with purchase documentation	$50	$0	$50	$50	$70	$120	$0	$120	$120	1.00	10	$0.000	$44.640	**$44.640**
Improve Irr. Scheduling	Per SPU CPA - Improve irrigation efficiency by better scheduling	$25	$0	$25	$25	$9	$34	$0	$34	$34	23.77	10	$0.000	$0.534	**$0.534**
Low Water Use Plantings	Per SPU CPA - Replace 300sq ft. lawn with low water req. plants	$25	$0	$25	$25	$9	$34	$0	$34	$34	10.31	10	$0.000	$1.231	**$1.231**
Xeriscaping	HDA per SPU CPA - Replace irrigated landscaping with zeriscape	$500	$1,000	$1,500	$500	$300	$800	$1,000	$800	$1,800	500.00	10	$0.744	$0.595	**$1.339**
Soil Moisture Sensor	Per SPU CPA - Install soil moisture sensors on automatic irrigation systems	$150	$0	$150	$150	$9	$159	$0	$159	$159	34.11	10	$0.000	$1.735	**$1.735**
Improve Perf. of Irr. Sys.	Per SPU CPA - repair, replacement, adjustmen of in-ground irr. system	$188	$0	$188	$188	$9	$197	$0	$197	$197	38.03	10	$0.000	$1.923	**$1.923**
Auto Rain Shut Off	Per SPU CPA - Install automatic rain shut-off on automatic irrigation systems	$50	$0	$50	$50	$9	$59	$0	$59	$59	10.66	10	$0.000	$2.063	**$2.063**
Rain Barrel Catchment	Per SPU CPA - Install 50 gallon barrels to gutte downspouts for irrigation	$50	$0	$50	$50	$9	$59	$0	$59	$59	1.99	10	$0.000	$11.050	**$11.050**
Greywater for Irrigation	Per SPU CPA - Install grey water collect/dist. system -new and remod. with sand filtration	$2,000	$0	$2,000	$2,000	$9	$2,009	$0	$2,009	$2,009	16.11	15	$0.000	$35.169	**$35.169**

Notes:
Shaded cells are data entry cells; other numerical cells are calculated
SPU CPA = Seattle Public Utilities Conservation Potential Assessment Final Project Report, May 1998. Delivery mechanisms were not explicitly identified for several programs.
Documentation, calculations of estimates and sources are identified on a more detailed source spreadsheet
Levelized costs are calculated according to the identified measure life assuming a 3.0% inflation rate, 6.0% cost of capital, 6.0% discount rate.
All estimates and calculated costs and savings impacts should be considered rough approximations for purposes of intial measure and program assessment.

Abbreviations: gpd = gallons per day; gpdpf = gallons per day per fixture; kgal = thousand gallons; TRC = Total Resource Cost Test HDA = Haiku Design & Analysis (Carl Freedman)

Existing Near Term Source Plans

Existing near term source plans include the replacement of Well 3, replacement of Well 2 and Shaft 3 with Wells 2-A and 2-B, recommissioning of Well 7 and installation of Well 15.

Based upon system standards, as shown on Figure 5-21, these wells would be adequate to firm the system and handle redundancy requirements for natural growth, as forecast in the Base Case SMS Forecast. However, they could not all be used at design capacity without exceeding the sustainable yield of the Leeward aquifer. For more optimal distributions of withdrawals, as well as more use from new or replacement sources, it would be advisable to seek windward aquifer sources within the planning period. One good option cost-wise might be the installation of a well in the Windward aquifer at Malau.

On a levelized basis, the most cost-effective measure to improve source availability turns out to be replacement of the pipes in the Palawai Grid, as discussed in the next section. Although this was not part of the near term source plan, it is now recommended, along with some other measures to be discussed in the proposed plan section.

Supply Options

FIGURE 5-44. Base Case Forecast Installed Capacity Requirements and Plans

Installed Capacity Less Largest Pump Requirements for Base Case - Elasticity = 1

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
Now Less Lrgst Pump	792,000	1,296,000	864,000	2,952,000
2009	1,357,441	1,008,550	2,044,160	4,410,151
2010	1,378,325	1,024,067	2,075,609	4,478,002
2011	1,401,321	1,041,152	2,110,238	4,552,711
2012	1,424,316	1,058,237	2,144,866	4,627,419
2013	1,447,311	1,075,322	2,179,495	4,702,128
2014	1,470,306	1,092,407	2,214,123	4,776,836
2015	1,493,302	1,109,492	2,248,751	4,851,545
2016	1,512,631	1,123,853	2,277,859	4,914,343
2017	1,531,960	1,138,215	2,306,967	4,977,142
2018	1,551,290	1,152,576	2,336,075	5,039,940
2019	1,570,619	1,166,937	2,365,183	5,102,739
2020	1,589,948	1,181,298	2,394,291	5,165,537
2021	1,611,333	1,197,187	2,426,493	5,235,013
2022	1,632,717	1,213,075	2,458,696	5,304,488
2023	1,654,102	1,228,963	2,490,899	5,373,963
2024	1,675,486	1,244,851	2,523,101	5,443,439
2025	1,696,870	1,260,739	2,555,304	5,512,914
2026	1,719,255	1,277,371	2,589,012	5,585,638
2027	1,741,639	1,294,002	2,622,721	5,658,361
2028	1,764,023	1,310,633	2,656,429	5,731,085
2029	1,786,407	1,327,264	2,690,137	5,803,808
2030	1,808,792	1,343,895	2,723,845	5,876,532

Additional Capacity Required to Meet System Standards

Year	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
Now Less Lrgst Pump	792,000	1,296,000	864,000	2,952,000
Additional Capacity Required to Meet Standard Redundancies				
2009	565,441	-287,450	1,180,160	1,458,151
2010	586,325	-271,933	1,211,609	1,526,002
2011	609,321	-254,848	1,246,238	1,600,711
2012	632,316	-237,763	1,280,866	1,675,419
2013	655,311	-220,678	1,315,495	1,750,128
2014	678,306	-203,593	1,350,123	1,824,836
2015	701,302	-186,508	1,384,751	1,899,545
2016	720,631	-172,147	1,413,859	1,962,343
2017	739,960	-157,785	1,442,967	2,025,142
2018	759,290	-143,424	1,472,075	2,087,940
2019	778,619	-129,063	1,501,183	2,150,739
2020	797,948	-114,702	1,530,291	2,213,537
2021	819,333	-98,813	1,562,493	2,283,013
2022	840,717	-82,925	1,594,696	2,352,488
2023	862,102	-67,037	1,626,899	2,421,963
2024	883,486	-51,149	1,659,101	2,491,439
2025	904,870	-35,261	1,691,304	2,560,914
2026	927,255	-18,629	1,725,012	2,633,638
2027	949,639	-1,998	1,758,721	2,706,361
2028	972,023	14,633	1,792,429	2,779,085
2029	994,407	31,264	1,826,137	2,851,808
2030	1,016,792	47,895	1,859,845	2,924,532

Anticipated Capacity Additions

Source Option	Wells 6 & 8	Wells 2 & 4	Wells 1, 9 & 14	Total
Well 3	432,000	432,000		864,000
Well 2-A		864,000		864,000
Well 2-B		864,000		864,000
Well 15			576,000	576,000
Recommission Well 7	864,000			576,000
NEAR TERM ADDITIONS	1,296,000	2,160,000	576,000	3,744,000
Deficit			1,283,845	
Base Case WW Addition			387,723	
Remaining Deficit	None	None	896,122	None
Resulting Installed Less Largest Pump	2,088,000	3,456,000	1,440,000	4,320,000
For Brackish System Only - Standards Don't Apply - Checking Requirements vs. Source				
Forecast Source Requirement	803,907	597,287	1,210,598	2,611,792
* Shown for all systems for information, though this exercise applies only to brackish systems.				
Capacity over Avg Day Forecasted Requirement			229,402	

System Maintenance and Replacement Needs

Any twenty year plan must consider system replacement needs as well as new source, in order to determine feasibility and costs.

Anticipated costs of system replacement needs can be estimated in a number of ways. One way is to schedule replacements based on installation dates of system elements. The estimated useful life of a facility depends upon size, material and location, but if these factors are known, a replacement schedule can be derived.

Another accepted way to schedule capital improvements is based upon inspection and condition assessment of actual facilities. For example, such flaws as rust or caving tank roofs are clearly visible upon inspection. Similarly, frequent breaks, pressure or water quality complaints, or high unaccounted-for water can also help to target problem pipes for replacement. In this method, items are budgeted based on condition and performance. This method generally applies to near-term budgeting.

A third method is to estimate an average annual requirement and budget for that. For example, on Lana‘i, with just under 80 miles of active pipeline, and an average useful life of fifty years - roughly 1.6 miles of pipe should be replaced per year. This is a valid method for a long term budget approximation. Depending upon the segments to be replaced, this will be more in some years and less in others, but it reflects the average pace of replacement necessary to maintain a system the size of Lana‘i's. Similar calculations can be done for other system facilities.

Usually, replacement schedules are drafted based upon a combination of these two methods, as is the case with the plan presented here.

Once projects have been identified, it must be determined whether and how they can be funded.

Typically, new or expanded source is funded by new meter fees. These may be called “Water System Development Fees”, “Facilities Capacity Charges”, “Tap-In Charges”, or simply “New Meter Fees”, but they refer to the charge paid to add a new meter to the system. This philosophy is sometimes encapsulated in the phrase “growth pays for growth”.

Replacement, renovation or repair of existing facilities is typically funded by rates and monthly or bi-monthly charges.

In preparing this plan, funding had to be distributed between Lana‘i Water Company, Inc. (LWCI) and Lana‘i Holdings, LLC. (LHI). LWCI purchases source delivery from it's parent company, LHI. Part of this arrangement is that LHI develops and drills new or expanded capacity. According to utility personnel, once source projects have been developed, LWCI must budget cost recovery for LHI to maintain, repair or replace them. Under the current structure, some costs are recovered by the utility, while others are borne by the company. Costs of projects in this plan have been assigned to either LHI or LWCI based upon discussions with utility personnel.

Once system needs are identified, and recovery needs determined, a rate and fee structure is designed to accommodate them.

Projects necessary for system maintenance have been identified and are classed in the following broad categories:

- Source
- Supply and Demand Side Efficiency
- Storage
- Pipeline and Valves
- Pumps
- SCADA Telemetry and Monitoring Needs

Source

The following projects, although source related, are anticipated to be funded through LWCI rates and fees because they involve replacement or renovation of existing source.

<u>Well 3 Replacement</u> Well 3 is out of service and in need of replacement. This source once delivered half a million gallons per day, but toward the end of its life pumpage was closer to 100,000 gallons per day. Well 3 had one particularly useful feature, which was that it could effectively serve either the Koele and Lana‘i City systems, Kaumalapau or supplement the service areas of Wells 2 & 4. The Well 3 Replacement will be located in the same area as the existing Well 3. It is expected to have an installed capacity of 864,000 GPD, with an average day capacity of 384,000 gallons and an average water delivery of 300,000 GPD. Installation costs provided by utility personnel total $1.7 million. Well 3 Replacement is expected to be on-line in the third quarter of 2010.

<u>Well 2 Renovation</u> Well 2-Shaft 3, although technically on line, is rarely used due to issues of both safety and facility condition. Well 2-Shaft 3 was once the island’s main source of irrigation water. Based upon water levels, Well 2-Shaft 3 should be the most economical source to operate. The Well 2 renovation involves replacement of the Well 2 portion of Well 2-Shaft 3. This project involves moving the pump facilities, controls and telemetry to the surface and renovating the well and pump facility. Anticipated capacity is 864,000 GPD installed, with an average day capacity of 384,000 gallons and an average water delivery of 300,000 GPD. Estimated costs provided by utility personnel are $900,000. Well 2 Renovation is expected to be on-line in 2012. Because of the project listed below, this Well 2 Renovation is also referred to as Well 2-A.

<u>Well 2-B</u> Well 2-B involves replacing the old Shaft 3 with a well drilled to tap into the old Shaft 3 source. Based on the behavior of water levels at Well 2 and Shaft 3, LWCI personnel believe that Well 2 and Shaft 3 tap separate dike compartments, and can be operated as two separate sources. Anticipated costs are $2,382,880. Anticipated capacity is 864,000 installed, with an average day capacity of 384,000 gallons and an average water delivery of 300,000 GPD. Well 2-B is expected to be on-line in the fourth quarter of 2014.

<u>Well 1 Replacement or Renovation</u> Well 1 was drilled in 1945. By 2030 it will be an 85 year old well. The pump and shaft were last replaced in 2005. Water levels in Well 1 are declining, as they

are in Wells 9 & 14. Part of the purpose of Well 15 is to distribute withdrawals in the hopes that water levels in these wells can stabilize, as well as for additional redundancy.

Well 4 Replacement or Renovation Well 4 is the island's most productive well at present. Although Well 4 appears to be in working order, replacement or renovation remains on the fringes of LWCI's plans, because by the year 2030 it will be an 80 year old well. It was drilled in 1950. The pump motor was last replaced in 2006. Project costs are estimated only roughly, at $1.75 million.   The existing pump is 900 GPM, or 1,296,000 GPD installed capacity. The size of the replacement pump would be determined based upon water levels at the time it is replaced.

The following projects would be funded by LHI as expansion source.

Well 15 Water levels in all three pumping brackish wells, Wells 1, 9 & 14, are declining. An additional well is required to distribute withdrawals, as well as to provide redundancy for the brackish system. Costs are estimated at $2,656,800.   Anticipated installed capacity is 864,000, with an average day capacity of 384,000 gallons. No additional source availability is assumed to result from this project.

Recommission Well 7 Well 7 could provide both reliability and improved distribution of withdrawals on the north end of the Leeward aquifer. Well 7 has the advantage of being situated such that, with transmission improvements, it could serve either Lana‘i City or the Irrigation Grid. Estimated costs to renovate Well 7 and construct transmission to the Lana‘i City system are $2,678,210.

Well 5 Replacement Well 5 was drilled in 1950. By the late 1980s, water deliveries from this well were declining, and the well was used mainly for backup. When it was in use, it had to be used with caution, and given time to allow water to recharge. Although Well 5 has been out of use since 1994, it was seen as a possible re-instated future source for years. More recently, general thinking has been that it would be more likely to replace this source than to revitalize the old well. Costs are estimated at $2,956,800. The costs of this project would be borne by LHI.

In addition to these three quasi -replacement sources, new source projects identified and described earlier in this chapter would be funded by LHI.

- High Level Potable Well Near Hi‘i Tank (between Hi‘i Tank and Well 3)
- Windward Well at Malau
- Windward Well at Maunalei
- Windward Well at Kehewai Ridge - 2,250’
- Windward Well at Kehewai Ridge - 2,750’
- Windward Well at Kauiki
- Windward Wells at Kauiki (Incremental)

Supply and Demand Side Efficiency

Indoor Conservation   Technical domestic savings potential was evaluated in the *Demand Analysis* chapter of this WUDP. The theoretical potential water savings from indoor conservation was estimated at 175,192 GPD. $1,480,419 is included in the designed rate structure for a "Direct Install" program to replace all existing, non-conserving toilets, showerheads and faucet aerators and clothes washers on the island. Replacement of clothes washers could be traded for an equivalent savings opportunity in the commercial or other sectors, such as tunnel washers, pre-rinse spray valves, efficiency improvements in cooling, or other efficiency measures. Estimated costs included funds for contracting the installation out and associated internal administration. Since residential dishwashers are not addressed in this program, their estimated savings potential is subtracted from the total estimated technical savings potential, resulting in a theoretical savings from this plan of 174,040 GPD.

It is never possible to achieve full theoretical technical potential with a conservation program. Assumptions in program design assume that only a portion of technical potential is achieved. Assuming that roughly 100,000 GPD in savings were actually attained (about 57% of technical potential), an estimated $2,337,600 in savings would result from this investment of roughly $1.5 million. This savings is comprised of $212,000 in pumping costs, and the avoided installation of roughly 1/3 of a well, using the Well at Malau as a median priced example. Although net present value cost estimates were not calculated, the savings promise to be substantial enough that the measure is anticipated to be cost-effective.

<u>Incentives for Landscape or Hotel Conservation</u> Landscape is the largest use of water on the island, estimated at over 1.1 MGD. Hotels are the largest customers, with over 0.27 MGD in metered uses on the meters specifically classed as hotel alone. Roughly half of that is thought to be used outdoors for irrigation of hotel properties, water features, and the like. Both represent major opportunities for efficiency savings.

Measures for landscape efficiency have been discussed in general terms above. In addition, the pricing structure designed to support necessary expenditures over the next 20 years should have the effect of flattening at least the more excessive landscape or other uses. One means to mitigate and avert potential rate shock is to assist those most affected with incentives and assistance to conserve. $225,000 has been included for this purpose. $25,000 would be spent to hire an expert conservation consultant to identify the most critical measures, with the bulk of the funds going to actual efficiency incentives or rebates for these sectors.

<u>Leak Detection Equipment</u> Unaccounted-for water analysis in the *Demand Analysis* chapter of this document documented high losses in the Palawai Irrigation Grid. However, long before that, the Lanaʻi Water Advisory Committee discussed high pressures, frequent water service interruptions due to pipe breaks at the MECO plant in the Miki Basin area. LWCI personnel described "walking the lines" to find visible leaks. A leak in a buried pipe that has become visible at the surface has usually been growing for some time. All of the circumstances listed are indications of severely leaky pipes. Moreover, high pressures reported in the Grid would put additional burden on pipes in poor condition. An unfortunate finding of the unaccounted-for water analysis was that even with recent repairs and replacements, unaccounted-for water remained high in the Palawai Irrigation Grid as of the first 6 billing periods in 2009. Leaks can go on for a long time without detection, if not actively sought. In highly permeable or sandy soils, even severe leaks can go undetected indefinitely.

One way to minimize such losses is a regular system audit with leak detection equipment. In the proposed capital plan, $150,000 is included for leak detection equipment. This should be enough to obtain a digital correlator, some correlating loggers, a pipe locator, a leak detector and some leak loggers.

Water losses are costly in terms of energy consumption, wear on pumps and facilities, service interruptions, lost revenues and lost opportunities to do useful things with the water. These costs can be insidious. A standard Water Audit Worksheet from the American Water Works Association was used to examine the leaks indited on Wells 2 & 4, with the result that annual economic losses from these leaks were roughly $300,000.

Storage

Replace Hi'i Tank and Hi'i Reservoir with New 2 MG Tank The 0.5 MG Hi'i Tank is old and in need of replacement. The tank is in poor condition, with rust on the roof and near the base of the tank. A portion of the base appears to be missing or cracked. These deficiencies were mentioned in the Sanitary Survey of the Manele System. The Hi'i Reservoir is also about fifty years old, has a concrete lining and a cover. A concrete reservoir of this age could also be one source of unaccounted-for water, if cracks have begun to develop in the concrete.

Hypalon Balls To Reduce Evaporative Losses at 15 MG Brackish Reservoir Lana'i Water Advisory Committee members frequently expressed concern about unaccounted-for water at or around the 15 MG brackish water reservoir in Palawai Irrigation Grid. Unaccounted-for water in the brackish system is about 19%. Three options to reduce evaporative losses were evaluated. An aluminum cover, a floating cover and hypalon balls. The most cost effective appeared to be the floating cover. In discussions with utility personnel, there was concern that the floating cover might not be as easy to work with logistically as the hypalon balls. Floating covers can be difficult to remove when they start to disintegrate. Hypalon was selected for inclusion in the capital proposal. Anticipated savings are 14,000 GPD.

Pipeline Replacement

Nine pipeline projects totalling roughly $11,946,921 were identified and reviewed. Of these, eight were included in the capital proposal.

Replace Broken and Leaking Pipe In the Central Palawai Irrigation Grid As noted above, unaccounted-for water on this portion of the system is 44.61%. Due to the high pressures, frequent breaks and visible leaks discussed above, it is believed that the lion's share of this unaccounted-for water actually is lost to leakage. Even a reduction in losses, leaving 15% unaccounted-for water would result in over 200,000 GPD in savings from Wells 2 and 4. The costs of these losses to the utility are over $200,000 per year. By offsetting electrical costs for 200,000 GPD of pumpage, while at the same time adding 200,000 gallons of source availability, this option, pencils out as the most economical of all the source options, on a levelized cost basis.

The project also includes segments upstream of the Palawai Irrigation Grid, from Well 3 to Well 2, from Well 4 to Well 2, and from Wells 2 and 4 to the Hi'i Reservoir. Portions of these upstream segments do not meet system standards.

Both fire protection and potable water for the planned industrial park are required in the area as well, meaning that at least some portions of these replacements may receive developer funding. For instance, 12” line from Hi‘i Tank to Miki Basin could be developer funded, while the rest of the project would be funded by the utility. An alternate option would be to make a dual connection, running a potable 8” line to the Kaumalapau system, and an 8” line from Hi‘i to the Miki Basin.

Apart from Miki Basin, most of the uses in the Palawai Irrigation Grid could be served by irrigation grade rather than potable grade lines. Meters requiring potable service could be relocated to the Kaumalapau line for potable water. Mapping the actual locations of meters served by these lines within the grid led to this option. This could reduce the cost of the replacement.

On-site storage poses some questions. In discussion with utility personnel, it appeared that the currently favored option might be to provide on site storage with pumping capability for fire protection. Gravity flow is generally preferred, and might be a better option. Since some storage is likely to be required as a condition of the proposed industrial park development, it may be possible to combine the required tank with the replacement of the Hi‘i Tank and reservoir. The developer could cover all or part of that replacement, up to whatever would be necessary to serve the Industrial Park without detriment to Manele, according to standards. This option would require a 12” transmission line, but would provide better fire flow to the site. It is important to note in this regard that the project as priced involves an 8” line, which is adequate combined with other projects here to meet the needs of current uses. Never the less, a 12” line may be the better choice.

The estimated cost used in the plan is $3,740,920. This includes potable grade ductile iron lines the same sizes as existing lines upstream of the reservoir, and 8” irrigation grade line downstream of the reservoir.

If ductile iron lines suitable for potable use are selected, or if the line is upgraded to 12”, whether potable or irrigation grade, to provide fire protection, the cost could go up. But in these cases it may also be that all or a portion of these project upgrades could be developer-funded. It would be advisable to consult with developers and make these decisions before the upgraded line is installed.

<u>Replace Asbestos-Concrete Pipe Segments in Lana‘i City, including PRV on 10” Asbestos Line</u> To the northeast of Lana‘i City, some of the old transmission lines are asbestos. These are at an age where repairs become necessary from time to time, especially at the joints. Working with asbestos creates safety hazards for field crews, as well as inefficiencies and inconveniences on the job due to the need for special precautions. The estimated cost of the project is $972,041.

<u>Upgrade Kaumalapau Line</u> The line to Kaumalapau is old and undersized to provide fire protection to the Kaumalapau Harbor and residences. Portions of this line are in poor repair. The estimated costs to upgrade this line is $3,958,217.

<u>Potable Line Connecting Miki Basin to the Kaumalapau Waterline</u> This project could be a requirement of the proposed Miki Industrial Park. However, the existing MECO facility in Miki Basin has substandard service and would also benefit.

Potable Line Connecting Well 7 to Upper End of Lana'i City Service Area Well 7 has the advantage of flexibility, in that it could serve either the city or the west end of the Palawai Irrigation Grid service area. There is also an advantage in the fact that the well has been drilled for some time, which should afford some cost savings. This project would be paid for by LHI.

Replace Old Steel Pipe Segments in Lana'i City About 1.62 miles of pipe in Lana'i City are old wound steel pipes. These are due for replacement. Estimated project costs are $1,202,755.

Connect Well 7 To West End Grid This is part of a phased project. Connecting Well 7 to the West end of the Palawai Irrigation Grid would enable services on that side to be served by Well 7. Although these services do not use much, this would provide some relief to Wells 2 & 4. Leaks on this end of the Palawai Irrigation Grid are not believed to be as severe as they are in the Miki Basin, where pressures were extremely high for a long time. Never the less, the line is of the same general vintage and will be well past due for replacement within the planning period.

Re-route Brackish Line to Save Electrical Costs This project is not included in the capital plan. It was evaluated for inclusion, as it was determined that roughly $29,250 in electrical costs per year could be saved if two hills along the transmission route could be avoided. The benefits of the re-alignment were not sufficient to warrant replacing the entire line. The benefits of replacing portions of the line, to attain part of the possible savings, were also examined. None of the options examined warranted line replacement or retrofit. However, it is suggested that when the brackish line does become due for replacement, it be re-routed as shown in Figure 5-48.

Pumps

Rolling Pump Replacement At present there are six or seven operating source pumps, depending upon whether Well 2 is counted, with four or five likely to commence or resume operations in the near future, those being Well 3 (relocated), Well 2-A and 2-B, Well 15, and possibly Well 7. A total of twelve operating source pumps with an assumed lifetime of fifteen years per pump leads to a replacement rate of about 0.8 pumps per year, or 4 pumps every 5 years. Since some of these will be new, not all are deemed to require replacement within the planning period. An estimated twelve pump replacements over the twenty year period were included in the capital plan, at a cost of $2,400,000.

Motor Control and Electrical Center Upgrades Regular maintenance, assessment and replacement of parts such as motors, electrical controls, impellers or other elements as needed can help to extend the operating life of pumps. An annual allowance of $50,000 is included within the capital plan, for a total of $1,000,000.

SCADA, Telemetry and Other Monitoring Equipment

Monitoring Replacements and Upgrades An annual allowance of $25,000 is included to allow for regular replacement and upgrade of telemetry, SCADA, controls, flow meters or other monitoring equipment, for a total over the planning period of $500,000.

FIGURE 5-45. Pipeline Projects

PRIORITY	DESCRIPTION	DISTRICT	INSTALL DATE	MATERIAL	DIAM	REPLACE ONLINE DATE	LENGTH MILES	LENGTH FEET	REPLACEMENT DIAMETER	ANTICIPATED COSTS	COMMENT
Replace Broken & Leaking Pipe in Central Palawai Irrigation Grid											
1	IGGP '4th' Leg - St A to St S -5401 to 5229	IGGP	1960	Concrete	12	0	1.850	9,769.849	6	$146,547.74	
1	IGGP '4th' Leg - Stations Y, S, J, P and rain gague	IGGP	1960		0	0	0.870	4,595.615	6	$68,934.23	
1	IGGP Loop Line along Kaumalapau Rd	IGGP	0		0	0	0.958	5,057.262	6	$75,858.93	
1	Manele Trans - Well 3 to Well 2 by fields 5401-02	MNPD	1968	Concrete Cylinder	16	0	1.415	7,473.349	12	$1,233,102.59	Near city but to Manele. One map says this leg is 8" transite.
1	Revised Mid-East Alignment Per John	IGGP	0		0	0	0.206	1,088.763	6	$16,331.45	
1	Revised West End Alignment Per John	IGGP	0		0	0	3.146	16,610.208	6	$249,153.12	
1	Second Leg - 5513-14 and 5507-08	IGGP	1951	Cement Mortar Lined	0	0	2.536	13,392.114	6	$200,881.71	
1a	Pipeline from Well 2 / Shaft 3 to Trnamission Main	MNPD	1955		0	0	0.875	4,617.825	12	$761,941.13	
1a	Pipeline from Well 4 to Well 2	MNPD	1952		0	0	0.721	3,807.123	12	$628,175.30	
1a	Pipeline from Wells 2 and 4 to Hii	LCTY	0		0	0	0.413	2,181.779	12	$359,993.54	
							12.990	68,593.887		3,740,920	
Replace Asbestos-Concrete Pipe Segments in Lana`i City											
2	6th Street Waterline - From Queens St. to Alapa St	LCTY	0	Asbestos	10	0	0.031	162.213	10	$25,143.02	
2	Line fr Cavendish Mtr Line to Koele	LCTY	0	Asbestos	12	0	0.114	601.841	12	$99,303.77	
2	Line fr Old Lanai Tank down to Line that Enters Qu	LCTY	0	Asbestos	10	0	0.270	1,427.991	10	$221,338.61	
2	Part of 12" Main Above Alapa to N. End Queens	LCTY	0	Asbestos	12	0	0.185	977.430	12	$161,275.95	
2	Queens Avenue	LCTY	0	Asbestos	12	0	0.158	833.334	12	$137,500.11	
2	Queens St to Lanai Ave Waterline - btwn 8th and 9t	LCTY	0	Asbestos	10	0	0.120	631.275	10	$97,847.63	
2	Waterline Connecting 6th Street Line to Queens St	LCTY	0	Asbestos	10	0	0.033	174.356	10	$27,025.18	
2	Waterline from Maunalei Line to Top of 6th Street	LCTY	0	Asbestos	12	0	0.233	1,227.921	12	$202,606.97	
							1.144	6,036.361		972,041	
Upgrade Line to Kaumalapau to Meet System Standards											
3a	KPAU Trans 3rd Leg - below WWTP to Top of Runway	KPAU	1962			0	1.757	4,707.121	8	$663,704.06	
3	KPAU Trans - top of runway to Airport Road	KPAU				0	0.865	4,568.984	8	$644,226.74	
3	Airport Road to Kaumalapau Tank Waterline	KPAU				0	2.656	14,024.948	8	$1,977,517.67	
3	Kaumalapau Tank to Kaumalapau Harbor Waterline	KPAU				0	0.904	4,771.408	8	$672,768.53	
										$3,958,217.00	
Connect Potable Kaumalapau Waterline to Miki Basin											
4	Waterline from Kaumalapau Line to Miki Basin	IGGP	0		0	0	1.179	6,227.393	8	$878,062.41	
										$878,062.41	
Commission Well 7 and Connect to System											
5	Connect Well 7 to City fr. In by Koele to 2MG tk	LCTY	0	Ductile Iron	12	0	0.604	3,190.322	8	$449,835.40	
5	Connect Well 7 to City (portion to line by Koele)	LCTY	0	Ductile Iron	12	0	0.333	1,758.911	8	$248,006.45	
							0.937	4,949.233		697,842	

FIGURE 5-45. Pipeline Projects - Continued

Replace Old Steel Pipe Segments in Lana`i City									
6	N of Lanai Avenue Waterline - fr Koele line to 3rd	LCTY	0 Steel	8	0	0.199	1,051.637	8	$148,280.82
6	Ninth Street Waterline - Lanai Avenue to Fraser Av	LCTY	0 Steel	10	0	0.190	1,001.682	8	$141,237.16
6	Ninth Street Waterline - Puulani Place to Lanai Av	LCTY	0 Steel	10	0	0.120	632.279	8	$89,151.34
6	Olapa Street Waterline - 9th to Kaumalapau Hwy	LCTY	0 Steel	8	0	0.332	1,752.642	8	$247,122.52
6	Palawai Lane Waterline	LCTY	0 Steel	8	0	0.335	1,767.013	8	$249,148.83
6	Potable Line North of City from Fraser to Lana`i	LCTY	0 Steel	0	0	0.186	981.787	8	$138,431.97
6	Potable Line North of City fr Lana`i Ave to Koel	LCTY	0 Steel	0	0	0.254	1,343.137	8	$189,382.32
						----------	----------		----------
						1.616	8,530.177		1,202,755
Connect Well 7 to West End Grid									
7	Connection for Well 7 to West End Grid (Re-aligned	IGGP	0	0	0	1.935	10,215.809	6	$153,237.14
						----------	----------		----------
						4.658	24,590.565		153,237
Replace Old Pipe In West End of Palawai Irrigation Grid		**Estimated Cost: $6.17 Million**							
8	IGGP '4th' Leg - St P to N - crosses 5325 & 5313	IGGP	1960	0	0	1.252	6,613.055	6	$99,195.83
8	IGGP '4th' Leg- Stns Y,S,J,P, rain gauge 5311-5223	IGGP	1960	0	0	0.841	4,440.507	6	$66,607.61
8	Revised West End Alignment Per John	IGGP	0	0	0	1.350	7,125.360	6	$106,880.40
8	West North West End of Grid	IGGP	0	0	0	0.887	4,684.214	6	$70,263.21
						----------	----------		----------
						23.390	118,928.184		342,947
									11,946,021

FIGURE 5-46. Pipeline Projects

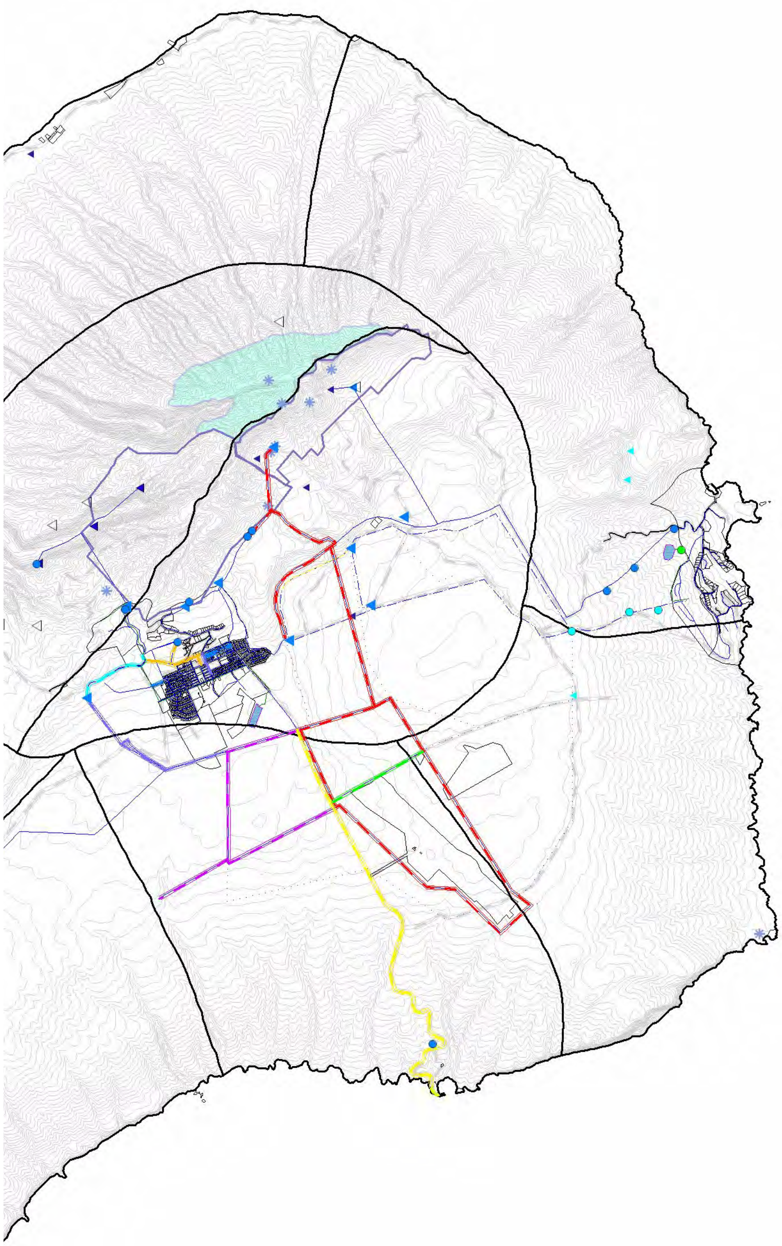
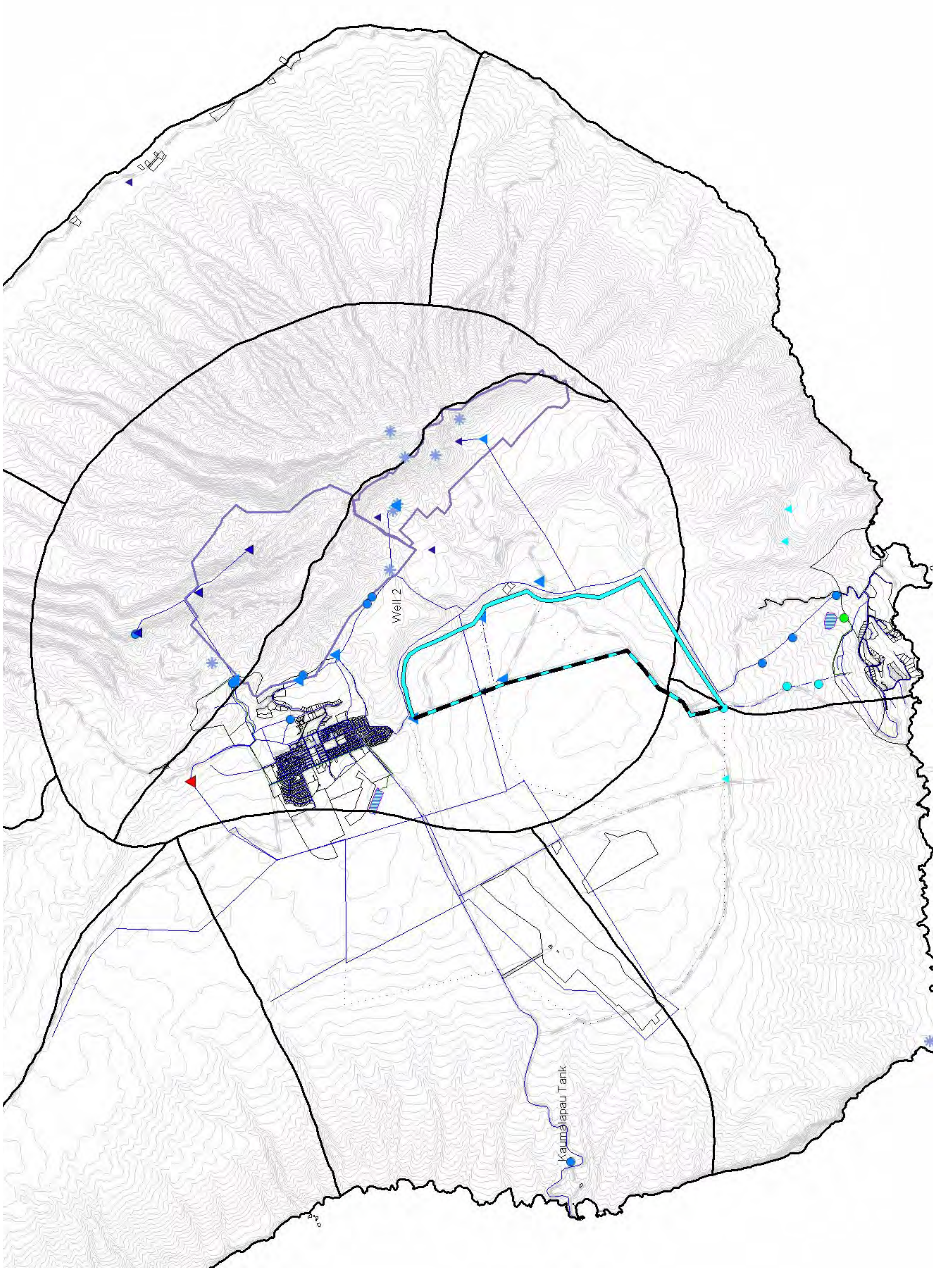


FIGURE 5-47. Alternate Route for Future Brackish Line



Aqua colored line is existing brackish line.
Dashed aqua and black colored line is proposed re-route upon replacement.

FIGURE 5-48. Initial Twenty Year Project List

Year	Project	Phase	Project Description	Budget	Antic Capacity GPM	24 Hrs	16 Hrs	Avg Day Capacity	Effective Source Addition	Assumed Pumping In 1996 Model	Comment
											See also Storage & Line Replacement projects, as these also have options that increase source availability.
[illegible]	Well 3 Replacement	Drill	Drill replacement for Well 3	1,000,000							
2009	Well 3 Replacement	Pump	Install pump	200,000							
2010	Well 3 Replacement	Develop & Equip	Install motors, controls, telemetry, site piping & appurtenances	500,000	600	864,000	576,000	384,000	**0**	Yes	GPD Reliability for existing capacity.
2010	Well 15	Design & Exploratory Drilling		1,155,000							
2011	Well 2 A - Renovation	Move pump & controls to surface		400,000							
2011	Well 2-B	Study	Determine interconnectivity between well 2 and shaft 3	500,000							
2011	Well 15	Develop & Equip	Install motors, controls, telemetry, site piping & appurtenances	1,501,800	400	576,000	384,000	256,000	**0**	No	Distribution of withdrawals to address declining water levels in Wells 1, 9 & 14.
2012	Well 2 A - Renovation	Equip and Develop		500,000	600	864,000	576,000	384,000	**0**	Yes	Renovation of existing well to firm non-firm capcity.
2013	Well 2-B	Design & Exploratory Drilling	Drill Well 2-B at site of existing Shaft 3	623,880							
2014	Well 2-B	Develop & Equip	Install motors, controls, telemetry, site piping & appurtenances	1,259,000	600	864,000	576,000	384,000	**300,000**	Yes	Although this is also "firming non-firm" capacity, LWCI hopes to gain effective capacity if water levels prove independent.
In Plan But Not Really Scheduled											
2016	Well 7 Renovation	Design, Pump Replacement, Site Renovation		575,000							
2017	Well 7 Renovation (see Trans in pipelines	Develop & Equip	Equip with Control Tank, Telemetery, MCC, Site Pipine Etc., and Connect to Lana'i City Upper Level	1,405,368	600	864,000	576,000	384,000	**300,000**	Yes	Although levelized cost estimates assume 500,000 GPD, it should be noted that water levels in wells on this side of the system are dropping with lower pumping rates than this, Could be only 300,000 GPD.
2018	Well 4 Replacement or Renovation	Design & Exploratory Drilling	Drill replacement for Well 3	750,000							
2020	Well 4 Replacement	Develop & Equip	Install motors, controls, telemetry, site	1,000,000	900	1,296,000	864,000	576,000	**0**	Yes	Tentative budget to replace or renovate existing old well.
2022	Well 1 Replacement or Renovation	Design & Exploratory Drilling	Drill replacement for Well 3	750,000							
2024	Well 1 Replacement	Develop & Equip	Install motors, controls, telemetry, site	1,000,000	300	432,000	288,000	192,000	**0**	Yes	Tentative budget to replace or renovate existing old well.
	Well 5 Replacement	Design & Exploratory Drilling	Drill replacement for Well 5 or Other	1,155,000							
	Well 5 Replacement	Develop & Equip	piping & appurtenances	1,801,800	600	864,000	576,000	384,000	**300,000**	Yes	Assuming Wells 2-B and 7 increase effective capacity as hoped, at this point, development of additional wells in the Leeward aquifer will be for distribution of withdrawals. If a 600,000 gallon (10% of total sustainable yield) resource reserve is maintained, with 300,000 GPD of that from each aquifer, the added yield of this well would be only 113,310 GPD.
Reclaimed Water Use											
	Reclaimed Line to Miki	Transmission	Provide irrigation source for Miki Basin	1,536,000				60,000	**60,000**		Costs for all options are presented, but the chosen one within the planning period is the line from Lana'i City to Miki Basin to offset potable water use for irrigation in that area, particularly at the new Industrial Park & Airport.
	Reclaimed Line to Manele	Transmission	Provide irrigation source for Manele	16,896,000				500,000	**500,000**		
	Reclaimed Line to Miki as Phase I	Transmission	Iirrigation source for Miki Basin & Manele	2,304,000				60,000	**60,000**		
	II	Transmission	Iirrigation source for Miki Basin & Manele	15,456,000				440,000	**440,000**		
New Source Alternatives - Unscheduled											
	High Level Potable Well Near Hi'i Tank	Design & Exploratory Drilling	Drill well between Hi'i Tank and Well 3.	1,080,000							
	High Level Potable Well Near Hi'i Tank	Develop & Equip	Install motors, controls, telemetry, site piping & appurtenances	1,636,800	600	864,000	576,000	384,000	**186,690**	No	Well for distribution of withdrawals in Leeward aquifer. Pumpage from the Leeward aquifer is already > 1.9 MGD. By this point, sustainable yield would have been reached, without resource reserve.
	Windward Well at Malau	Design & Exploratory Drilling	Drill well in windward aquifer at Malau near Keomoku Road.	905,000							
	Windward Well at Malau	Develop & Equip	Install motors, controls, telemetry, site piping & appurtenances	1,971,800							
	Windward Well at Malau	Transmission	Install roughly 15,0000' of pipeline to connect Malau Well to system.	3,600,000	600	864,000	576,000	384,000	**300,000**	No	
	Windward Wells at Maunalei	Design & Exploratory Drilling	Recommission or drill new wells in Windward aquifer near Maunalei sources.	1,270,000							
	Windward Wells at Maunalei	Develop & Equip	Install motors, controls, telemetry, site piping & appurtenances	5,481,000							
	Windward Wells at Maunalei	Transmission	Install or repair existing transmission as necessary.	1,250,000	1,800	2,592,000	1,728,000	1,152,000	**750,000**	Partially	Assumes 3 wells in Maunalei, with use of existing transmission lines, but with repairs, improvements & connection to that line. Costs vary depending upon whether or not existing transmission lines can be utilized. IF completely new transmission is required, then Wells at Kehewai Ridge are cheaper, as is reclaimed water line from Lana'i City to Manele. Reclaimed line would not be cost-effective until the proposed

FIGURE 5-48. **Initial Twenty Year Project List - Continued**

Year	Project	Phase	Project Description	Budget	Antic Capacity GPM	24 Hrs	16 Hrs	Avg Day Capacity	Effective Source Addition	Assumed Pumping In '96 Model	Comment
	Windward Well at Malau	Design & Exploratory Drilling	Drill well in windward aquifer at Malau near Keomoku Road.	905,000							
	Windward Well at Malau	Develop & Equip	Install motors, controls, telemetry, site piping &	1,971,800							
	Windward Well at Malau	Transmission	Install roughly 15,0000' of pipeline to connect Malau Well to system.	3,600,000	600	864,000	576,000	384,000	**300,000**	No	
	Windward Wells at Maunalei	Design & Exploratory Drilling	wells in Windward aquifer near Maunalei sources.	1,270,000							
	Windward Wells at Maunalei	Develop & Equip	Install motors, controls, telemetry, site piping & appurtenances	5,481,000							
	Windward Wells at Maunalei	Transmission	Install or repair existing transmission as necessary.	1,250,000	1,800	2,592,000	1,728,000	1,152,000	**750,000**	Partially	Assumes 3 wells in Maunalei, with use of existing transmission lines, but with repairs, improvements & connection to that line. Costs vary depending upon whether or not existing transmission lines can be utilized. IF completely new transmission is required, then Wells at Kehewai Ridge are cheaper, as is reclaimed water line from Lana`i City to Manele. Reclaimed line would not be cost-effective until the proposed build-out scenario was reached in Lana`i City & Koele.
	Windward Well at Kehewai Ridge - 2,250' Elevation	Design & Exploratory Drilling	Drill well in windward aquifer at	1,370,000							
	Windward Well at Kehewai Ridge - 2,250' Elevation	Develop & Equip	telemetry, site piping &	1,954,800							
		Transmission	Install roughly 15,0000' of pipeline to connect well to	5,950,000	600	864,000	576,000	384,000	**300,000**	No	Although the transmission route may appear strange for this option, the project has been designed to avoid damage to the core remaining intact native habitat on Lana`i.
	Windward Well at Kehewai Ridge - 2,750' Elevation	Design & Exploratory Drilling	Drill well in windward aquifer at Kehewai Ridge.	1,370,000							
	Windward Well at Kehewai Ridge - 2,750' Elevation	Develop & Equip	Install motors, controls, telemetry, site piping &	2,018,800							
	Windward Well at Kehewai Ridge - 2,750' Elevation	Transmission	Install roughly 15,0000' of pipeline to connect well to	5,950,000	600	864,000	576,000	384,000	**300,000**	No	Although the transmission route may appear strange for this option, the project has been designed to avoid damage to the core remaining intact native habitat on Lana`i.
	Windward Wells at Kauiki	Design &	Drill well in windward aquifer at	1,570,000							
	Windward Wells at Kauiki	Develop & Equip	Install motors, controls, telemetry, site piping & appurtenances	1,929,800							
	Windward Wells at Kauiki	Transmission	Install roughly 15,0000' of pipeline to connect well to system.	7,425,000	600	864,000	576,000	384,000	**300,000**	No	Costs shown include replacement of Maunalei Transmission. If this is not necessary, or for subsequent incremental wells, costs are reduced considerably. Costs without Maunalei transmission would be $4,864,800 per new well, vs. $10,924,800 as shown. Even if existing Maunalei transmission can be used, at some point it may need to be up-sized.
	Windward Wells at Kauiki - Incremental	Design & Exploratory Drilling	Drill well in windward aquifer at Kauiki.	1,545,000							
	Windward Wells at Kauiki - Incremental	Develop & Equip	Install motors, controls, telemetry, site piping &	1,559,000							
	Windward Wells at Kauiki - Incremental	Transmission	Install roughly 15,0000' of pipeline to connect well to	1,760,800	600	864,000	576,000	384,000	**300,000**	No	As noted above, costs of incremental wells become lower. However, with a resource reserve, at this point all available source within the Windward aquifer as well as the Leeward aquifer would essentially have been developed.
	Windward Wells at Kauiki - Incremental	Design & Exploratory Drilling	Drill well in windward aquifer at Kauiki.	1,545,000							
	Windward Wells at Kauiki - Incremental	Develop & Equip	Install motors, controls, telemetry, site piping &	1,559,000							As noted above, costs of incremental wells become lower. However, at this point all 3 MGD within the Windward aquifer as well as the

FIGURE 5-48. Initial Twenty Year Project List - Continued

Year	Project	Phase	Project Description	Budget	Antic Capacity GPM	24 Hrs	16 Hrs	Avg Day Capacity	Effective Source Addition	Assumed Pumping In '96 Model	Comment
	Windward Wells at Kauiki - Incremental	Transmission	Install roughly 15,0000' of pipeline to connect well to system.	1,760,800	600	864,000	576,000	384,000	**300,000**	No	Leeward aquifer would have been developed, with only 77,912 additional source available from this well if a resource reserve is maintained.
	Supply and Demand Side Management Projects										These projects are not capitalized. However, they would add to expenses needing to be recovered, so are added here. Assumes replacement of all non-conserving toilets and other fixtures. These projects plus the hypalon cover and replacement of Palawai Grid line bwlow combine to an estimated 485,000 GPD in
	Direct Install / Rebate of Toilets and Other Efficient Fixtures for Residences, Hotels and Others			1,480,419					**100,000**		
	Incentive Program for Hotel and Landsape Customers			225,000					**15,000**		
	Leak Detection & Water Audit Program - Equipment			150,000					**43,000**		
	Landscape Conservation Program			675,000					**111,000**		
	Portion of Watershed Fence Project - For Third Increment Only			3,000,000							
	Storage Projects										
	Replace Hi`i 0.5 MG Tank & Line Hi`i Reservoir OR		Replace 0.5 MG Hi`i Tank and re-line 1 MG Hi`i reservoir								* Not selected per discussions wutility. Cost would be $1.415 million.
	Replace Hi`i Tank & Reservoir with 2 MG Tank		Replace 0.5 MG Hi`i tank and 1 MG Hi`i reservoir with 2 MG	5,000,000							
	Replace Kaumalapau Tank		Design & Construct tank to serve needs of Kaumalapau. Construct tank, appurtenances,	75,000							
2012	Hypalon Balls at 15 MG Brackish Res.		Install hypalon balls to reduce evaporative losses at 15 MG	495,000					**14,000**		Estimated 14,000 GPD reduction in losses.
	Line Replacement										
	Replace Broken & Leaking Pipe in Central Palawai Irrigation Grid			3,740,920					**202,000**		Eliminating losses increases available capacity without additional strain to the aquifer. Levelized costs estimated based upon higher installation costs than are now shown, ($3.84 million, assuming ductile iron pipe. This was the most cost-effective resource option even with the ductile iron pipe assumption.) Costs shown here involve high-pressure PVC.
	Replace Asbestos-Concrete Pipe Segments in Lana`i City & PRV on 10" Asbestos Line			972,041							
	Upgrade Kaumalapau Line			3,958,217							
	Connect Potable Kaumalapau Line to Miki Basin			878,062							
	Connect Well 7 to Distribution Systems			697,842							
	Replace Steel Segments in Lana`i City			1,202,755							
	Connect Well 7 to West End Grid			153,237							
	Replace Old Pipe In West End of Palawai Irrigation Grid			342,947							
	PRV Valve Above Miki Industrial			9,000							
	Replace Kaumalapau PRV			9,000							
	Replace PRV below Hi`i			9,000							
	Replace Ninth St. PRV			9,000							
	Other PRV Replacement as Needed			9,000							
	Pump Replacement										
	Rolling Pump Replacement			2,400,000							7 currently operating source pumps, plus 2 or 3 more likely to operate in near future, plus new source pumps for well s15 and 2b - a total of 12 source pumps w assumed lifetime of 15 years per pump. 200K for replacement 20 years
	Rolling Upgrades to Motor Control & Electrical Centers			1,000,000							Regular maintenance, assessment and replacement of parts such motors, electrical or other needs can help extend the life of pumps. Some annual budget is necessary to insure this. $50 K per year for 20 years

FIGURE 5-48. Initial Twenty Year Project List - Continued

Year Project	Phase	Project Description	Budget	Antic Capacity GPM	24 Hrs	16 Hrs	Avg Day Capacity	Effective Source Addition	Assumed Pumping In '96 Model	Comment
SCADA, **Telemetry & Monitoring Needs** Replacements & Upgrades			500,000							Contingency for telemetry or other system monitoring needs, such as large flow meters, etc. 25K per year over 20 years.
							From Rates & Monthly Charges **Improvement**		From New Meter Fees **Expansion**	
		ESTIMATED 20 YEAR SYSTEM CAPITAL NEEDS	**101,066,889**				**36,312,479**		**64,754,410**	**With Build-Out Scenario**
		Assumes that a 20 year roll-in, with a return on equity of 10% would work out to an average carrying cost of about 5%	**5,053,344**				**1,815,624**			
		Annual Revenues					914,116			660,932 from B&C report and Balance Sheet submitted for PUC Docket 2008-032, plus 253,184, from Pro Forma statement submitted for
		Annual Loss Currently Covered by C&CR					843,920			767,761 from B&C report and Balance Sheet submitted for PUC Docket 2008-032, plus 76,159, from Pro Forma statement submitted for
		Increase in Cost of Labor					80760			Source: Brown & Caldwell Report Lana`I Water System Acquisition Appraisal, May 2009 Draft
		New Facilities and Rolling Stock					197,038			Source: Brown & Caldwell Report Lana`I Water System Acquisition Appraisal, May 2009 Draft
							----------		OR TOTAL **5,335,010**	**With Base Case Development Only**
		Subtotal Additional Revenue					**2,035,834**			
		Annual Revenue Requirements					**3,851,458**			

Revenue Requirements To Cover Capital Expenditures

The total cost of projects identified and included in the Capital Plan in the event that the build-out scenario were chosen is $99,530,889. This amount is further divided into “Maintenance” or “Expansion” projects. Maintenance projects are those which would be funded by the utility through its rates and monthly or bi-monthly charges. Expansion projects are those which would be covered either by LHI, or other developers as needed. These projects are typically recouped in “New Meter Fees”. These are sometimes called “Facility Capacity Charges”, “Tap-In Charges”, or “Water System Development Fees”. They are the same thing. The term “New Meter Fee” has been used here. Developer-funded or in-kind projects are not included in this analysis. One example is a possible on-site storage tank for fire protection at the Miki Basin. If this is built, it would be funded by the developer. Neither LWCI nor LHI would be likely to fund construction of such a project. However, such projects once dedicated to the utility become the responsibility of LWCI to maintain, operate and or replace.

In the previous draft of this chapter, the total amount of projects to be covered by rates and charges within the planning period was estimated at $34,776,479. Some of the projects are specifically scheduled, others are unscheduled and assumed to roll in gradually over the twenty year period. Assuming a twenty year roll-in, with a 10% return on equity, the carrying costs work out to an average of about 5% per year. Annual carrying costs for maintenance and demand management projects were estimated at $1,738,824 per year.

Previously it was thought that sufficient reclaimed water to warrant a line from Lana‘i to Manele would not be available until after the 20 year time frame, so reclaimed water costs had not been added into the base case forecast for the twenty year time period. Since the October 2009 draft of this document, the use of 60,000 gallons of reclaimed water at Miki Basin had been added in to the near term plan. The potential added charges could be covered through either rates or new meter fees, so the change was examined both ways. If covered by rates, this would bring annual revenue requirements to $1,815,624.

Some additional costs are assumed based upon Table 4-5 of the May 29, 2009 DRAFT *Lana‘i Water System Acquisition Appraisal* for LWCI, and on the 2008 *Pro Forma* Statement of Income for Non-Potable Brackish Operations in PUC Docket 2008-03222. These sources list existing annual as roughly $660,932 per year for LWCI and $253,184 for LHI. Existing annual revenue losses covered by CCR are estimated at $767,761 per year for LWCI and $76159 for LHI, for a total existing operating expense of about $1,758,036. Increased costs of labor and cost of new facilities and rolling stock are also taken from the DRAFT *Lana‘i Water System Acquisition Appraisal*. Increased costs of labor are estimated at $80,760. Revenue requirements for new facilities and rolling stock are estimated at $197,038.

Adding revenue requirements for the annual carrying cost of the proposed program ($1,738,824), plus existing revenue requirements ($1,758,036), assumed increases in cost of labor ($80,760), new facilities and rolling stock ($197,038), one arrives at an average annual revenue requirement of $3,774,658 in 2008 dollars. With the addition of the Miki Basin project, the annual revenue requirement would be $3,851,458.

Billing data were broken down into user classes and evaluated for relative percentage of total water sales by classes and usage amounts. These percents were then applied to overall revenue requirements to derive starting revenue targets for each use and consumption class. Assignment of costs was adjusted to provide for discounted rates for low water use in all classes, to encourage conservation, and to discourage excessive irrigation. The resulting charges per thousand gallons of water are presented in Figures 5 -55 and 5-56. Rates are shown with and without financing of the Miki Basin reclaimed project, since it could be financed by rates or fees. Bi-monthly meter charges were not re-calculated, and are presented in Figure 5-54.

FIGURE 5-49. Proposed Bi-Monthly Charges Based Upon Capital Plans

Bi- Monthly Meter Fees		
	Relative	Bi-Monthly
Meter Size	Capacity	Rate ($)
5/8"	1	25
3/4"	1.5	37.5
1"	2.5	62.5
1-1/2"	5	125
2"	8	200
2-1/2"	12	300
3"	16	400
4"	25	625
6"	50	1250
8"	80	2000
hydrant meters 3" charged daily $28.69 / day	25	625

The rate design shown in Figures 5-50 and 5-51 includes rates for both potable and brackish service, and is steeply tiered to encourage conservation. A relatively low “lifeline” rate is maintained across the low end of all use classes.

Certain policy recommendations are reflected by the rate design. It is designed for equity, especially for those whose uses reflect only basic necessity for livelihoood. It is designed to strongly encourage conservation. A third policy statement is made in the balance of costs between fresh and potable brackish water. Although the brackish and potable systems are registered separately under the PUC, this rate design addresses both, adding additional tiers to the brackish system as well as the potable. One might tend to think that potable water should be more expensive than brackish water, since it is of higher quality. At present, the brackish sources are generally less expensive than the potable on Lana‘i. However, water levels of the brackish sources on Lana‘i have been declining much more rapidly than those of the fresh sources. Continuing decline in water levels will make these sources more costly. All of the water on Lana‘i comes from one aquifer system. Nor is it clear that irrigation in Manele, where the brackish source is used, need be cheaper than irrigation in Lana‘i City. Although the rate design spreadsheet was set up such that these sources of water can be charged differently, the draft structure presented below sets irrigation charges for brackish and potable water at the same rate.

After the rate in the first column of rates in Figure 5-50 were presented, CCR expressed some concern about the relative fraction of cost that was assigned to the Manele Golf Course. All other rate columns, including the second column in Figure 5-51, have brought that fraction down, in varying amounts. The rate designs in Figure 5-56 have more tiers, to help address the irrigation question fairly.

FIGURE 5-50. Possible Rates Based Upon Replacement and Operating Needs

Rates Per 1,000 Gallons	$ / Kgal No Miki Proj	$ / Kgal w / Miki Proj
Res SF <=200	1.25	1.35
Res SF >200 - 500	1.95	2.00
Res SF >500-1,000	2.55	2.60
Res SF >1,000-1,500	4.65	5.15
Res SF >1,500-2,000	6.75	6.75
ResSF >2,000	7.95	8.00
Res MF <800	1.25	1.35
Res MF >800-2000	1.95	2.00
Res MF >2000	3.45	5.00
*assumes 4 units per meter		
Ag <5000	1.25	1.25
Ag >5000	1.85	1.85
Hotel <+200 GPD/room	1.25	1.35
Hotel >200 to 350 GPD /room	1.95	2.50
Hotel >350 to 500 GPD /room	3.50	5.60
Hotel >500 GPD / room	7.15	7.15
Commercial, Gov`t. & PQP <500	1.25	1.35
Commercial, Gov`t. & PQP >500-1,000	1.95	2.50
Commercial, Gov`t. & PQP >1,000-2,000	2.65	3.50
Commercial, Gov`t. & PQP >2,000-5,000	4.65	5.65
Commercial, Gov`t. & PQP >5,000	6.65	7.25
Irrig & Devel <500	3.70	2.50
Irrig & Devel >500-1000	4.75	3.50
Irrig & Devel >1,000-2000	5.80	5.60
Irrig & Devel >2,000 -5000	6.85	7.00
Irrig & Devel >5,000	7.95	8.00
Brackish Irrig & Devel <500	3.70	2.50
Brackish Irrig & Devel >500-1000	4.75	3.50
Brackish Irrig & Devel >1,000-2000	5.80	5.50
Brackish Irrig & Devel >2,000 -5000	6.85	7.25
Brackish Irrig & Devel >5,000	7.95	8.00

Revenue Requirements To Cover Capital Expenditures

FIGURE 5-51. Possible Rates Based Upon Replacement and Operating Needs

Rates Per 1,000 Gallons	No Miki Proj	No Miki Proj	w Miki Proj	w Miki Proj
Res SF <=200	1.75	1.80	2.00	1.95
Res SF >200 - 500	2.85	2.85	2.85	2.85
Res SF >500-1,000	4.05	4.05	5.00	5.00
Res SF >1,000-1,500	5.75	5.75	5.75	6.00
Res SF >1,500-2,000	7.00	7.00	7.50	7.50
ResSF >2,000	8.75	8.75	9.25	9.25
Res MF* <800	1.75	1.75	2.00	2.00
Res MF >800-2000	2.85	2.85	2.85	2.85
Res MF 2,000 - 4,000	4.05	4.05	4.50	4.50
Res MF 4,000 - 8,000	5.75	5.75	5.75	5.75
Res MF >8000	7.00	7.00	7.50	7.50
*assumes 4 units per meter				
Commercial Gov`t. , PQP <500	2.05	2.05	2.25	2.25
Commercial and Gov`t. , PQP >500-1,000	2.85	2.85	2.85	2.85
Commercial and Gov`t. , PQP >1,000-2,000	3.65	3.65	3.65	3.65
Commercial and Gov`t. PQP >2,000-5,000	4.75	4.75	5.00	5.00
Commercial and Gov`t. PQP >5,000	5.15	5.15	5.15	5.15
Hotel <+200 GPD / room	2.05	2.05	2.25	2.25
Hotel 200 to 350 GPD / room	2.85	2.85	2.85	2.85
Hotel 350 to 500 GPD /room	4.75	4.75	5.00	5.05
Hotel >500 GPD / room	6.50	6.50	7.25	7.25
Ag <500	1.75	1.05	1.10	1.10
Ag <5000	1.05	1.10	1.10	1.15
Ag >5000	1.05	1.15	1.25	1.25
Irr & Devel <500	4.35	4.35	4.35	4.50
Irrig & Devel >500-1000	5.35	5.35	5.35	5.35
Irrig & Devel >1,000-2000	6.50	6.50	6.50	6.50
Irrig and Devel >2,000 -5000	7.70	7.70	7.70	7.70
Irrig and Devel >5,000	8.50	8.50	8.50	8.50
Brackish Irr & Devel <500	4.35	4.35	4.50	4.50
Brackish Irrig & Devel >500-1000	5.35	5.35	5.65	5.65
Brackish Irrig & Devel >1,000-2000	6.50	6.50	6.50	6.50
Brackish Irrig and Devel >2,000 -5000	7.70	7.70	7.70	7.70
Brackish Irrig and Devel >5,000	8.75	8.75	8.75	8.75
Manele GC <50,000	4.30	4.30	4.45	4.45
Manele GC 50,000 - 100,000	5.35	5.35	5.50	5.50
Manele GC 100,000 - <250,000	6.50	6.50	6.50	6.50
Manele GC 250,000 - < 500,000	7.70	7.70	7.70	7.70
Manele GC >500,000 - 650000	8.75	8.75	8.75	8.75
Manele GC >650,000	15.00	15.00	15.00	15.00

Cost recovery on an estimated $64,754,410 based upon build-out meter counts would lead to a cost of $27,621.75 or $28,261.60 for a new 5/8" meter, even without the reclaimed project. Clearly most of the community can not and will not pay that. It would be impossible to fund the proposed build-out scenario without in-kind contribution. The bulk of the costs of a build-out scenario would probably be recovered through real estate sales, rather than new meter fees.

FIGURE 5-52. Projected Costs Per Meter - Based on Full Build-0ut Within 20 Years

Meter Size	Relative Capacity	Build-Out New Fee Rate	Build-Out New Fee Rate w / Miki
5/8"	1	$27,621.75	$28,261.60
3/4"	1.5	$41,432.63	$42,392.40
1"	2.5	$69,054.38	$70,654.00
1-1/2"	5	$138,108.75	$141,308.00
2"	8	$220,974.00	$226,092.80
2-1/2"	12	$331,461.00	$339,139.20
3"	16	$441,948.00	$452,185.60
4"	25	$690,543.75	$706,540.00
6"	50	$1,381,087.50	$1,413,080.00
8"	80	$2,209,740.00	$2,260,928.00
hydrant meters 3" charged daily	25	$690,543.75	$706,540.00
		- - - - - - - -	- - - - - - - -
		daily rate	daily rate
hyd meter charged daily		$1,891.90	$1,935.73

Alternatively, the improvements needed to the year 2030 according to the base case forecast would require only $5,335,010 in cost recovery over the planning period, and could be accommodated with a meter fee structure that started at $532 per meter without the reclaimed project. The projects included in this theoretical new meter fee are Well 15, Renovation and Recommissioning of Well 7, and the connection of Well 7 to the Lana‘i System. With the Miki Basin reclaimed project, the cost recovery would rise to $6,871,010, and can be accommodated with a fee structure starting at $686 for a 5/8 inch meter.

FIGURE 5-53. Projected Costs Per Meter - Based on Base Case Forecast

Meter Size	Relative Capacity	New Meter Fee Base Case	New Meter Fee Base w/Recl.
5/8"	1	$532	$686
3/4"	1.5	$798	$1,029
1"	2.5	$1,331	$1,715
1-1/2"	5	$2,661	$3,430
2"	8	$4,258	$5,488
2-1/2"	12	$6,387	$8,232
3"	16	$8,516	$10,976
4"	25	$13,306	$17,150
6"	50	$26,613	$34,300
8"	80	$42,580	$54,880
hydrant meters 3"	25	$13,306	$17,150
hyd meters charged daily		$28.69 / day	$46.99 / day

Revenue Requirements To Cover Capital Expenditures

FIGURE 5-54. Basic Source Plan

Options in Order of Levelized Cost w/Adjustments	Gal	Average Day Ability to Meet Demand	Cumulative Aquifer Withdrawals	Cumulative Leeward Aquifer	Cumulative Windward Aquifer	Conservation and Reclaimed
Existing System		1,685,224	2,241,222	1,913,310	327,912	307033
Well 2 Replacement (2-A)	300,000	1,985,224	2,541,222	2,213,310	327,912	
Shaft 3 Replacement (2-B) * , **	150,000	2,135,224	2,691,222	2,363,310	327,912	
Well 15 * , **	100,000	2,235,224	2,791,222	2,463,310	327,912	
Well 3 Replacement **	200,000	2,435,224	2,991,222	2,663,310	327,912	
Well Near Hi'i Tank (btwn Hi`i and Well 3) **						
High Level Well Near Well 5 / Well 5 Replacement						
Well 7 Recommission						
Palawai Grid Pipe Replacement	200,000	2,635,224	2,991,222	2,663,310	327,912	200,000
Toilet and Fixture Replacement Program	100,000	2,735,224	2,991,222	2,663,310	327,912	300,000
Landscape Conservation	111,000	2,846,224	2,991,222	2,663,310	327,912	411,000
Hypalon Cover on 15 MG Reservoir	14,000	2,860,224	2,991,222	2,663,310	327,912	425,000
Annual Water Audit and Leak Detection Program	40,000	2,900,224	2,991,222	2,663,310	327,912	465,000
Hotel Incentives Program	20,000	2,880,224	2,991,222	2,663,310	327,912	485,000
Tiered Rate Structure						
Reclaimed Water Lana`i City & Koele	82,710	2,962,934	2,991,222	2,663,310	327,912	567,710
Reclaimed Water Manele	25,771	2,988,705	2,991,222	2,663,310	327,912	593,481
Windward Well at Malau	300,000	3,288,705	3,291,222	2,663,310	627,912	
Windward Well sat Maunalei (3)	750,000	4,038,705	4,041,222	2,663,310	1,377,912	
Windward Wells at Kauiki	300,000	4,338,705	4,341,222	2,663,310	1,677,912	
Windward Wells at Kauiki - Incremental	300,000	4,638,705	4,641,222	2,663,310	1,977,912	
Windward Well at Kehewai Ridge - 2,250' /oth wndwrd	300,000	4,938,705	4,941,222	2,663,310	2,277,912	
Windward Well at Kehewai Ridge - 2,750' /oth wndwrd	300,000	5,238,705	5,241,222	2,663,310	2,577,912	
Reclaimed Water Lana`i City & Koele	184,661	5,423,366	5,241,222	2,663,310	2,577,912	778,142
Reclaimed Water Manele	20,796	5,444,162	5,241,222	2,663,310	2,577,912	798,938
Ocean to Brackish	250,000	5,694,162	5,241,222	2,663,310	2,577,912	

* Wells are assumed to be installed, though they do not yield as much as anticipated.

** Levelized cost fof Well 2-B at 150,000 instead of 300,000 goes from $2.97 to $4.35. Well 15 goes from $4.16 to $8.05, & Well 7 from $6.02 to $8.08.

*** Well between Hi`i Tank and Well 3 could serve either system & appears to be less expensive than Well 7. Levelized costs go from 4.49 at 300KGal to 6.60 at 150 K

**** It may be desirable to go straight to Malau Well rather than Hi`i Tank or Well 7

***** As conservation savings are achieved, leeward aquifer wells can raise closer to design pumpage. Some resource reserve is still recommended.

The source plan on the previous page has not been adjusted for Miki Basin, since it already accounts for additional water to be generated at the treatment plants.

Conclusion

Several issues have been addressed in this chapter.

A list of options has been delineated that can meet either the base case or build-out forecast. These options have been characterized based on costs and other factors. Even at presumed build-out of Phase II, the source plan assumes only 313,938 GPD in new reclaimed water will become available island-wide, with only 267,371 of that in Lana'i City. For this reason, transmission for 500,000 GPD from Lana'i City to Manele is not included in the 2030 source plan. The basis for these assumptions is discussed in Chapter 4, specifically the base case forecast and Phase II build-out forecasts from Figure 4-54 on page 4-59 are used in the source plan table above. Aside from normal growth at Manele, Koele and within Lana'i City, the only capital plan designed specifically to offset potential pumpage with reclaimed water within the planning period is the Miki Basin project. The possible use of reclaimed water has also been mentioned in relation to or more new developments in Lana'i City. This may be useful to the extent that this is possible and can off-set water that would otherwise be pumped.

A few rate and fee structures to address system inadequacies and repairs necessary over the next twenty years have been provided. These rates addresses both potable and brackish systems, and are steeply tiered to encourage conservation. These rate and fee structures were designed to enable the utility to meet fore-casted growth in a self sufficient manner.

Based on discussions with utility personnel, certain source replacement projects are covered by LWCI, through it's rate structure. The source projects included in this rate structure are Well 3 replacement, Well 2-A, replacing Well 2; Well 2-B, replacing Shaft 3, and replacements of Wells 1 and 4. All other source construction is assumed to be paid for by LHI, and covered by the "New Meter Fee". The reclaimed project to Miki Basin was treated flexibly. Both adjusted rates and fees have been designed to enable this project so that it can be funded in either fashion or provide flexibility to accommodate one of similar cost.

Approximately 485,000 GPD in conservation potential has been identified. A substantial investment has been added to the capital plan to enable these savings to be realized with the proposed rate structure.

Although conservation programs and watershed protection are not normally capitalized, they do need to be recovered within the rates, so these have been included in the proposed rate structure.

With regard to watershed expenses, the inclusion of a portion of the funding necessary to construct Increment 3 of the Lana'ihale Fence in the capital plan would mean that according to the proposed rate structure, utility rate-payers would be making a contribution to help insure that the third increment of the Lana'ihale fence gets built. A corollary of this contribution should be that continued development entitlements are contingent upon timely construction of this fence.

Conclusion

Two sets of "New Meter Fee" structures have been derived. The "New Meter Fee" structure covers source investments made by LHI. The base case "New Meter Fee" includes only Well 15 and the connection of Well 7 to the distribution system, because these were existing and near-term plans for source and could meet the base-case scenario. These sources could be traded for other selections with some minor adjustments. This new meter fee remains quite reasonable, starting at $532 or $686 per 5/8" meter, depending upon how the Miki Basin reclaimed project is funded.

Long term source projects are in the "New Meter Fee" for the build-out scenario. The purpose of this analysis was to examine what sort of cost recovery might be necessary if the utility were to fund the sources intended in the build-out plan. According to this analysis, "New Meter Fees" would be prohibitively expensive, in excess of $25,000 for a 5/8" meter, if build-out were to occur within the planning period. It would not be possible to recover this cost from a "New Meter Fee". If the utility had to fund source development, these sources could not get built at this pace, and build-out would not occur over the twenty year planning period. If these sources are built, they will likely have to be dedicated as in-kind contributions.

Although several new sources have been identified, they would not be sufficient to meet build-out of the full CCR proposals at existing unaccounted-for water and per-unit consumption rates. The ability to build-out these plans will depend upon how successful the company is at bringing these rates down, as well as upon performance of the resource with changes to pumpage distribution and amounts, the state of the watershed, climatic influences and other factors.

CHAPTER 6

Source Water Protection

In this Chapter

Key Points

- Lana`i is unusually dependent upon its mauka watershed, because Lana‘i is dependent upon fog drip. Over 65% of the recharge in the primary high level aquifer for Lana‘i is believed to be attributable to fog drip. Loss of fog drip from Lana‘i Hale would lead to the loss of over 50% of the water levels in the Central aquifer, essentially the only viable water source for the island. Estimates from studies elsewhere indicate that fog drip interception by mountain forests increase precipitation by as much as 30%, and recharge by 10-15%.

- The watershed on Lana'i is a low elevation cloud forest, with a strong mix of mesic species. Maintaining native cover becomes especially important in light of its role in the water budget for Lana'i and the rising inversion layer. Yet less than 30% of the native cover in the cloud forest remains.
- Threats to the watershed include: habitat alteration by feral animals, human activity and invasive species; continuing intrusion of exotic plant and animal species which can trample, prey on or out-compete native species; loss of critical populations; loss of native pollinators and other keystone species; introduced pathogens and insects; erosion; drought, and; high vulnerability to fire due to mesic conditions combined with the spread of fire inducing weeds.
- Key management measures include: fencing the most valuable watershed; eliminating feral animal ingress to fenced areas; removal of non-desirable weed and animal species; planting of desirable native species; erosion and fire prevention measures; and limiting human activities in key areas. More specifics are provided.
- Where drinking water is concerned, prevention of pollution is less expensive and more efficient than cleaning it up. One of the first tasks in any effective prevention program is to identify and inventory wells to be protected, areas that feed them and activities or sources of pollutants that pose a potential risk or could degrade water quality.
- Drinking water wells on Lana'i were mapped, and a computer model was used to evaluate the area surrounding each well which could contribute to its water withdrawals within a 2, 5, 10, 15, 20 and 25 year time periods.
- Water that can reach a well within two years can contribute bacteria and viruses to the drinking water in that well. Although chemical contaminants may be persistent well beyond 10 years, this is the time frame broadly used in wellhead protection programs, as it is assumed that within that time frame protective measures may be taken in the event of a spill.
- Among the potential contaminant sources identified were the following: Wells 1, 9 and 7 are located in or near former pineapple fields. Well 9 is also near some former underground storage, and Well 7 near some old above ground storage. Traces of atrazine have been found in Well 1 in the past. Well 8 is within 1,000 feet of the Koele golf course. A list of contaminants that may be generated by the types of activities found is provided.
- Potential management strategies and measures are described. These include regulatory measures such as overlay zones and prohibitions, non-regulatory measures such as purchase of easements or incentivization of best management practices, guidelines, education and others.
- The recommended wellhead protection strategy involves an overlay zoning ordinance which either prohibits or prescribes best management practices for various uses at different times of travel. Also included in the strategy are non-regulatory measures, such as guidelines for mixed use developments, protective land agreements, incentives and education for best management practices or protective measures, and measures to improve well siting. Implementation of this ordinance would require coordination between the DWS and other agencies, particularly the Planning Department.
- If water levels in pumping wells reach half their initial head level, this is now grounds for designation proceedings, based on a January 31,1990 decision by the CWRM. CCR has also offered voluntary guidelines which set action levels at about 2/3 of initial head. These are delineated in

the well operating guidelines section. Upon reaching a designation trigger or lowest allowable level, pumpage in a well is expected to stop. Upon reaching an action level, a well is to receive scientific review and investigation, as well as some public scrutiny.

- Action levels and lowest allowable levels from CCR's voluntary well operating and management guidelines, as well as designation triggers, are provided on page 6-121.

Watershed Protection

The Role of the Forest in Water Production

The Hawaiʻian Islands are unique in their geology, their geographic isolation, their species endemism and their beauty. Rising 16,000' from the ocean floor at sea level, the tallest island rises nearly another 14,000' more, while the smallest barely tops the surface.

The Hawaiʻian archipelago is a 1,500 mile chain of volcanic islands and atolls, created over more than 20 million years. The oldest islands are Kure atoll and Midway at the northwest extent of the archipelago. Rock formations on Kauaʻi have been dated between 5 and 6 million years old, while the islands of Hawaiʻi and Loʻihi are still growing.

Formed by volcanic eruption, shaped and molded by winds, wave action, erosion, rain and even ice (Mauna Kea sported an ice cap during the Pleistocene era), Hawaiʻi is also unique in its hydrologic qualities. Volcanic basalts include some of the most permeable formations on earth. Given the steep, mountainous terrain of much of the islands, highly permeable rocks and soils are an especial boon to water recharge in some areas. In other areas, denser lava flows, ponded lava, deposits of alluvium or volcanic ash, and rifts and dikes help to contain water, even creating warm, high elevation brackish water pockets in some places.

Surrounded by water and blessed with some of the wettest places on Earth, Hawaiʻi nevertheless is located in a fairly arid area, with rainfall in the open ocean surrounding the islands averaging only 25" to 30" per year. Yet Mount Waiʻaleʻale on Kauaʻi receives over 400" of rain per year.

The secret to Hawaiʻi's natural abundance of water lies in a convergence of winds upon its richly forested mountains. Northeasterly trade winds gain moisture and warmth as they flow for thousands of miles over the tropical Pacific. As these winds reach the islands they are deflected upslope, cooling as they rise and causing moisture to condense. From equatorial regions to the south, air heats and rises, flowing toward the poles. Meanwhile high, cold air from polar regions sinks and flows toward the equator. High elevation cool winds traveling from the northeast subside toward the ocean surface. This subsiding air forms a layer that blocks the rise of the trades up the mountains. The result is a subsidence inversion known as the trade inversion. The trade inversion causes a layer of warmer air to form between 4,800' and 7,000'. When the warm, moisture laden trades rise up the mountains, the rising air is held down by this inversion layer. This convergence of moisture laden air leads to the condensation and release of moisture in Hawaiʻiʻs cloud forests.

If not for Hawaiʻi's mountain forests, most of this moisture would simply run off immediately to the sea. Instead, as this moisture condenses, it adheres to thousands of stems, leaves, twigs, lichens and other surfaces in the watershed.

FIGURE 6-1 Cloud Forest

The multi-leveled, thickly vegetated nature of Hawai‘ian cloud forests provide abundant surface area to help capture and collect large amounts of water. The mosses, lichens, ferns, leaf litter and soils of the forest floor also help to increase the collection and storage value of the forest. The mist laden air surrounding the forest, and the abundant shade from multiple levels of vegetation, help to decrease evapotranspirative losses that would normally occur in a warm, highly vegetated region.

By breaking the impact of heavy rains, holding large quantities of water with surface tension and absorption, and thus allowing a slower, more manageable impact to the ground via stem and leaf drip, Hawai‘ian cloud forests not only reduce the erosive impacts of freshets, but also enable higher and more sustained quantities of recharge. The sponge-like ability of the mosses and fern layers, as well as root-zone soil strata, help to facilitate recharge and minimize water loss during dry periods, holding moisture and keeping the ground shaded.

Hawai‘i’s watershed forests contribute to the high quality of the islands’ waters. Forests have been compared to the kidneys in the body, which filter impurities out of the blood. Particles are removed by adhering to leaves, stems and soils. Certain compounds, especially nutrients, can be absorbed by leaves or root systems. Leaf matter and well graded soils also help filter particles of water.

Hawai‘ian cloud forests are particularly good water managers, and perform the five functions discussed above, namely: 1) collection of water, 2) storage of water, 3) regulation of the discharge of water, 4)erosion control and 5) improving water quality.

Collection of Water
As moisture laden air travels over the ocean and up the mountains, it comes into contact with the abundant plant cover in the forest. The moisture condenses, adheres to, and is absorbed by vegetation and forest litter. Every stem, leaf, twig and bit of moss helps to collect water.

Storage of Water
Hawai‘ian forests are characterized by a dense understory of ferns and mosses, and by multiple levels of plant surfaces. The multidimensional layers and dense understory, and especially the carpet of moss and ferns that typify Hawai‘ian watersheds serve, not only as excellent collection systems but also as storage reservoirs for water. Abundant surface area and multiple surface layers help to absorb and hold more water and to reduce evapotranspirative losses even where large amounts of plant materials are present. Mosses, lichens and ferns are also able to hold large quantities of water.

Regulation of the Discharge of Water
During a heavy rain, the forest canopy and dense under- layers break the impact of falling raindrops, while the sponge-like abilities of mosses and forest floor plants, as well as root-zone soil strata help to hold the water. The understory and groundcovers also help to keep the air and soil in the watershed moist, while facilitating continued recharge and minimizing water loss during dry periods.

Control of Erosion
Erosion control results from the ability of the canopy and other vegetative layers to break the impacts of heavy rain, as well as from the soil holding capacities of the roots. The roots and dense growth serve to keep soil aerated and penetrable, helping to prevent run off, and also preventing the soil from becoming so dry and exposed that it becomes powdery and blows away. In this way, the healthy forest cover helps to promote recharge and minimize soil loss.

Improvement of Water Quality
The watershed forest helps to keep water clean. Impurities in water are removed by adhering to leaves, stems and soil particles. Certain compounds, especially nutrients, can also be absorbed or taken up by both leaves and root systems. The leaves and well graded soils found in a healthy watershed also help to filter particles out of the water.

The effects of Hawai‘ian forests on island recharge are profound. Perhaps the most dramatic example is the island of Lana`i, one of the least forested of all the main islands, with relatively low rainfall and a sustainable yield of only 6 MGD.

FIGURE 6-2 Role of Forests in Hydrologic Cycle

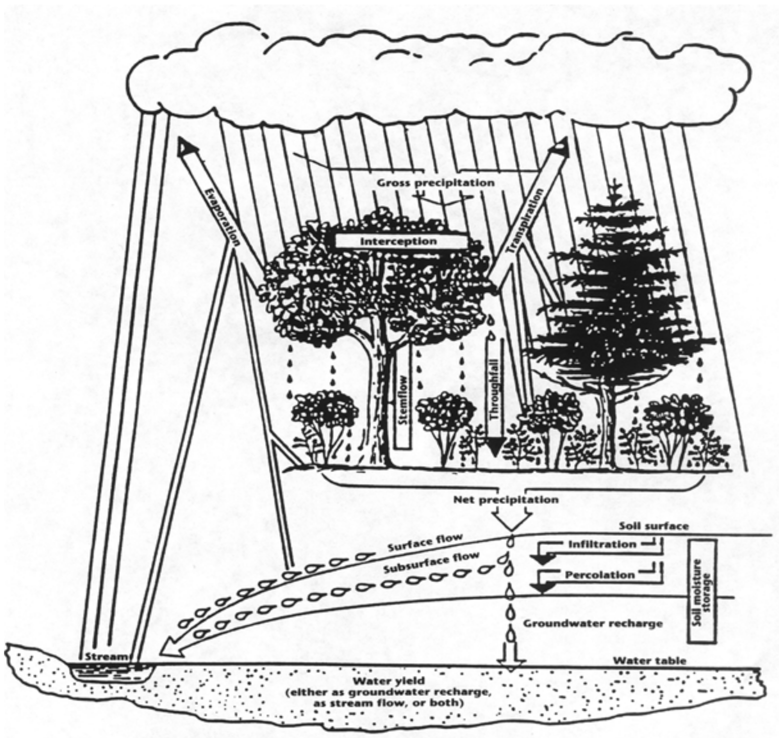


Illustration of the role forests play in the hydrological cycle and watershed protection. (Source: Cassells, Hamilton & Saplaco)

A 1967 State Land Bureau study investigated soils and vegetation on Lanaʻi Hale and concluded that they were more typical of an area receiving 60" / year of annual rainfall - or nearly double the amount received on most of Lanaʻi - than of the 35-40" that actually fall on Lanaʻi Hale. More recently, *A Numerical Groundwater Model for the Island of Lana`i, Hawaiʻi* (CWRM-1, Hardy, '96) estimated that over 65% of the recharge in the primary high level aquifer for Lanaʻi was attributable to fog drip, and that the loss of fog drip from Lanaʻi Hale would lead to the loss of over 50% of the water levels in the Central aquifer, essentially the only viable water source for the island. Lana`i is unusually dependent upon fog drip. Estimates from studies elsewhere indicate that fog drip interception by mountain forests increase precipitation by as much as 30%, and recharge by 10-15%.

The mauka cloud forests are as vulnerable as they are important to the water budget of the islands. Hawaiʻian forest ecosystems evolved in extreme geographic isolation, over 2,400 miles from the nearest continent, with an estimated species introduction rate of one in every 10,000 years, Hawaiʻian species were not exposed to the same pressures and competition as continental species. The result is that many Hawaiʻian species are not well equipped to defend against invasive weeds from more competitive environments, nor from exotic animal pressures such as grazing, browsing, trampling and imported diseases, pests and pathogens. Introduced species can over-run native ecosystems.

Lana`i has suffered the ravages of such introductions. In his 1993 article, "Lana`i - A Case Study: The Loss of Biodiversity on a Small Hawai'ian Island"; (*Pacific Science*; Vol.. 47, no. 3; pp 201-210, University of Hawai`i Press, © 1993), Robert Hobdy estimated that, of the original plant communities on Lana`i, more than 2/3 have been lost. This circumstance is particularly worrisome on Lana`i, where sustainable ground water yield is less than 10% that of Molokai, and less than 2% that of Maui.

Theoretical, empirical, anecdotal and modeling evidence indicate that loss of forest cover, and associated loss of fog drip, has likely impacted water recharge on Lana`i.

The State Land Study Bureau (Sahara et. al '67, quoted from CWRM-1, Hardy '96) studied the vegetation and soils on and around Lana`ihale and concluded that the vegetation and soils of the forest were more typical of one receiving 60" per year than 35 or 40". They attributed this apparent anomaly to the continuous cloud cover. Hardy, in *A Numerical Ground Water Model for the Island of Lana`i, Hawai'i*, describes several such investigations into fog drip on Lana`i. Given repeated, essentially undisputed conclusions that the forest cover contributes to fog drip, it is a short step to the conclusion that loss of forest cover will alter effective precipitation, and hence, via the water budget, recharge.

In "*The Hydrological Importance of a Montane Cloud Forest in Costa Rica*", (Chapter 2.3 of Tropical Agricultural Hydrology, John Wiley & Sons, ©1981), F. Zadroga describes preliminary data from a 5 year experimental catchment research project in the Monteverde Cloud Forest Reserve. Comparing rich montane forest cover with deforested watersheds, he notes a differential effect in wet season direct run-off as compared to dry-season flows. Deforested areas experienced higher run-off during wet seasons, but were unable to sustain flows during dry seasons. On the other hand, forested watersheds continued to yield flows above "rainfall" levels even during the dry season. Areas lacking in forest vegetation had substantially lower yields in terms of percent of direct rainfall over time. The preliminary findings seemed to indicate that the presence of montane cloud cover makes a significant contribution to sustained flows / recharge. Potential reasons mentioned for increased ability to sustain flows in forested areas included increased precipitation from cloud mist or cloud droplet catchment in forested areas, low evapotranspiration due to low insolation from closed canopy, high air-moisture content, and increased ability to intercept clouds.

This finding seems to echo Lana`i's experience as summarized by Hobdy ('93). In an excellent chronology of human activities leading to denudation of the slopes, he describes accounts and observations of witnesses in the late 1800s and early 1900s, and early efforts to preserve or recover forest. *(This narrative is summarized in the timeline/Figure following this introduction.)* Lawrence Gay, in his *True Stories of the Island of Lana`i* noted that the Maunalei stream traveled a mile from its source, but that older Hawaiians remembered it flowing all the way to the sea. In the late 1800s, taro production in Maunalei had to be discontinued, because goats on the cliffs above had denuded the land to such a degree that it had become dangerous to work below. Traditional wetland taro terraces, or lo`i may still be found in Maunalei Valley. George C. Munro, in *Story of Lana'i*, also described hearing from an old Hawai'ian that Maunalei Stream once ran all the way to the ocean. Stearns noted that Maunalei Gulch was perennial prior to the development of Maunalei Tunnel around 1940, although apparently it was not perennial all the way to the sea. Combined, these comments give us the picture that flows at Maunalei Stream had once been sufficient to support taro, and that flows had diminished even before the remainder was essentially eliminated with development of the tunnels. Bowles ('74) and Hardy ('95) both indicate that the loss of recharge resulting from loss of forest cover may have contributed significantly to drawdowns in the wells (CWRM-1, Hardy, '96, pg. 125)**.**

Such conclusions are also supported by Hardy's *Numerical Groundwater Model for the Island of*

Lana`i, Hawai'i (CWRM-1, Hardy, 1996). The model uses a fog drip to rainfall ratio of 0.72, arrived at by averaging studies quantifying precipitation collected in open areas as compared to under forest cover. It uses empirical and / or calculated data for elements such as rainfall, direct run-off, evapotranspiration, and soil characteristics to arrive at water level and draw down estimates assuming various pumping and recharge scenarios. One of the model runs examines the loss of fog drip from the island. The greatest impacts are observed in the areas over 2,000', under which the primary high-level water source is located. In this area it is estimated that 8.87 MGD is attributable to fog drip, vs. a total recharge estimate of 13.5 MGD.

The model scenarios indicate that loss of fog drip alone, with no pumping, would have a greater regional effect on the Central Aquifer Sector than pumping existing wells to 6 MGD (CWRM-1, Hardy, 1996, p. 112). In this high level aquifer area, the loss of fog drip would lead to the loss of over 50% of water levels. Since the model used is unable to account for additional loss of recharge due to erosion and compaction of soils that would be associated with loss of watershed, this may even be a conservative estimate. "...The results clearly indicate that the reduction of forest cover would affect ground water levels drastically,....[and]... make.. a strong case for the maintenance of fog drip efficient vegetation above the 2,000' elevation. "...Recharge should be protected and enhanced to guarantee a reliable ground water resource..."It is important to remember that the overriding factor for governing actual fog drip...is providing the medium upon which fog drip can condense and be harvested from the air. Therefore, changes in the type and density of the forest cover are more likely to change actual fog drip on Lana`i than changes in the surrounding ocean or global climate." (Hardy pgs. 126, 95 & 26)

A recent study by Pacific Environmental Engineering, (Final Report: Lana'i Fog Drip Study, May 29, 2009), found even higher precipitation under Cooke Pine than had been previously estimated. This study did not compare Cooke pine to native vegetation, nor analyze differences in subsurface soil characteristics such as moisture and compaction, but it did highlight the importance of fog drip. While Cooke pine seem to have much to offer in terms of increasing effective precipitation, it cannot and should not be concluded that they are more effective than, nor that they should replace, native vegetation. Nor is this suggested in the Lana'i Fog Drip Study. The concern is raised here because Figure 50 in that document, labeled "Potential Acreage for Cooke Pine Restoration (by Suitability Class)" indicates a candidate Cooke Pine planting area which overlaps the extent of the best remaining native habitat. The map merely indicates areas where Cooke Pine could be effective at fog drip catchment, and where slopes, terrain, wind characteristics, etc. were likely to be suitable for Cooke Pine. This is all valid as far as it goes. It simply does not address the question of native habitat at all. Caution should be taken not to misinterpret this as a recommendation that remaining native vegetation be replaced by Cooke pine.

A more recent article "Hawai'ian Native Forest Conserves Water Relative to Timber Plantation Species and Stand Traits Influence Water Use", Kagawa, Sack, Durate and James, Ecological Applications 19(6), 2009, pp. 1429-1443 studied native 'ohi'a forest versus invaded eucalyptus and evergreen ash, and found that native forest was the better water manager.

Despite abundant evidence pointing to the importance of forested watershed in sustaining the small, susceptible water resources of this island, multiple accounts attest to the fact that Lana`i's watershed has been both degraded and reduced dramatically over the past two centuries. Hobdy ('93) estimated that only 30% or less of the original cloud forest cover in Lana`i remains.

Lana'i Water Advisory Committee Process in Watershed Plan Development

Given that forested watershed is critical to maintaining water availability, and that Lana`i's forested watershed is diminishing, it was determined that the Water Use & Development Plan would not be complete without a skeletal plan for watershed protection and implementation measures. The following section represents a peer reviewed cooperative, consensus effort at developing the basis for watershed protective efforts over the planning time frame.

The group started by identifying two existing plans, the CCR's proposal for a stewardship plan at that time (not the same as the present plan) and a species recovery plan for Lana`i, entitled *Lana'i Plant Cluster Recovery Plan,* published by the US Fish & Wildlife Service, September 1995. These two plans were sent to a panel of over 20 resource managers, most of whom had experience in Lana`i, with the request that each be reviewed as a potential watershed plan to incorporate by reference, and that each panel member offer suggestions for the top priority actions needed to protect the Lana`ihale watershed. Written comments were followed up with a three island skybridge meeting, in which priorities for forest management were discussed. The results of these efforts are incorporated in the proposed plan, by unanimous agreement of the Lana'i Water Advisory Committee.

The proposed plan reflects certain principles to which the Lana'i Water Advisory Committee was committed. Specifically, the group unanimously agreed that any plan should afford maximal protection for the water resource, protecting biodiversity to the greatest extent possible. The group concluded that preservation of native biodiversity would be the most protective for the watershed, given that systems are more stable and able to withstand challenges when their inherent parts are intact.

There are multiple, complex inter-dependent relations between species in any system, and it has been noted that there also appear to be keystone species, without which entire systems unravel. In matters of biodiversity, the committee determined that the most cautious approach for the watershed would be to encourage the maximum preservation of native biodiversity.

Finally, the committee determined that respect for cultural resources and consistency with community values should help to guide the plan. Management of ecosystems has to account for lifestyle and needs of the community. For example, there are roughly 400 hunting licenses out of a population of roughly 2,500 in Lana`i. There are also gathering rights which will be eliminated if the species gathered disappear. Given the need to balance community values, lifestyles and concerns, a series of public meetings were held in which several alternatives were presented and discussed.

Concurrently, a second committee, of which several advisory committee members were a part, met to determine the best path for biodiversity preservation on the island of Lana`i. Although these two groups met separately and for somewhat different purposes, they ended up reaching similar conclusions regarding the management of Lana`ihale, and presented suggestions at a public forum hosted together, and ultimately formed a partnership with other agencies to protect Lana'i's forest and watershed.

Setting

Lana`i is an 89,280 acre (361 sq. km.) island, nearly 2,500 miles (4,022.5 km) from the nearest continent (2,400 miles from California, 4,000 miles from Japan, 2,400 miles from the Marquesas, Samoa & Fiji).

The summit of Lana`i is about 3,370' (1,027.85 meters) high. Lana`i was created by a single shield volcano, built by eruptions at the summit along 3 rift zones, (Stearns & MacDonald, 1983), and possibly a fourth, northern rift zone. (CWRM-1, Hardy, 1996), referring to gravity survey by Krivoy & magnetic survey by Malahoff). The principal rift zone trends northwest-ward, the other rift zones trend southwest toward Kaholo Pali and Kaunolo Bay; and the last south-southwest-ward, toward Manele. Palawai basin is the remnant of a caldera. Just to the west of Palawai, Miki Basin is a nearly filled pit-crater. Cross sections of several additional subsidiary cones and pit craters have been identified.

Lana`i stone has been dated from 0.81 million to 1.46 million years old. The lavas are *theolitic basalts*. These are igneous rocks composed of calcic plagioclase feldspar and pyroxene, relatively rich in silica, and poor in sodium and potassium. Some contain olivine as well. Basalts are low viscosity lavas that form in volcanoes with gently sloping flanks. Basalt lava flows are the *Pahoe-hoe*, which means "ropey", and indeed looks like smooth ropes or layers, or *A'a*, which means "hurt" and is sharp and fragmented.

Because Lana`i lies to the lee of Maui, precipitation is low. The summit receives roughly 38" (96.52 cm) of rain per year, as compared to over 400" (1,016 cm) per year on parts of the neighboring island of Maui. This orientation has also given the island a somewhat unusual topology. What would normally be the "windward" slopes of the island are relatively sheltered from wind, precipitation and wave action. As a result, Lana`i does not have the dramatic windward facing sea-cliffs of Maui or Molokai. However, the southwest is fully exposed to both waves and south-westerly storms, which has allowed the formation of high sea cliffs on her "leeward" side, and a wind-formed dune ridge to the southeast. Pinnacled rocks on the north of the island are also the result of erosion by northeasterly winds.

The hydrogeology of Lana`i is unusual in terms of the predominance of high level water, including the presence of high-level brackish water in at least one location, accompanied by geothermal heating. High level water occurs within 3.8 miles (6.1142 km) of the coast line all around the island. In addition, the north west rift zone is quite wide, possibly as much as 4 miles (6.436 km) across at some points. Such features, as well as numerous dike and fault boundaries have introduced some difficulty in monitoring and understanding the shape of the aquifer and fresh /salt water interface. The south side of the island has essentially no cap rock, but thick alluvial deposits or possibly cap-rock on the north side may serve to deter discharge of water to the ocean and saltwater intrusion.

FIGURE 6-3 Chronology of Land Use Conservation & Water in Lana'i

1400 AD -	Hawai`ians arrived - peak population prior to Cook was estimated at between 3,000 - 3,250 people. Fire, wood, thatch used, some ag - some clearing, some burning for ag and use of wood, etc.
1675 -	Kahuna named Kawelo maintained perpetual bonfire - kept burning for many years, must have cost a lot of trees - the site is one of the worst examples of erosion today
1778 -	Few months before Cook's arrival, warring raid from King of Hawai`i Kalaniopu`u, and his Chief Kamehameha (who eventually united the Hawai`ian islands) (Kamehameha was about 25 yrs old) Kalaniopu`u was upset because he had been defeated by the king of Maui Kahekili. His army descended on Lana`i and destroyed the entire population, ate the food and crops, burned all the houses and other improvements
1778 -	Cook arrived in Hawai`i
1779 -	Clerke recorded Lana`i's existence while departing

Watershed Protection

1778 -	Goats and European hogs introduced to Hawai`i
1791 -	Sheep introduced to Hawaiʻian islands
1793 -	Cattle introduced to Hawaiʻian islands
early 1800s -	Goats introduced to Lana`i - causing noticeable damage within 30 years Before the introduction of goats, there was apparently an extensive and unique forest of `akoko covering upland basins of Palawai and Miki (Succulent bark with good moisture, goats stripped the bark - killing the trees. `akoko = (Chamaesyce celastroides, var. lorifolia) At first, goats didn't penetrate the summit - there was plenty of good eating below.
1823 -	First known visit of caucasian to Lana`i - Reverend William Ellis to Hawai`i Estimated population of the island 2,500
1823 -	Lana`i island population about 2,500
1848 -	The Great Mahele in Hawaiʻi. Government heard peoples claims for land, and awarded it to chiefs and commoners. Lana`i had 13 ahupua`a
1852 -	First distribution of land to commoners in Lana`i
mid 1800s -	Sheep to Lana`i (probably in connection with small colony of Mormons that settled in Palawai basin) later under Walter Murray Gibson, decision was made to raise goats for skins and sheep for wool
1865 -	Lana`i Ranch started
1867 -	Gibson estimated 18,000 goats and 10,000 sheep on Lana`i.
1867 -	Peck vs. Bailey, 8 Hawaiʻi 658 Determined appurtenant rights, right to amount of water used on the land at the time of the Great Mahele.
1870 -	Botanist Dr. William Hillebrand visited Lana`i with J.M. Lydgate. Lydgate described the island as “pretty well denuded of its forest cover:” and observed that “only on the summit of the island ridge was that mantle really intact and undisturbed” (Lydgate 1920)
1875 -	First two Norfolk Island pine planted on Lana`i.
1876 -	Gibson noted that “the isles are becoming naked at a fearful rate”.
1880s	Late 1880s European hogs introduced, but succumbed to a virulent hog cholera epidemic a few years later.
1886 -	Complaint was filed against Gibson by 5 Hawaiʻian families, for placing undue pressure on their livelihoods by charging / limiting access to gathering, fishing and water resources necessary for the subsistence lifestyle of the day. Many water sources were controlled by Gibson, including Waipaʻa. The Waipaʻa Tunnel was not drilled until 1924, so this must have referred to a spring source nearer the shoreline.
1888 -	Gibson passed away and left Lana`i lands to his daughter and her husband, Frederick Hayselden. Hayselden focused primarily on sheep ranching.
1895 -	Lonoaea vs. Wailuku Sugar Co., 9 Hawaiʻi 651 (1895) determined prescriptive rights - rights obtained by adverse use of water for statutory period of adverse possession.
1898 -	Munro estimated 50,000 sheep and a large but undetermined number of goats. Lowland already mainly destroyed. Animals wandering up into mesic and cloud forest areas and denuding mid-elevation canyonlands on the windward side. Human population about 174.

Source Water Protection

	Attempts made to control rampant erosion by planting Bermuda grass. Eucalyptus and Norfolk pine also planted in Koele. WATER RESERVOIRS BUILT AT KOELE AND KAIHOLENA GULCH.
1898 -	Maunalei Sugar Co. started by Heyselden.
late 1800's	Taro production in Maunalei Gulch discontinued because rocks dislodged by goats from denuded cliffs above.
1899 - 1901 -	Epidemic among Chinese workers on sugar plantation reduces company employee population from 710 to 12. This, combined with brackish water helped to guarantee the end of the sugar plantation.
1900 -	GAY WELL A CONSTRUCTED.
1902 -	Heyselden destroyed a local well in KAUNOLU, by damaging the traditional Hawaiʻian plaster work. The well went brackish. The wells he depended upon for sugar production in KEOMOKU were also too brackish to continue using for irrigation.
1902 -	Charles Gay purchased ⅔ of Heyselden's holdings at auction.
1902 -	Charles Gay arrived on island and began more controlled operations focusing on cattle and some agriculture. In 1965, Gays eldest son, Lawrence Gay was noted to recall that mid elevations had extensive areas of tree skeletons on the northern plateau and in the central basin above 1000'. (305 m) around the period (1902) they had arrived on Lana`i.
1902 -	Island population less than 100. Droughts resulting from loss of forest cover - brought reduced productivity and famine to Lana`i residents in the first decade of the twentieth century. Gays arrived on the island. Gays began intensive goat and sheep eradication efforts.
1903 -	Gay purchased Hayselden's remaining interests in Lana`i.
1905 -	The two-story company store and hotel at Keomoku was dismantled and floated across the channel to Lahaʻina, where it became the Pioneer Inn.
1907 -	Gays purchased Kaa & Kaohai ahupua`a. At this time more than half of the lands of Lana`i were still in the hands of Hawaiians, but this percentage was diminishing rapidly.
1908 - 1911 -	Drought
1910 -	Gays invited Territorial Forester Ralph S. Hosmer to help them with a long term recovery plan. Hosmer wrote a 27 page report, recommending more fencing and animal eradication, followed by tree and grass planting to speed the revegetation on the lower slopes.
1910 -	Gays forced to sell most of their holdings Lana`i Company - formed by a group of bankers Initial plan was to focus on sugar beets
1911 -	Small piggery started at Waiapa`a on the slopes above the Palawai basin. Unsuccessful because of non-dependability of water supply remaining hogs released and became feral Munro noticed signs of forest damage in the summit cloud forest, and mounted a successful effort to rid the island of hogs
1911 -	Lana`i Company hired George C. Munro to run the ranch 799 head of cattle present, but sheep count was estimated at 20,558 Munro recommended transition from sheep to cattle; this recommendation was approved

Watershed Protection

1911 -	MAUNALEI TUNNELS 1 & 2 CONSTRUCTED
1911-1921 -	Munro spent much time shooting sheep and goats completed fenceline around the mountain started by the Gays
1911-1937	Munro introduced many species of plants for erosion control and reforestation some of which became pests, choking out native species Melinis minutiflora - molasses grass Paspalum dilatatum - dallis grass Panicum maximum - guinea grass Atriplex semibaccata - Australian saltbush Araucaria columnaris - Cook Pine Leptospermum scoparium - manuka Cauarina glauca - longleaf ironwood Myrica faya - firetree
1916 -	By this time large scale sheep farming was finished
1917 -	Baldwins purchased Lana`i from the Lana`i Company of the time Baldwin's focused on cattle ranching. 4,000 head of cattle in 1917.
1918 -	50 acres of Kanepu`u dry forest fenced by Gay et al
1918 -	MOUNTAIN HOUSE TUNNEL DRILLED
1920 -	Two bird species: `akialoa (Hemignathus obscurus lanaiensis), and Lana`i hook-billed finch (Dysmorodrepanis munroi) gone by 1920. Both birds primary habitat had been the `akoko forests.
1920 -	12 axis deer introduced to Lana`i from Molokai. Multiplied in the Palawai basin, hunted for sport and meat. Munro later mentioned that he regretted this. Population at this time estimated at 185.
1920-	GAY TUNNEL CONSTRUCTED
1921 -	By this time, only 208.25 acres out of the entire island were still owned by Hawaiians.
1921 -	First crop of pineapples planted on Lana`i by Gay.
1922 -	Baldwins sold Lana`i to James Dole, who immediately began preparing Palawaii Basin for pineapple growing. Razing and destroying an enormous non-native invasive cactus population in the process.
1922 & 1926	Munroe makes systematic fog drip observations. *Letter to the Editor,* Hawai'ian Forester and Agriulturist 19(2) pp. 45-46. Unpublished analysis by Munro also given to company as late as 1954
1924 -	Dole Company started planting pineapple fields.
1924 -	Waiapa'a TUNNEL CONSTRUCTED
1925 -	By this time over 2,000 laborers, including many immigrants, had moved to Lana`i to work in the pineapple fields. Brought considerable numbers of poultry and other birds with them.
1926 -	First pineapple harvest on Lana`i. Kaumalapau Harbor was opened, and the crop shipped by barge.

Source Water Protection

1927 -	Territorial Forester Charles S. Judd made a visit to Lana`i. Noted that forest was making a substantial recovery under Munro's management.
1929 -	Munro noticed a sudden decline in numbers of forest birds, which had previously seemed to be recovering.
1929 -	Munroe, *Norfolk Island Pine for the Wet Forest*, <u>Hawiian Forester and Agriculturist</u> 26(3), pp 126-127.
1930 -	Hogs eradictaed. Human population had exploded to 2,356, more than 10x the number of a decade before. The vast majority, about 78% were either Japanese or Filipino,. The remaining 22% were a mix of Hawaiians, Koreans, Puerto Ricans, Chinese, Haole and Portuguese (in descending order of population).
1930 -	W.O. Clark recommended tunneling in Maunalei Gulch.
1931 -	Three more species of birds gone: `o`u (Psittirostra psittacea), Lana`i Creeper (Paroreomyza montana montana), and Lana`i Thrush (Myadestes lanaiensis lanaiensis). Munro believed that there must have been an inadvertent introduction of some avian disease against which the native birds had no defense.
1931 -	9 month drought.
1936 -	MAUNALEI SHAFT 1 & 2 CONSTRUCTED
1937 -	`i`iwi (Vesstiaria coccinea) gone
1937	Munro retired. Deer numbers still low at this time, but in 1950 reminiscences, regretted the introduction.
1940 -	H.T. Stearns estimated 6.46 recharge for high level aquifer; 21.26 MGD for entire island. 6,150 acres (24.89 $km^{2)}$ were set aside as the Maunalei Forest Reserve through a surrender agreement between the Hawai'ian Pineapple Company and the Territorial Government.
1945 -	WELL 1 DRILLED
1946 -	WELL 2 DRILLED
1948 -	George Munro wrote a letter to Colin G. Lennox (president of the Board of Agriculture and Forestry) seeking his assistance in persuading Hawai'ian Pineapple Company to additionally fence of the Kanepu`u dry forest to protect it from cattle and deer. He recounted his long efforts to do so, but registered frustration that it "all has been to no effect".
1950 -	Cattle completely gone from the island. (Cattle ranching discontinued when pineapple began).
1950s	Several hectares of pine trees were planted on the summit to enhance fog drip, but little else in the way of forest management was initiated by government or company during this period.
1950 -	WELLS 3 , 4, & 5 DRILLED.
1950 -	KAIHOLENA TUNNEL HOLE 3 CONSTRUCTED.
1953 -	H.T. Stearns estimated sustainable yield at 3+ MGD.
1954 -	Mouflon sheep introduced as potential game animal.

Watershed Protection

1954 -	SHAFT 3 CONSTRUCTED.
1955 - 1958	Fog Drip Study by Ekern, published 1964 Direct Interception of Cloud Water on Lana‘i Hale, Hawai‘i, Soil Science Society of America Proceedings, vol. 28, n. 3, pp. 319-421.
1957 -	Hawai‘ian Pineapple Company rescinded the surrender agreement & terminated forest reserve status.
1959 -	Hawai‘i Water Authority publishes study on development of Lana`i groundwter and fog drip importance.
1960 -	Pronghorn antelope introduced - did not adapt well.
1960 & 1961 -	K.E. Anderson estimated safe yield at 2.2 and 2.3, respectively. Ultimate high level aquifer supply estimated at 3.6 to 4.8 MGD. At the time appreciable amounts of Maunalei Tunnel water flows bypass the water system, are not accounted, and probably flow into the sea.
1961 -	Carlson, N.K.; *Fog and Lava Rock, Pine and Pineapples*, American Forests 67(2); pp. 8-11, and 58-59.
1961 -	Groundwater Use Act , Hawai‘i Revised Statutes, §177.
1963 -	Otto Degener published warning concerning the future of Lana`i's native flora.
1964 -	P.C. Ekern estimates that rainfall precipitation is augmented by 30″ per year beneath a mature Norfolk Pine.
1970s -	Castle & Cooke and State wildlife managers decided to eradicate goats from the island.
1971 -	Spence & Montgomery documented diminishing forest diversity at Kanepu`u dry forest.
1973 -	Hobdy sends report to State Forester documenting diminished forest diversity at Kanepu`u. Document calls for fencing, deer removal, enrichment plantings of rare species.
1973 -	W.M. Adams estimates that optimum drilling sites for high quality water are in the southeast area between Lopa and Naha. Lower quality between Kiolohia and Lopa.
1973 -	McBryde vs. Robinson 54 Hawai‘i 173 N 15.
1974 -	S.P. Bowles estimates infiltration recharge of 6.5 gpd.
1976 -	Last sighting of the `amakihi (Hemignathus virens wilsoni).
1981 -	Goats eliminated.
1983 -	J.F. Mink estimates recharge at 9.3 MGD; sustainable yield of 6 MGD. Sets a primary recharge area of 14 square miles, and a secondary recharge area of 10 square miles.
1982 -	Pronghorn antelope gone.
1983 -	K.E. Anderson suggests that a freshwater supply estimate of 4.1 - 5.5 MGD be used for planning purposes.
1984 -	Heteropsylla cubana - the Leucaena psyllid - infested and defoliated haole koa in lowlands, deer began migrating upland - deer numbers began to increase rapidly.
1985 -	K E. Anderson reviews water supply and concludes existing infrastructure is capable of supplying 2.7 MGD.

Source Water Protection

1986 -	Ordinance 1578 establishes Manele Project District. Initial project configuration includes 395.34 acres of Single Family, Multi-Family, Commercial, Golf Course, Hotel, Park & Open Space Uses.
1986 -	Ordinance 1580 establishes Koele Project District. Initial project configuration involves 468.3 acres of Single Family, Multi - Family, Commercial, Golf Course, Hotel, Park & Open Space Uses.
1986 -	Well 6 DRILLED.
1987 -	Well 7 DRILLED.
1988 -	Government deer census estimated over 3,700 deer on the northern half of the island alone.
1989 -	Lana\`i Company publishes Water Resources Development Plan for the Island of Lana\`i, Hawai'i, by M&E Pacific.
1989 -	Well 10 DRILLED (aka Lana\`i 10) . This was drilled in response to suggestion that an exploratory well be drilled in the southwestern sector of the Palawai Basin, outside the range of the high level aquifer, and outside the primary and secondary recharge zones. This was an attempt to test whether the basal aquifer could deliver any viable supply. If chlorides were low enough it could prove economical to utilize - and if this had been the case, there would have been a viable source outside the high level aquifer. Instead, high level, geothermally heated and highly brackish water was found.
1989 -	Lana\`i Company filed a petition with the State Land Use Commission to reclassify 138.577 acres from Rural and Agricultural Designations to Urban in order to develop the Manele golf course and related facilities.
1989 -	K.E. Anderson estimates recharge at 8.89 MGD, S.Y. at 6.22 MGD.
1990 -	State Water Resources Protection Plan by JF Mink includes discussion of Lana\`i aquifers. Further update 1993.
1990 -	County Water Use and Development Plan published. Key issues for Lana\`i involved how to accommodate the combined resort and pineapple economy with limited water. Alternate water sources for golf-course irrigation were proposed.
1990 -	Petition to Designate Lana\`i as a State Groundwater Management Area filed by a group of citizens on Lana\`i. CWRM finds that reasonable estimates are recharge: 9 MGD, and sustainable yield : 6 MGD.
1990 -	WELLS 8, 9, 12 & 13 DRILLED. Well 9 is on the border between Mink's "primary" and "secondary" recharge areas. Wells 12 & 13 were a further test to see if the basal aquifer could deliver practical supply. They are located in the island's southeast rift zone. The wells are basal with 4 - 5 feet of head. Chlorides were 900 - 1400 mg/L. Well 12 tested at 100,00 gpd, and Well 13 at less than 42,000.
1990 -	Dole Company announced the closing of pineapple operations.
1991 -	Ordinance 2066 prohibits use of potable water on all golf courses.
1991 -	Land Use Commission issued a Decision and Order, granting the reclassification for Manele, pursuant to several conditions; one of which was that no potable water from the high level groundwater aquifer would be used for the golf course irrigation, and that instead only alternative, non-potable sources of water would be used.
1992 -	Coastal and strand community had been largely destroyed - 3% remained

Watershed Protection

Arid grassland & shrubland ~ 20% remained, mostly in N. & E., Much species diversity eliminated
Dry forest community - 2% remained
Mesic forest community - 3%
Cloud forest community - 30%
threatened with Myrica, Psidium or Leptospermum thickets, Melinis grass, etc.

1992 - Ordinance 2132 increases Manele Project District from 395.34 acres to 556.34 acres. Major changes are addition of 201 acres of golf course, and reduction of 25 acres of Open Space.

1992 - Ordinance 2139 increases Koele Project District from 468.3 acres to 618 acres. Major changes are addition of 332.4 acres of golf course and reduction of 201.5 acres of Open Space.

1992 - County Water Use and Development Plan Draft - Revisited Lana`i issues given the new economic direction of the island. Key issues were the need for better water auditing and control - there seemed to be wide unexplained swings in consumption, high water losses and overall need for better monitoring and conservation. This recommendation applied not only to systems, but was also put forth with regard to hydrologic data gathering. Dual potable and non-potable water systems were also recommended for the Manele Project District.

1993 - Council Chair requests stop work at Manele golf course pursuant to violation of condition of County Code §19.70.85 prohibiting use of water from the high level aquifer for Manele. Three months later, council elects to defer, enforcement of §19.70.085 is deferred given certain conditions. 750,000 gpd allowed for the interim, with some restrictions, in Resolution 93-42.

1993 - State Land Use Commission issued an Order to Show Cause because it believed that Lana`i Co. had failed to comply with Condition 10 of it's District Boundary reclassification for Manele, prohibiting the use of high level water for irrigation of Manele Golf Course.

1993 - County Council Resolution 93-42 also establishes Lana`i Water Subcommitee, with sunset at the end of the year to monitor the use of water from the high-level aquifer. Subcommittee has 9 members. 3 from company, 3 from Lanai‘ans for Sensible Growth, and 1 each from CWRM, Planning Commission and State Water Commision.

1994 - Bill is proposed to amend §19.70.85 to allow withdrawal of 650,000 gpd. Heard first by Planning Commission. Planning Director recommends total allowance fo 650,000 gpd; and that subcommittee be impaneled as a subcommittee of the Human Service, Water and Ag Committee. Recommended subcommittee composition includes 3 from Company, 3 from Lanai‘ans for Sensible Growth, 1 each from CWRM, Planning Commision and State Water Commission as before, with the addition of the Directors of Public Works and of Water Supply.

Mid 1990s - Goats re-introduced.

1995 - Council Subcommittee Established with the following membership: 2 from Company, 2 from Lanai‘ans for Sensible Growth, 1 Councilmember, Lana`i Planning Commission Chair, Planning Director, Public Works Director, the Water Supply Director as an ex-officio non-voting member, and one additional non-voting member from Lanai‘ans for Economic Growth and Stability.

1995 - Ordinance 2410 increases Manele Project District from 556.34 acres to 872.25 acres. Major changes are additon of 258 acres more single-family development, reduction of 29 acres of golf course, reinstatement of 45 acres of open space and addition of 21.4 acres of multi-family development.

1995 - WELL 14 DRILLED.

1996 - State Land Use Commission issued cease and desist order requiring Lana`i Company to stop using water from the high level aquifer for golf course irrigation, and to file a plan with the LUC within 60 days saying how it would comply.

1996 - CWRM publishes a Numerical Ground Water Model for the Island of Lana`i, Hawai‘i ; by Roy Hardy ; CWRM-01.

Source Water Protection

1996 -	An additional Lana'i Water Resources Management Plan is published by the Company, in response to the State Land Use Commissions May 17th 1996 Decision and Cease & Desist Order. It essentially stated that since efforts to develop a practical basal source with wells 10, 12 and 13 had failed, it was impractical to continue to rely on purely non-potable, non-high-level sources. It notes that Time Domain Electrormagnetic Resistivity surveys performed by Black Hawk had indicated that the extent of the high level aquifer was larger than previously expected. It stated that principal recharge to the basal lense is leakage from high level groundwater compartments beyond the rim of the Palawai. The recharge itself was considered too brackish for use. The report concluded that brackish water from the high-level aquifer was the only practical source for alternate irrigation.- A month later, the company filed a supplement with additional cost information. There were no alterations to the conclusions.
1996 -	State Commission on Water Resource Management establishes a Lana`i Water Working Group to try to reach consensus on water issues. Composition is identical to that of the council subcommittee, which was scheduled to dissolve at the end of the year.
1996	Council Subcommittee sunset December 31st.
1997 -	Water Working Group established by the State Commission on Water Resource Management sunsets.
1997 -	In January and again in April, the Board of Water Supply resolves to continue working with the Working Group until the County Water Use and Development Plan is completed, and to consider establishment of ongoing committee to work on unresolved issues. Board continues discussions on pros and cons of this decision and on what form the committee should take until 1999.
1997-	Final Report of the Lana`i Water Working Group established under CWRM is submitted. Board moves to accept this report as the "interim" draft WUDP until the Lana`i WUDP chapter is approved through the usual process.
1996 -	Ordinance 2515 amended County Code Section 19.71.055 relating to irrigation of the Koele Golf Course. Amends section D on Irrigation by changing phrase from no high level groundwater to no high level aquifer groundwater . Then proceded to establish conditions under which the Director of Public Works and Waste Management may authorize use of the high level aquifer for golf course irrigation. Events that trigger such allowance include but are not limited to: chemical contamination of a non-potable source, resulting in chemical concentrations not approved for golf course application; a water transmission line break in the non-potable line; failure of non-potable pumping systems, failure in sewage reclamation systems, draw down of reservoirs and irrigation water features for fire fighting or other emergencies or electrical power failure in delivery facilities. In no case is drought to be deemed an unanticipated event warranting issuance of such permit. Prior to such emergency approvals, the golf course owner shall have provided to the director supporting documentation of relevant facts and events, a plan showing that no continuous physical connection will be made between potable and non-potable systems, a remedial plan to restore non-potable water use including schedule; and a plan detailing how other critical uses will be accommodated, source to be used, distribution priority to residents, etc. Such permit when issued to be valid for only 30 days, with provision for longer lasting permits if deemed necessary by director and council. Failure to comply with remedial plans warrants refusal of extensions, weekly progress resorts must be submitted by golf course owner, amounts not to exceed 250,000 gpd.
1996 -	Ordinance 2516 further amends County Code 19.71.055 by adding Section E, entitled re-seeding or re-grassing, enabling a golf course owner to apply for use of up to 27,000 gpd PER FAIRWAY to supplement non-potable irrigation sources in order to establish new plantings. One fairway to be irrigated at a time. No more than 4 fairways per calendar year. Re-seeding or re-grassing allowable only between May and October; each fairway to be re-seeded or re-grassed NO MORE THAN ONCE under this provision. Reiterates several

	conditions listed above: no permanent interconnections; provision for other priority uses; if irrigation emergency occurs during already-permitted re-seeding or regrassing, the replanting activity may continue, but only such that the combined total of re-grassing or re-seeding and the other emergency use does not exceed 250,000 gpd.
1997 -	Lana`i Water Working Group Report passed February '97.
1998 -	Ordinance 2743 decreases Manele Project District from 872.25 to 868 acres. Major change is reduction of 51 acres of single family, addition of 25 acres of multi-family, addition of about 19 acres of open space, and addition of 6.6 acres to hotel site.
1999 -	Board Resolution No. 5 (1999) establishes the Lana`i Lana'i Water Advisory Committee. Composition: 2 voting members from Lana`i Company, 2 voting members from Lanai'ans for Sensible Growth; 1 voting member from the Lana1i Planning Commission; councilmember from the island of Lana`i, with voting rights; 3 residents of Lana`i who are not affiliated with any of the aforementioned entities; 1 non-voting member from Lanai'ans for Economic Growth and Stability, DWS as the lead agency and staffing source, and other county and state agencies such as Planning, Public Works, CWRM, DLNR-DOFAW or others to participate as desired, but without voting privileges. Executed on March 16th, 1999.
2001 -	Lana`i Forest and Watershed Partnership MOU signed. Efforts to construct fence and management undertaken by multi-entity partnership.
200 -	First increment of Lana'i Hale Summit Fence completed.
2008 -	WELL 15 (briefly aka Well 11) - drilling permit issued. Well is not yet drilled as of 2009 update.
Sources:	Hobdy, Robert; "Lana`i - A Case Study: The Loss of Biodiversity on a Small Hawai'ian Island"; *Pacific Science*; vo. 47, no. 3; pp 201-210, University of Hawai`i Press, © 1993 Lana`i Community Plan (1998); prepared for the Maui County Council by the Lana`i Planning Commission; the Maui County Department of Planning; the Lana`i Citizen Advisory Committee; and Consultants; Community Resources, Inc. & Michael T. Munekiyo Consulting, Inc. CWRM; Numerical Ground Water Model for the Island of Lana`i, Hawai'i ; by Roy Hardy; CWRM-01; State Commission on Water Resources Management; well data base dated 2001

Lana`i Plant Communities

Range: The Lana`ihale Cloud Forest ranges from about 2,100' (700 meters) to the summit at about 3,370' (1,023 meters) in elevation, along the ridgetops and gulches of the mountain summit in Lana`i. The Lana`ihale forest covers all or part of the Kealiakapu, Kealia Aupuni, Palawai, Kamao, Kaohai, Pawili, Kaunolu, Kalulu, Maunalei, and Kamuku ahupua`a. Access from town is achieved via the Lana`ihale summit road, and by various 4 wheel drive roads to the northeast end.

Because of the low elevation of this cloud forest, it contains a strong mix of mesic species and is immediately surrounded by mesic forest and shrubland. These communities, where contiguous, are not entirely distinct. Therefore, it is recommended that management measures be extended to the buffering mesic areas. The Lana`ihale mesic forest ranges from 900' (300 meters) to 2,400' (800 meters) in steep gulch lands surrounding the summit cloud forest, and extends into the summit forest.

Plant Taxa and General Plant Community Types:

Native species commonly found in the area include `ohi`a, pukiawe, `olapa, a`ali`i, mamane and uluhe.

A list of flowering plants, indicating endangered, proposed, candidate and SOC (Species of Concern) plants of Lana`i is provided in Figure 6-5. Also provided are lists of the ferns, lichens and hepatics, of Lana`ihale.

Native plant communities have been classified by Dr. Samuel Gon, III of The Nature Conservancy according to an adaptation of the method used by Wagner, Herbst and Sohmer in the Manual of the Flowering Plants of Hawai`i. According to this classification, predominant plant communities in Lana‘ihale include a mixture of:

Metrosideros polymorpha / Cheirodendron sp. (‘Ohi`a / `Olapa or Lapalapa)
Metrosideros polymorpha / Dicranopteris spp. (`Ohi`a/Uluhe)
Dicranopteris sp. lowland wet shrubland (Uluhe)

Also present are:
Dodonaea spp / Stypelia tameiameiae (`A`ali`i / Pukiawe)
Osteomeles anthyllidifolia (`Uulei)
Acacia koa (Koa)
Diospyros sanwicensis (Lama)
Nestegis sandwicensis (Olopua or Lapalapa)

Loss of Plant Communities

According to Hobdy (93) About 30% of native Hawai‘ian vascular plants have been recorded in Lana`i, roughly 345 species. Of these, about 70 have disappeared, including 8 endemics. The Bishop Museum Flowering Plant Checklist lists 205 endemic and indigenous species. The U.S. Fish & Wildlife Service lists 36 endangered, 3 proposed, 3 candidate and 25 “species of concern” (hereinafter SOC).

The attached Figure 6-5 lists these endangered, proposed, candidate, and SOC plants, of which 35 are found in Lana‘ihale. Hobdy has developed a user-friendly classification of native plant communities on Lana`i based on moisture, elevation, plant community and soil type. The following Figure, from his 1993 article (*Case Study*), paints a dismal picture of what has already happened to biodiversity on Lana`i. This Figure more or less answers the question “What have we lost so far” (or “what have we not yet lost”)?

Vegetation Community	Annual Moisture	Percent Remaining	Percent of Island
Cloud forest	35-50" (875-1250 mm)	30% remains	2%
Mesic forest	27-35" (675-875 mm)	3% remains	7%
Dry forest	20-27" (500-675 mm)	2% remains	36%
Arid grassland & shrubland	8-20" (200-500 mm)	20% remains	49%
Coastal and strand	8-18" (200-450 mm)	3% remains	6%

Source: Hobdy, 1993

Status of Remaining Plant Communities

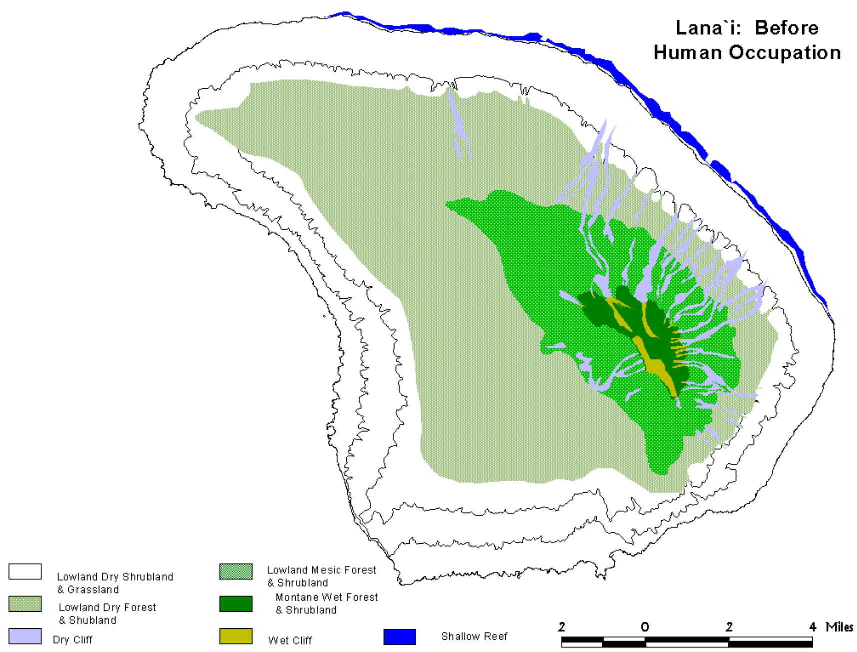
The Nature Conservancy, using a classification with more segregation of categories, but based on the same sorts of considerations, divides the island into seven main types of communities. This Figure does not look at the overall percent of native community remaining, but rather asks the question, within the remaining pockets of native plant communities, what percent of plants is actually native? In other words, the Figure below answers the question “How pristine is the remaining native cover?”

VEGETATION COMMUNITY	ELEVATION RANGE	PERCENT NATIVE
wet cliff	2,700-3,300'(823.5 - 1,006.5 m)	75%
montane wet forest & shrubland	2,800-3,300'(854 - 1,006.5 m)	75%

lowland mesic forest &shrubland	1,500-3,300(457.5 - 1,006.5 m)	50%
lowland dry forest & shrubland	1,600-1,800'(488 - 549 m)	25%
dry cliff	400-3,300'(122 - 1,006.5 m)	75%
lowland dry shrubland & grassland	500-3,200'(152.5 - 976 m)	50%
non-native	0-3,100' (0 - 945.5 m)	5%?

The map below shows estimated ranges of the pre-contact extent of the communities listed above.

FIGURE 6-4 Lana'i Vegetation Before Human Occupation



Threats to Lana'i Hale Plant Communities

Prior to Polynesian colonization, Lana`i was covered with native vegetation. The introduction of Polynesian agriculture and fire modified the vegetation primarily in the coastal and lowland areas. The arrival of Europeans accelerated the destruction, with the introduction of ranching, cattle, sheep, pineapple, cane, goats, pigs, etc, axis deer, mouflon sheep.

Although the Lana`ihale ecosystem is unique, many of the threats to the watershed affect the entire island. The major threats include habitat alteration, invasive plants & animals, erosion, pathogens, human activity and drought. These are further described in Figures 6-7 and 6-8, which follow.

FIGURE 6-5 Flowering Plant Species on Lana`i - Endangered, Candidate, Threatened, Species of Concern

found in Lana`ihale	Status	Family	Genus	Species	SubSpecies (var. if indicated)	Description
	E	Amaranthaceae	Achyranthes	splendens	var. rotunda	
	E	Apiaceae	Spermolepis	hawaiiensis		tiny, seasonal shrub in the Parsley family. found in dry areas 1,000-2,500'
Y	E	Asteraceae	Bidens	micrantha	kalealaha	erect, perennial herb in the Sunflower family. found in dry to mesic forests and shrublands. 1.5-5' tall. Lana`i Hale.
Y	E	Asteraceae	Hesperomannia	arborescens		small, shrubby tree in the Sunflower family, 5-15' tall. slopes and ridges of wet forests. (1,000'-2,200')
	E	Asteraceae	Tetramolopium	lepidotum	lepidotum	white flowered daisy in the Sunflower family found in dry lowland areas (500'-1,000')
	E	Asteraceae	Tetramolopium	remyi		shrub in the Sunflower family found on dry exposed ridges or flats in lowland & dry shrubland areas (500'-2,500')
Y	E	Camapanulaceae	Clermontia	obliongifolia	mauiensis	terrestrial shrub or tree in the Bellflower family, with dark, smooth glossy green leaves, and white calyx type flowers with white or purple stamens. 6-21' tall. orange berries. mesic valleys to wet forests, 1,200-3,600'.
Y	EX	Camapanulaceae	Cyanea	lobata	baldwinii	four to seven foot tall palm-like shrub in the Bellflower family. mesic to wet forest (2,000' - 3,000') , extinct. a single plant was found in 1919 by Munro. The same plant was still alive as of 1935. Munro propagated seeds from this plant, and they survived around his home site until at least 1940.
Y	E	Camapanulaceae	Cyanea	gibsonii		was Cyanea macrostegia gibsonii. palm-like lobeliad tree in the Bell-flower family, 3-21' tall. bird-pollinated, found in wet to mesic areas (2,490-3,180')
Y	E	Campanulaceae	Brighamia	rockii		}lula, h~h~. succulent in the Pink family. has stout, unbranched stem, thicker at base. 3-15' tall. calyx type flower has white corolla with green to yellowish green tube. grows on windward sea cliffs to 1,400'. also found in Maunalei valley.
Y	E	Caryophyllaceae	Silene	lanceolata		subshrub in the Pink family. small flowers at end of stems, in clusters, with smooth white petals. reddish brown seeds. dry to mesic areas, 900'-5,490'. Maunalei Valley .
	E	Convolvulaceae	Bonamia	menziesii		
	E	Cyperaceae	Cyperus	trachysanthos		
Y	E	Cyperaceae	Gahnia	lanaiensis		tufted, perennial Sedge, 980'-3,020' range, first described at 2,919' elevation
Y	E	Cyperaceae	Mariscus	fauriei		low-growing Sedge found in mesic shrubland (1,000'-2,500')
Y	E	Fabaceae	Caesalpinia	kavaiensis		uhi uhi, k~wa`u, kea shrub or tree in the Pea family. 12-30' tall, thick rough dark gray bark, pinate (divided) leaves, red flowers. dry to mesic forests 240'-2,760' . Hawaiians made spears and fishing implements from the hard, durable wood.
	E	Fabaceae	Sesbania	tomentosa		prostrate shrub in the Pea family found in lowland coastal areas 50'-1,500'
	E	Fabaceae	Vigna	owahuensis		twining vine in the Pea family, found in dry lowland areas 50' - 1,500'
	E	Gentianaceae	Centaurium	sebaeoides		ephemeral herb in the Gentian family, found in coastal habitats 50'-750' elevation
Y	E	Gesneriaceae	Cyrtandra	munroi		shrub in the African violet family found in lowland wet forest (980'-2,202')
	E	Gooeniaceae	Scaevola	coriacea		dwarf naupaka. prostrate perennical herb in the Goodenia family.
Y	E	Lamiaceae	Phyllostegia	glabra	var. lanaiensis	perennial herb in the mint family lowland mesic to wet forest 2,490' - 3,180' gulch bottoms & sides, steep areas
	E	Malvaceae	Abutilon	eremitopetalum		shrub in the mallow family, bird pollinated lowland dry forest, historical range 690'-1,710' currently only at around 1,100'
	E	Malvaceae	Abutilon	menziesii		shrub in the mallow family, bird pollinated found in low, dry shrubland (500-1,400')

	E	Malvaceae	Hibiscus	brackenridgei	brackenridgei	sprawling, deciduous shrub found in dry, lowland areas (500'-2,000')
	E	Poaceae	Cenchrus	agrimonioides	agrimonioides	
	E	Poaceae	Panicum	fauriei	var. carteri	
	E	Portulacaceae	Portulaca	sclerocarpa		perennial herb in the purslane family. pale, grayish-green leaves. clusters of 3-6 flowers at the end of stems, white or pink metals about 10 mm long, with tufts of hair underneath. likes dry habitats, 3,090'-4,890'. Found on Po`opo`o islet off the coast of Lana`i.
	E	Rhamnaceae	Gouania	hillebrandii		
Y	E	Rubiaceae	Gardenia	brighamii		small tree in the coffee family, up to 15' tall. dry forest species. 1,050' -1,560'. Kanepu‘u.
	E	Rubiaceae	Hedyotis	mannii		subshrub in the Coffee family. mesic to wet forest.
Y	E	Rutaceae	Zanthoxylum	hawaiiensis		moderate sized tree in the Rue family. found in mesic forest habitats. 2,000' - 4,500'
Y	E	Santalaceae	Santalum	freycinetianum	var. lanaiensis	small gnarled tree (Sandalwood) w/ bright red flower clusters, bird pollinated, lowland dry to high-elevation mesic, or wet
Y	E	Solanaceae	Solanum	incompletum		pÇpolo kã mai. shrub in the Nightshade family. Up to 9' tall. reddish prickles on stem. mesic to dry forest. 1,800' - 6,100'.
Y	E	Urticaceae	Neraudia	sericea		9' - 15' shrub in the Nettle family. Mesic to dry forest. 2,000'-3,000'.
	E	Violaceae	Isodendrion	pyrifolium		
Y	E	Violaceae	Viola	lanaiensis		subshrub in the Violet family, lowland wet forest to lowland mesic shrubland 2,200' - 3,200'
Y	PE	Loganiaceae	Labordia	tinifolia		k~makahala. Shrub or small tree in the Logania family. 3.5 - 30' tall. Mesic to wet forest, ridges, slopes or understory of open canopy. 900' to 2,300'.
Y	PE	Rubiaceae	Hedyotis	schlechten-dahliana	var. remyi	trailing herbaceous shrub in fern understory. Coffee family. 2,500' - 3,000'
Y	PE	Rutaceae	Melicope	munroi		
Y	C	Caryophyl-laceae	Schiedea	pubescens	var. pubescens	
	C	Fabaceae	Canavalia	pubescens		found in mesic to dry areas, bird pollinated
Y	C	Laminaceae	Phyllostegia	imminuta		sub-erect perennial shrub in the Mint family. mesic gulches of Lana`i Hale. 2,040' - 2,190'
Y	SOC	Asteraceae	Bidens	campylotheca	campylotheca	erect perennial herb in the Sunflower family. 2 ' - 12' tall. wet to mesic areas 300'-3,600'.
	SOC	Asteraceae	Bidens	mauiensis		decumbent perennial herb in the Sunflower family 0.3' - 1' tall. coastal bluffs, dunes and dry slopes. 150' - 1,800'.
Y	SOC	Agavaceae	Pleomelde	fernaldii		small, branched tree in the Agave family w/palm-like leaves mesic to dry forest 1,600' - 3,000'
Y	SOC	Araliaceae	Tetraplasandra	kavaiensis		tallish (24' - 75') tree in the Ginseng family. mesic to wet forest. 1,950' - 4,800'.
	SOC	Asteraceae	Tetramolopium	conyzoides		
	SOC	Brassicaceae	Lepidium	bidenatum	var. owahiense	
Y	SOC	Campanulaceae	Delissea	lanaiensis		four to six foot tall palm-like shrub in the Bellflower family. mesic to wet forest (2,000' - 3,000') , extinct?
	SOC	Capparaceae	Capparis	sandwichiana		
	SOC	Caryophyl-laceae	Schiedea	menziesii		Sprawling subshrub in the Pink family. Found in Maunalei valley. dry forest ledges and cliffs. 90' - 1,020'
	SOC	Euphorbiaceae	Chamaesyce	celastroides	laehiensis	
	SOC	Fabaceae	Acacia	koaia		smallish, gnarled tree in the Pea family. less than 35' high. mesic and dry, open habitats. wood is harder and pods narrower, than those of Acacia koa. 180' - 6,180'
Y	SOC	Gesneriaceae	Cyrtandra	lydgatei		shrub in the African violet family. 2' - 8.5' tall. flowers at ends of stalks, in dense clusters. leaves in unequal pairs. white berries. wet forest (1,500' - 2,700'). Maunalei Valley and Hale.
	SOC	Lamiaceae	Haplostachys	munroi		
Y	SOC	Malvaceae	Hibiscadelphus	crucibracteatus		tree up to 18' tall in Mallow family. rounded crown. trunk about 16 cm. diameter. Puhielelu Ridge in Lana`i about 2,250'.
Y	SOC	Poaceae	Dissochondrus	bifloris		tall, perennial Grass with narrow, spike-like tufted flowers. sharply keeled, flat blades. diverse mesic forests, often on slopes. 1,400' - 3,150'.
	SOC	Poaceae	Eragrostis	deflexa		
	SOC	Poaceae	Eragrostis	mauiensis		
	SOC	Poaceae	Panicum	ramosius		
	SOC	Portulacaceae	Portulaca	molokiniensis		`Ihi. stout perennial herb in the Purslane family. older stems have a pale, corky layer of second-ary growth. headlike clusters of flowers with white or pink petals, 10 mm long. dark brown seeds. coastal areas, sea cliffs and steep, rocky slopes. 30-345'.

	SOC	Portulacaceae	Portulaca	villosa		perennial herb in the Purslane family. erect sub-shrub. pale, grayish-green leaves. dark, reddish-brown seeds. clusters of 3-6 flowers at the end of stems, white or pink metals 8- 10 mm long, with tufts of hair underneath. dry rocky or coralline areas, 0-1,200'.
Y	SOC	Rubiaceae	Morinda	trimera		
Y	SOC	Rutaceae	Melicope	hawaiensis		Mokihana, kãkae moa, manena. 9' - 30' tall shrubs or trees in the Rue family. smooth, pale brown bark. dry to mesic areas, 1,830' - 3,660'.
	SOC	Santalaceae	Exocarpos	gaudichaudii		Heau, a`u, sandalwood tree. small tree or shrub 4.5 - 21' tall. found on ridges in mesic forest and shrub land. 750' to 1,075'. bears small fruit with hard seed.
	SOC	Solanaceae	Nothocsestrum	latifolium		
Y	SOC	Thymelaeaceae	Wikstroemia	bicornuta		}ki`a, kauhi. straggling shrub to small tree in the }ki`a family. Dark green leaves, lighter on lower surface. 3'-7' tall. 2,700' - 3,150' elevation. wet forest. highest ridge of Lana`i.
	E		Ctentis	squarmigera		endangered terrestrial fern found in Lana`i Hale.

FIGURE 6-6 Two Native Lana‘i Species: Kawau and Cyrtandra

The left column indicates whether the species is found in Lana`ihale. Descriptions are provided for Lana`ihale species.

This Figure was compiled from the Bishop Lists, US F&WS list, the Manual of Flowering Plants of Hawai‘i (Wagner, Herbst and Sohmer, 1990), with guidance and assistance from Robert Hobdy, formerly of the State DLNR Division of Forestry and Wildlife.

FIGURE 6-7 Threats to Lana'i's Flowering Plant Species

Threat	Explanation of Problems Caused by Threat
Habitat Alteration	The small size of remaining populations of certain species can leave them vulnerable. Loss of numbers can lead to loss of genetic vigor, increased susceptibility to disturbances & diseases and other problems. The small extent of remaining intact ecosystems may prove too small to support certain target species Introduction of exotic species, particularly if these are invasive, can destroy large tracts of land very rapidly Poorly planned management efforts can inadvertently alter habitat.
Invasive plants	A list of invasive plant species needing control in and around Lana'ihale is provided in Figure 8. This Figure also describes some of the problems associated with these plants.
Invasive animals	examples below
Axis Deer (Axis axis)	Axis deer were introduced 1920s. After elimination of goats in 1981, deer moved upland and numbers have increased dramatically. It is possible that a psyllid leafhopper of koa haole contributed to this movement upland, since koa haole had been major source of food for deer in the lowlands. In 1988, the deer population reached 10,000. The majority of deer are noted just mauka of the kiawe belt on the north east side of the island. DOFAW staff also notes that there appears to be evidence that there may be two somewhat distinct populations of axis deer on Lana`i: one makai (in the kiawe belt) and the other mauka (in and around Lana'ihale and upper elevations). This theory is based on observations of game trails that extend upward from the kiawe and downward from the mesic forest, but seem to be discontinuous at or about mid-elevation. Axis deer are considered the primary threat to the watershed at this time, largely due to their behaviours of browsing, trampling and rubbing, described further below.
	Browsing damages or destroys plants by eating green portions
	Trampling removes vegetation, removes leaf litter important to soil-water relations promotes erosion, compacts soils, opens areas to invasive plants and animals (carried as seed in digestive tracts, droppings, fur, etc.)
	Rubbing destroys cambium layer of trees, esp. from bucks rubbing felt off antlers
Mouflon Sheep (Ovis musimon)	Browse on native vegetation, trample, etc. Introduced in 1954. Well adapted to ridge and gully lands
Sheep (Ovis aries)	catastrophically large numbers of sheep around the turn of the century (50,000) Greatly reduced by 1920, eliminated entirely from Lana`i by the late 1950s.

Goats (Capra hircus)	introduced in early 1800s eliminated 1981 trampling, grazing, erosion, etc.
Cattle (Bos Taurus)	eliminated about 1950 trampling, grazing, erosion, etc.
Pigs (Sus scrofa)	first piggery 1911, pigs eradicated in 1930 by George Munro trampling, wallows, grubbing, erosion, etc.

Birds	Loss of native pollinators (birds, insects) causes threat to remaining habitat Introduction of pest birds that feed on native insects that pollinate native plants Introduction of pest birds that compete with native birds for food, nesting sites, etc. Examples include the Japanese White Eye and the Japanese Bush Warbler, which compete for food & nesting sites, or Cardinals, believed to feed on sandalwood fruits. More information is found in Figure 13. Introduction of bird diseases including avian malaria (protozoan), avian pox (virus) Introduction of insects carrying avian diseases, especially mosquitoes, which carry avian malaria and avian pox
Rats (Rattus rattus rattus, Rattus exulans Rattus norvegicus)	Rats feed on fruits, flowers and seeds of native plants, girdle or strip branches, and prey on native birds. Rattus rattus rattus, the arboreal black rat, believed to have had the greatest impact among rats and mice on flora and fauna.
Mice (Mus domesticus)	Like rats, mice feed on fruits and flowers of Hawai‘ian plants, and/or girdle and strip branches. Sandalwoods are especially vulnerable to rodent damage. Predation on seeds reduces reproductive viability.
Slugs	Slug damage and live slugs have been observed on native species, such as Viola lanaiensis). Seedlings and young tender shoots are especially susceptible
Insects	Descriptions of problem insect species are found in Figure 9.
Pathogens	Spike disease - affects sandalwood in India, believed to be in Hawai‘i Santalum heart rot - affects sandalwood (mostly dry to mesic, but some in Lana‘ihale) Santalum seed fungus - affects sandalwood (mostly dry to mesic, but some in Lana‘ihale)
Humans	Human and animal traffic in and around remaining communities Example - roughtly half of the remaining plants of a certain species (Gahnia lanaiensis) grow adjacent to the Munro Trail. conversion of native ecosystems to agricultural uses , pasture Ex: Most of dryland habitat long ago cleared for pasture, harming Abutilon eremitopetalum, Abutilon menziesii, Tetramolopium remyi) pineapple cane vandalism illegal collection fires resulting from human activities or spread by human-introduced species inadvertent damage from poorly executed management efforts

Erosion	Self-perpetuating cycle. Animals lead to compaction of soils, loss of plants, and erosion. Erosion leads to more loss of plants. Loss of plants leads to more erosion
Drought	May be exacerbated by diminishing fog drip. Exacerbated by loss of ground cover in the forest - ground dries quickly & stays dry longer can also lead to viscious cycle . Die back of plants leads to less fog drip. Less moisture leads to more die back of plants. This cycle increases threats from fire and erosion.

A list of invasive plants that pose threats to the watershed is provided in Figure 6-8. Typical invasive behaviors include crowding out other vegetation, displacement of understory, allelopathy or release of compounds that inhibit growth of other plants, and provision of fire fuel or stimulation. Among the more damaging are christmas berry (*Shinus terebinthifolius*), strawberry guava (*Psidium cattleianum*), manuka (*leptospermum scoparium*), guava and *Tibouchina herbacea.*

FIGURE 6-8 Invasive Plants in Lanaʻihale and Surrounding Mesic Areas

Genus	Species	Common Name	Description
Andropogon	viginicus	broomsedge	boggy open mesic and dry habitats, releases allelopathic substances. fire stimulated, and fuel for fires. Dormant during rainy season. May enhance erosive properties.
Asclepias	physocarpa	balloon plant	erect shrub in the milkweed family. grows up to about 6' in height. highly invasive in disturbed areas. seeds dispersed by wind.
Hedychium	gardnerianum	kahili ginger	agressive invader of wet forests, especially well lit areas and streambeds. dispersed by birds. also spreads vegetatively. forms large continuous clumps, displaces understory.
Lantana	camara	aggressive grass. crowds out other species. carries fire, fire stimulated. seeds dispersed by wind. affects mostly dryland areas. Introduced to Lana`i in two places, on the north end and on the golf course. Known populations were removed, but follow-up is needed.	thorny shrub, forms impenetrable thickets, crowding out other plants. biological controls have reduced aggressiveness somewhat. especially bad in dry lowland areas. normally does not grow over 15' hight, but can get to 40' if supported.
Leptospermum	scoparium	manuka	New Zealand shrub. Crowds out native vegetation, especially on Lana`i Hale.
Leucacaena	leucocephala	koa haole	nitrogen fixing tree, forms dense thickets, excludes other vegetation, esp bad in low, dryland areas,but also affects mesic to wet areas.
Melinis	minutiflora	mollasses grass	dry mountain ridges, mesic to wet forests. forms dense mat, smothers other plants. fuel for fires. spreads fires.
Myrica	faya	firetree	rapidly growing, invades mesic and wet habitats. Forms dense, monotypic stands. Nitrogen fixing, capable of altering ecosystems. Suspected of allelopathic activity. Grows from 984' to the summit. Colonizing. Lana`i Hale south slope has one of the major infestations in the state.
Panicum	maximum	guinea grass	drougt resistant, allelopathic, carries fire under dry conditions, highly invasive. Especially problematic in dry areas.
Paspalum	conjugatum	Hilo grass	low growing grass. spreads in shady partial openings and occupies distrubed areas in forst understory. not as habitat-altering as molasses grass
Pennisetum	clandestinum	kikuyu grass	invades dry, mesic and wet forest habitats. forms thick mat that prevents reproduction of native taxa.
Pennisetum	setaceum	fountain grass	aggressive grass. crowds out other species. carries fire, fire stimulated. seeds dispersed by wind. affects mostly dryland areas. Introduced to Lana`i in two places, on the north end and on the golf course. Known populations were removed, but follow-up is needed.
Pluchea	symphytifolia	sourbush	forms dense thickets in dry to wet habitats
Prosopis	pallida	kiawe	highly invasive tree to dry areas and lowlands. Overtops other lowland vegetation.
Psidium	cattleianum	strawberry guava	one of the most agressive exotic invasive species. forms dense stands, capable of displacing all other palnt species. Has allelopathic properties. Fruit is dispersed by birds.
Rubis	rosifolius	thimbleberry	low to mid height, weak-stemmed shrub. Has small red berry and prickles on stems. Grows in mesic to wet areas
Schinus	terebinthifolius	christmas berry, brazilian pepper	tree. forms dense monotypic stands. found in Kanepu`u and on the lower slopes of Lana`i Hale. Massive dispersal by birds follows fruiting in Nov.-Dec. Christmasberry invades dry to mesic sites
Tibouchina	herbacea	aggressive grass. crowds out other species. carries fire, fire stimulated. seeds dispersed by wind. affects mostly dryland areas. Introduced to Lana`i in two places, on the north end and on the golf course. Known populations were removed, but follow-up is needed.	wet forest invader, crowds out native species. Especially invasive where native cover has been disturbed

FIGURE 6-9 Native Lana'i Ferns - Amau and Uluhe

Ferns

Native Hawai'ian ferns help to collect and hold water, and to improve water holding capacity of the soils. They help to limit loss of water through evapotranspiration by keeping the forest floor cool.

Native ferns serve as nesting sites for certain native birds. Munro records certain native Lana`i bird species nesting in and amongst ferns, possibly to help hide themselves from the predatory Pueo (native owl).

Like all other species, ferns also contributed to the general biomass and level of soil nutrients.

The following Figure describes some of Lana'i's native ferns.

FIGURE 6-10 Pteridophytes (Ferns) Native to Lana`i

Family	Genus	Species
Psilotaceae	Psilotum	nudum
		complanatum
Lycopodiaceae	Phlegmariusrus	filiformis
		phyllanthus
	Huperzia	erosa
		x. gillettii
		serrata
		x sulcinervia
	Lycopodium	venustulum
	Palhinhaea	cernua
Selaginellaeae	Selaginella	arbuscula
Botrychiaceae	Sceptridium	subbifoliatum
Ophioglossaceae	Optioglosum	petiolatum
		polyphyllum
	Ophioderma	pendula
Marattiaceae	Marattia	douglasii
Gleicheniaceae	Dicranopteris	linearis
	Diplopterygium	pinnatum
	Sticherus	owhyhenis
Schizaeaceae	Schizaea	robusta
Pteridaceae	Adiantum	capillus-veneris
	Coniogramme	pilosa
	Pteris	cretica
		excelsa
		x hillebrandii
		irregularis
	Doryopteris	decipiens
		decora
		subdecipiens
	Pellaea	ternifolia
Vittariaceae	Haplopteris	zosterifolia
Hymenophyllaceae	Gallistopteris	baveriana
	Gonocormus	saxigragoides
	Mecodium	recurvum
	Sphaerocionium	lanceolatum
		obtusum
	Vandenboschia	cyrtotheca
		davallioides
		draytoniana
Cyatheaceae	Cibotium	chamissoi
		glaucum
		menziesii
Dennstaedtiaceae	Hypolepis	hawaiiensis
	Microlepia	strigosa
	Pteridium	decompositum
Lindsaeaceae	Lindsaea	repens var. macroaeana
	Odontosoria	chinensis
Thelypteridaceae	Pseudophegopteris	keraudreniana
	Cyclosorus	cyatheoides
		hudsonianus
		interruptus
		sandwicencis
	Thelypteris	globulifera
Blechnaceae	Dodia	kunthiana
	Sadleria	cyatheoides
		pallida
		souleyetiana
		squarrosa
Aspleniaceae	Asplenium	acuminatum
		x adiantum-nigrum
		aethiopicum

		contiguum
		cookii
		horridum
		lobulatum
		macraei
		nidus
		nomale
		sphenotomum
	Hymenasplenium	excisum
		unilaterale
	Diellia	erecta
Woodsiaceae	Athyrium	microphyllum
	Deparia	fenzliana
		marginalis
		prolifera
	Diplazium	arnottii
		molokaiense
		sandwichianum
Dryopteridaceae	Ctenitis	latifrons
		squamigera (endangered)
	Cyrtomium	caryotideum
	Dryopteris	fusoatra
		glabra
		mauiensis
		sandwicensis
		unidentata
		wallichiana
	Nothoperanema	rubiginosa
	Tectaria	cicutaria var. gaudichaudii
	Elaphoglossum	aemulum
		crassifolium
		paleaceum
		parvisquameom
		pellucidum
		wawrae
	Nephrolepis	cordifolia
		exaltata ssp. hawaiiensis
Grammitadaceae	Adenophorus	abietinus
		hillebranii x. tripinnatifidus
		hymenophylloides
		tamariscinus
	Grammitis	hookeri
		tenella
	Lellingeria	saffordii
	Oligadenos	pinnatifidus
Polypodiaceae	Lepisorus	thumbergianus
	Microsorum	spectrum
	Polypodium	pellucidum
Courtesy of Herbarium Pacificum, Bishop Museum		

Hepatics, Mosses and Lichens

The health of a watershed, and therefore its water catchment ability, can be rapidly assessed by the abundance of pendulous lichens and mosses on the branches of the trees.

Lichens and mosses are excellent interceptors of moisture from fog. Hanging *Thalli* have a high surface area to volume ratio, which means more surface area to intercept rainfall. Mosses and lichens help to keep the temperature in the cloud forest cool, allowing for more water condensation.

The diversity of a healthy epiphyte and bryophyte community also lends stability. A monotypic plant community is ultimately unstable and more vulnerable to outside threats.

Mosses and lichens provided food and home to various species. For instance, *Usnea* species are often inhabited by rare, cryptic spiders. *(Personal communication: Dr. Cliff Smith of UH Botany Dept.)*

Figures 6-11, 6-12 and 6-13 list native mosses, lichens and hepatics of Lana`i, respectively, based on information provided by Bishop Museum. Dr. Christopher Puttock, Collection Manager of Botany for the Bishop Museum, has indicated that the list of hepatics is likely a vast underestimate, and suggests that the true list "will probably be similar to that of Molokai (91 taxa) and perhaps half of Maui (137)".

Threats to Mosses and Lichens and Algae

Threats to ferns, mosses, lichens and algae are largely similar to those facing the flowering plant communities described in the Figure above. Of particular concern for the survivial of these specific communities are:

- trampling, browsing, ungulate traffic
- insect pests such as the Chinese two-spotted leaf- hopper
- exotic weeds
- loss of critical population size / habitat size
- predation by introduced rodents, snails, slugs, birds
- erosion
- fire damage
- introduced pathogens

(Sources: Personal communications, Dr. Cliff Smith of UH Botany Dept., and Dr. Christopher Puttock of Bishop Museum Dept. of Natural Sciences)

FIGURE 6-11 Mosses on Lana`i

GENUS	SPECIES	VARIETY	BAUTHOR	TAUTHOR
Acroporium	fusco-flavum	fusco-flavum	(Par.) Broth.	
Aerobryopsis	wallichii		(Brid.) Fleisch.	
Anoectangium	euchloron		(Schwaegr.) Mitt.	
Baldwiniella	kealeensis		(Reichardt)Bartr.	
Bryum	angustirete		Broth.	
Campylopus	fumarioli		C. Mull.	
Campylopus	hawaiicus	hawaiico-flexuosus	(C. Mull.) Jaeg.	(C.Mull.) Frahm
Campylopus	hawaiicus	hawaiicus	(C. Mull.) Jaeg.	
Campylopus	umbellatus		(Arnott) Par.	
Daltonia	contorta		C. Mull.	
Dicranella	hochreuteri		Card,	
Distichophyllum	freycinetii	freycinetii	(Schwaegr.) Mitt.	
Distichophyllum	paradoxum		(Mont.) Mitt.	
Ectropothecium	sandwichense		(Hook & Arnott.)	
Ectropothecium	viridifolium		Bartr.	
Entosthodon	subintegrus		(Broth.) Miller, H.	
Eurhynchium	vagans		(Jaeg.) Bartr.	
Fissidens	bryoides		Hedw.	
Fissidens	delicatulus		Angstr.	
Fissidens	elegans		Brid.	
Fissidens	hoei		Pursell	
Fissidens	kilaueae		Hoe & Crum	
Fissidens	lancifolius		Bartr.	
Fissidens	nothotaxifolius		Pursell & Hoe	
Glossadelphus	zollingeri	filicaulis	(C. Mull.) Fleisch.	(Fleisch.) Fleisch.
Glossadelphus	zollingeri	filicaulis	(C. Mull.) Fleisch.	(Fleisch.) Fleisch.
Holomitrium	seticalycinum		C. Mull.	
Homaliodendron	flabellatum		(Sm.) Fleisch	
Hookeria	acutifolia		Hook. & Grev.	
Hookeria	acutifolia		Hook. & Grev.	
Isopterygium	albescens		(Hook.) Jaeg.	
Leucobryum	gracile	gracile	Sull.	
Leucobryum	pachyphullum		C. Mull.	
Leucobryum	seemannii	seemannii	Mitt.	
Macromitrium	brevusetyn		Mitt.	
Macromitrium	emersulum		C. Mull.	
Macromitrium	piliferum		Schwaegr.	
Macromitrium	reinwardtii		Schwaegr.	
Palamocladium	wilkesianum	wilkesianum	(Sull.) C. Mull.	
Palamocladium	wilkesianum	sciuroides	(Sull.) C. Mull.	(C.Mull.) Wijk &
Philonotis	hawaica		(C. Mull.) Broth.	
Philonotis	turneriana	turneriana	(Schwaegr.) Mitt.	
Pogonatum	tahitense		Schimp. ex	
Racopilum	cuspidigerum		(Schwaegr.)	

Rhizogonium	pungens		Sull.	
Rhizogonium	spiniforme		(Hedw.) Bruch	
Sematophyllum	hawaiiense		(Broth.) Broth.	
Taxithelium	mundulum		(Sull.) Bartr.	
Thuidium	hawaiense		Reichardt	
Tortella	humilis		(Hedw.) Jenn	
Tortella	tortuosa		(Hedw.) Limpr.	
Trichosteleum	hamatum		(Dozy & Molk.)	
Trichosteleum	bartramii		Mill	
Vesicularia	perviridis		(Angstr.) C. Mull	
Weissia	ovalis		(Williams) Bartr.	
Courtesy of Herbarium Pacificum, Bishop Museum				

FIGURE 6-12 Lichens of Lana`i

GENUS	SPECIES	VARIETY	BAUTHOR
Anaptychia	sorediifera	colorata	(Muell. Arg.) Du Reitz & Lynge
Anthracothecium	sandwicense	convexum	Zahlbr.
Anthracothecium	sandwicense		Zahlbr.
Arthonia	cinnabarina		(DC.) Wallr.
Arthopyrenia	phaeoplaca		Zahlbr.
Arthotelium	macrothecum		(Fee) Mass.
Bacidia	alutacea		(Kremp.) Zahlbr.
Bacidia	alutacea	minarum	(Kremp.) Zahlbr.
Bacidia	choriciae		Zahlbr.
Bacidia	medialis		(Tuck.) Zahlbr
Bacidia	personata		Malme
Bacidia	sandwicensis		H. Magn.
Bombyliospora	domingensis		De Not
Buellia	subcallispora		H. Magn.
Catillaria	cuvatula		H. Magn.
Catillaria	intermixta	trachonoides	(Nyl.) Am.
Catillaria	vacillans		H. Magn.
Chiodecton	perplexum		Nyl.
Cladina	sylvatica		(Hoffm.) Nyl.
Cladonia	angustata		Nyl.
Graphina	sulphurella		Zahlbr.
Graphis	illinata	apoda	Eschw.
Graphis	leptocarpa		Fee
Graphis	lineola		Ach.
Gyrostomum	dactylosporum		Zahlbr.
Lecidea	granifera	leucotrapa	(Ach.) Vain.
Leptogidium	byssoides		(Carrahlbr.)
Microthelia	albidella		Muell. Arg.
Ocellularia	exnthismocarp		(Leight.) Zahlbr.
Ocellularia	multilocularis		Zahlbr.
Ochrolechia	pallescens		(L.) Mass.
Opegrapha	prosodea		Ach.

Opegrapha	subcervina		Zahlbr.
Pannaria	lurida		(Mont.) Nyl
Parmelia	tinctorum		Despr.
Parmentaria	lyoni		Zahlbr.
Phaeographis	dentritica		(Ach.) Muell. Arg.
Phaeophysica	UN		UN
Phaeotrema	rocki		Zahlbr.
Physcia	picta		(Sw.) Nyl
Physcia	picta		(Sw.) Nyl
Physcia	sorediosa		(Vain.) Lynge
Pleurotrema	rocki		Zahlbr.
Pseudocyphellaria	flavicans		(Hook.) Vain.
Pseudopyrenula	octomera		H. Magn.
Pyrenula	sublateritia		Zahlbr.
Pyxine	retirugella	capitata	Nyl.
Ramalina	extenuata		H. Magn.
Ramalina	faurieana	contracta	Zahlbr.
Ramalina	faurieana		Zahlbr.
Ramalina	microspora		Kremp
Ramalina	sideriza		Zahlbr.
Ramalina	subpollinaria		Nyl.
Sphinctrina	microcephala		(Sm.) Nyl.
Sticta	weigelii		Isert
Usnea	australis		Fr.
Usnea	condensata		Mot.
Usnea	dasycera		(Nyl.) Motyka
Usnea	rubicunda		Stirt
Xanthoparmelia	subramigera		(Gyeln.) Hale
Courtesy of Herbarium Pacificum, Bishop Museum			

FIGURE 6-13 Hepatics of Lana`i

GENUS	SPECIES	BAUTHOR
Frullania	neurota	Taylor
Jubula	hutschinsiae	(Hooker) Dumortier
Courtesy of Herbarium Pacificum, Bishop Museum		
* Bishop Museum staff suggest that this list probably under-represents		
Hepatics on Lana`i, and that the true list would probably be more		
similar to those of Molokai (91 taxa) and perhaps half of		
Maui (137 taxa).		

FIGURE 6-14 Native Lana'i Snails

Terrestrial Mollusks of Lana`i

Estimates of the number of species of terrestrial mollusks in Hawai'i vary. Loope ('98) quotes S. Miller of the US F& W Service as stating that there are about 1,263 historically described species of Hawai'ian Land Snails, of which about 900 species, or 71% are extinct. (Mac, M.M.; P.A. Opler; C.E. Puckett Haecker; and P.D. Doran "Status and Trends of the Nation's Biological Resources", 2 volumes; U.S. Department of the Interior, U.S. Geological Survey; Reston, Va.; Chapter on Hawai'i & the Pacific Islands by Lloyd Loope, 1998). A review of the U.S. Fish & Wildlife Service Species List from February 1st, 2000 indicates 640 endangered, threatened, candidate or species of concern snail taxa. Hobdy ('93) estimates that there were once roughly 780 species of snails endemic to the Hawai'ian islands ("Lana`i - A Case Study: The Loss of Biodiversity on a Small Hawai'ian Island"; *Pacific Science*; vo. 47, no. 3; pp 201-210, University of Hawai`i Press, © 1993). According to Severns (personal communication 1999), there were 763 species of taxonomically valid species of snails recognized as Hawai'ian, of which all but 2 to 4 are endemic. Most were single-island endemics. An additional 16 species questionably belong to Hawai'i, and a further 14 are possibly senior synonyms (prior descriptions under a different name).

Earlier articles have estimated that there were once 42 species of native land snails on Lana`i. However, more recent work estimates 71 species. (See Figure prepared by Mike Severns, based on Cowie, Catalog of Native Land & Fresh Water Molluscs of the Hawai'ian Islands, Backhuys Publishers, Lieden, 1995 and others. These are listed in Figure 6-15.

Although native snail fauna is among the more diverse groups of native species, some experts believe that most species of Hawai‘ian snails radiated from members of a single genus of progenitors, *Tornatellides*, which has been found on bird feathers throughout the Pacific islands. (Personal communications, Dr. Michael Hadfield, Mike Severns).

Snails were and integral and abundant part of the original, uniquely endemic ecosystems of Lana`i. Most native snails are single island endemics, existing no where else on Earth. Snails in Hawai‘i mainly eat fungus, lichens and algae off leaves of trees. It is not clear whether this could have any beneficial impact on the trees, or how important this role was. Snails, like other abundant life forms, were part of the nutrient cycle, contributing to the total biomass, soil nutrients, and so forth. They were a dietary component of certain native birds. The endangered Po`ouli (Melamprosops phaeosoma) eats snails (Gon), and it is believed that certain extinct species of large flightless birds ate snails (Severns), although apparently the larger snails were not eaten. (Severns, personal communication; Pilsbry, Manual of Conchology, Storrs & James, Ornithological Monographs 45 & 46, James Juvik, Atlas of Hawai‘i, 3rd Edition).

Severns has explained a phenomenon noticed during the time when sheep were on Lana`i, in which mollusc populations seem at first to increase with disturbance of native communities, though in the long run they may be adversely affected. He believes that invasive mammals, such as sheep ate lower stature plants / trees at the edge of the forest, exposing large, shallow-roooted `ohi`a trees to winds which they were not capable of withstanding. When the trees fell, they extended the range of the fringe (semi-forest, semi-scrub) habitat, and certain populations adapted to inhabit fringe areas expanded.(Severns, personal communication, information from article in preparation for Pacific Science)

Snail species are described in Figure 6-15.

FIGURE 6-15 Native Snails of Lana`i

Family	Sub Family	Genus	Sub Genus	Species	Preferred Habitat, Food,Habits, Elevation Ranges and Other Notes	Max Size mm	Description
Helicinaidae		Pleuropoma	Pleuropoma				have opercula (trap door)
				kaaensis	Dry land, W. Lana`i	3.10	
				lacinosa		3.20	
				piliformis	Found on Lana‘i Hale.	3.50	
Achatinellidae	Achatinellae	Partulina	Eburnella		Eburnellas live in Lana‘i Hale and fringe forest. live in trees, feed on lichens & algae. nocturnal		
				variabilis	Scrub `ohi`a areas, likes habitat that gets some light, vegetation not too dense, not usually found in the tops of trees. may be adapting to live on guava	18.00	semi-gloss shell
				lactea	Variation of variabilis	22.00	
				semicarinata		18.00	
				hayseldeni	Variation of semicarinata	18.00	well defined, sharp ridge around body keel that runs around periphery of the last whorl.
			Partulina		Lana‘i Hale & fringe forest, uluhe & scrub `ohi`a areas feeds on lichens and algae, nocturnal, lives in trees. lives at somewhat lower elevations than other Partulinas (2,000-4000' on W. Maui) , but found on Hale		dull, rough shell,
				crassa		22.00	
	Auriculellinae	Auriculella			Tree dweller, feeds on lichens and algae, nocturnal.		
				brunnea		8.00	
				lanaiensis		5.80	
	Pacificellinae	Lamellidea	Lamellidea				
				gracilis		3.75	
	Tornatellidinae	Tornatellaria					
				cincta		5.00	
				trochoidea		4.00	
		Tornatellides	Tornatellidides				
				acicula		3.00	
				macromphala		2.75	
				perkinsi		3.00	
				procerulus		3.50	
				terebra		3.00	
Amastridae	Amastrinae	Amastra	Amastra		Lana`i once had large Amastras. These tend to be more ground-dwelling. They live under rocks, under ferns and other ground vegetation, and in leaf litter. Can live in mesic and fringe, down to dry-forest. Somewhat lower elevation than Partulinas, but lived in Hale.		
				aurostoma		25.00	

				balteata		23.60	
				biplicata		23.00	
				durandi		20.00	
				grayana	Found in Lana`i Hale on ground	21.50	
				longa	Disappearance noted in 1912.	12.00	
				magna		36.00	largest known Amastra in Amastra genus. (Corelia is in a different genus)
				moesta		15.80	
				nucula		12.00	
				obscura		16.50	
				pusilla		8.50	smallest amastra on Lana`i
				rubristoma		19.30	
		Amastra	Heteramastra	fraterna		10.00	
		Laminella			Tree dwellers, feed on lichens and algae, nocturnal		
				concinna	Found on koele side of summit, about 3,000'	11.20	
				circumcinta	Color variation of concinna	12.00	striped. this is the only striped Laminella.
				gracilor		15.50	
				remyi	Very similar to tetrao. Found behind koele.	14.00	
				tetrao	Very similar to remyi. Found behind koele.	17.20	
		Tropidoptera					
				alata	Found behind koele	8.50	
				lita		10.00	
	Leptachatininae	Leptachatina	Leptachatina		Fringe to grassy areas	14.00	bullet shaped, shiny shells
				impressa	Found behind koele	7.00	
				lanaiensis		8.00	
				longiuscula		10.50	
				perkinsi	Found on ridges of gulches	10.50	
				semipicta	Found behind koele	8.00	
				smithi	Found in mountains behind koele	9.25	
				subovata	Was once abundant	7.30	
				supracostata		6.30	
Pupillidae	Nesopupinae	Lyropupa	Lyropupa				
				lanaiensis		2.50	
				rhabdota		2.50	
			Lyropupilla				
				sparna		2.20	
			Mirapupa				
				costata			
		Nesopupa					
			Limbatipupa				
				newcombi		1.65	
			Nesodagys				
				rhadina	Likes damp rocks, smooth, barked trees	1.95	
				thaanumi	Found in moss on tree trunks	2.75	
				wesleyana	Likes damp rocks, smooth, barked trees	2.00	

			Nesopupilla				
				baldwini	Found on top of Lana`i Hale	2.50	
				dispersa	Found freshly dead in mahana gulch	1.53	
		Pronesop-upa					
			Pronesopupa				
				boettgeri			
				hystricella			
Endodontidae		Cookecon-cha			Found on the ground, live in cracks between rocks, fallen logs, etc.		
				lanaiensis	Found in Koele and on Hale	4.77	flat rounded spire
				ringens	Likes wet forest. Found on Koele and on Lana'ihale	4.61	
		Endodonta		concentrata	Found on the ground, live in cracks between rocks, fallen logs, etc.	5.43	flat angular spire
Succineidae	Succineinae	Succinae	Succinae	caduca			
		Succinea	Truella	rubella	Fringe to drier areas		fingernail-thin
Helicarioni-dae	Euconulinae	Euconulus	Nesoconulus				
				kaunakakai	Under talus	2.33	
				subtilissimus	Ground dwelling	2.36	
	Mycrocysti-nae						
		Hiona	Hionella				
				perkinsi	Likes ground moisture, high elevations	6.50	
		Philonesia	Haleakala		Live in wet forest, like forest understory, very susceptible to dessication, typically likes higher elevations and wetter areas than Partulinas.		have thin, almost transparent shells, charcoal gray to black,
				diducta	Found under lichens on a`alii shrubs	4.81	
				interjecta		6.28	
				turgida	Found under lichens on trees	5.50	
			Philonesia	maunalei	Found in talus under kukui tree	6.33	
Zonitidae	Gastrodonti-nae	Striatura	Pseudohy-alina	discus		3.40	
	Zonitinae	Nesovitrea		pauxilla		5.00	
		Philonesia	Haleakala		Live in wet forest, like forest understory, very susceptible to dessication, typically likes higher elevations and wetter areas than Partulinas.		have thin, almost transparent shells, charcoal gray to black,
				diducta	Found under lichens on a`alii shrubs	4.81	

Figure courtesy of Mike Severins

Sources: Cowie, Catalog of Native Land & Fresh Water Molluscs of the Hawai'ian Islands, Backhuys Publishers, Leiden, 1995, and others

Threats/ Concerns to Native Snail Populations

Threats to snails in Lana`i include predation by rats, other snails, and possibly birds; altered and diminished habitat, introduced pathogens, and the risk of damage from human activities. These threats are delineated below. (*Source:Personal communications, Dr. Michael Hadfield and Mike Severns*)

- **Predation by other snails**

Oxachilus aliaris

Introduced predatory snail, eats natives.
Believed by Severns to have been introduced during WWII.
By the 1960s, most ground-dwelling snails were extinct.
Mucous coating smells of garlic.
Eats young snails when hatched.

Euglandina Rosea

Introduced predatory snail from the Florida swamps.
Not yet reported on Lana`i ,
Due to its agressive nature, forest managers should be on the alert for this predatory snail.
Introduced to the islands intentionally in 1958 to control another species of introduced snail.

A comparison of the life cycle of the predatory *Euglandina* to that of native snails such as *Achitinella* and *Partulina* highlights the vulnerability of the native snails. Whereas Achitinella and Partulina mature slowly (6-7 years), and live to a maximum of about 20 years, producing only 1 to 7 offspring per year, the introduced Euglandina takes less than a year to mature, produced more than 600 eggs per individual per year, and has a life span of up to 5 years. (Loope, 1998, in Mac, M.M.; P.A. Opler; C.E. Puckett, Haecker; and P.D. Doran *Status and Trends of the Nation's Biological Resources*, 2 volumes; U.S. Department of the Interior, U.S. Geological Survey; Reston, Va..; Chapter on Hawai'i & the Pacific Islands by Lloyd Loope, quoting Mike Hadfield et al 1986) - (Hadfield, M.G.; *Extinction in Hawai'ian achetelline snails*; Malacologia; 27:67-81; 1986)

- **Possible predation by other animals such as introduced birds**

- **Habitat of choice:**

  Native snails remaining are found living in low vegetation. This makes them more vulnerable to predators loss of natural habitat and possible introduction of diseases by introduced snails or slugs.

- **Invasion of non-host plant species**

  For example, Eucalyptus or other species that eliminate natural habitat species and which do not provide host for native snails.

- **Poorly planned management efforts**

  Even well-intentioned attempts to help retain and enhance habitat could pose a threat. Proposed fence lines or other forest management facilities should be surveyed to insure that snail populations are not disturbed.

FIGURE 6-16 Native Birds of Lana'i

Family	SubFamily	Genus	SubGenus	Species	Sub species	Common Name	Description
Fringillidae		Himatone		sanguina		apapane	Only remaining endemic forest bird in Lana`i. adult has crimson body with white belly and under-tail coverts, and black tail and wings. first plumage on the young is brown. strong flier, flies high in small groups from one part of the forest to another. keeps mainly to tree tops. wings vibrate loudly in flight. active in tree tops, hopping from one flower to another. food, nectar, insects and caterpillars.
Fringillidae		Paroreomyza	maculata	montana		Lana`i creeper, alauwahio	Wilson called this Paroreomyza maculata montana. Hawai'ian names: Alauwahio, Alauwi, Lauwi. short flights, food in bark of tree trunks and branches. pretty, chirping call. yellowish green upper body with lemon-yellow under body. about 5" long. nest was compact ball of fine grass stems and skeleton leaves, 1.75" across the bowl, 0.75" deep, 0.5" thick. last seen in 1937 per Munro.
Antidae		Branta		sandwicensis		Nene	Listed as Nesochen sandwichensis by Munro, but not mentioned by him as being on Lana`i. Ornithological monographs list as Branta sandwicensis. Both refer to it as nene. black, brown and buff with greyish parts. hind neck, cheeks, chin and throat black, also black ring around lower throat. 23"-28". webs on feet smaller than other geese. feeds on berries. lived and fed mainly in dry upland country; wintered and raised young in lowland lava flows. noted as living from sea level to 2,200' by Munro. nest was a hollow in the ground, or eggs laid on surface and surrounded by pieces of brush. Munro reported laid 3 to 6 cream white eggs. eggs 3.36"x2.35", but usually only 2 chicks. Nene on Maui typically lay about 4 eggs. Hawaiians used to hunt nene for food, esp. during molting season.
Fringillidae		Dysmorodrepanis		munroi		hookbilled finch	Perkins called it Dysmorodrepanis munroi. Not clear if Munro thought it was finch or drepanid? Endemic to Lana`i. nearly extinct per Munro in 1944. bird found in 1913 by Munro had upper body light grey with tinge of green, white mark over the eye, but it was molting. found in Kaiholena Valley in 1913, and later in Waiakeakua. beak unusual in that mandibles curved toward each other so that only the tips touched. Retiring bird. Munro believed that this bird used to live in the akoko forest (Euphorbia lorifolia) that originally covered the Lana`i plains. Munro took one feeding on the fruit of an opuhe (Urera sandwichensis), which has fruit about the same size. lived in upper forest and plains of Lana`i. between the islands.
Fringillidae		Hemegnathus		obscurus	lanaiensis	Akialoa	Munro calls it Hemignathus obscurus lanaiensis (Rothschild). Rothschild described male as black olivaceous green, with dirty yellow breast and cream white under tail covers. However both Munro and Perkins thought that this must have been either a younger bird or if an adult, one not in its breeding stage, as they found it to be quite yellow. The female was a dull greayish olive, with yellowish abdomen. By 1944, Munro felt it was probably extinct, as it had not been seen in many years. It was seen hunting for insects on an o`hi`a. Munro believed it had also inhabited the akoko forest. it hunted for insects on the trunks and limbs of trees, and Perkins noted that the one he saw seemed rather tame, continuing to hunt for food at times not 5 yards distant.

Fringillidae		Hemignathus		virens		Amakihi, honey creeper	Bishop museum printout lists Hemignathus virens. Ornithological monographs list Loxops virens. Munro calls it Chorodrepanis virens chloroides. Known as the Lana`i amakihi. Type of honeycreeper. Looks not described specifically, but Munro mentions that the species vary little in size, with total length varying from 4.2 to 4.75 inches. He noted that Perkins felt that the species inhabiting Hawai‘i, Molokai, Maui and Lana`i were essentially the same. He describes the Kaua‘i and Hawai‘i amakihis, and foregoes description of the appearance of the Molokai, Maui or Lana`i species. The Kaua‘i species had bright green upper parts, with yellowish under parts. The Hawai‘i species was described as being much yellower than the Kaua‘i species, with a smaller bill. Kihi means curved, and describes the shape of the bill. One assumes that the Lana`i species was also green on top and yellow underneath. The Lana`i amakihi was once very common in the forest, but numbers were reduced by introduction of bird diseases. Munro says that they were plentiful prior to 1923, when the town was built. By the writing of his 1944 book, he says that they were very much reduced in numbers as of a few years ago and their chance of survival slight. The forest was small and of no considerable elevation, and its proximity of the town lent little protection through isolation. Munro observed a nest and noted that it was 3.75" wide by 3.5" deep, with a 1.75" hollow at the top, with the characteristic odor of the Drepanine birds. The Lana`i amakihi had this odor so stronly that, "A bird flying past to windward left the odor plainly perceptible in the air." Munro saw a nest in a small tree 12' from the ground. The female approached and tried to lure him away by scolding and fluttering. The nest overhung the steep valley side, but was hidden by the trees above from owls. It was made of grass and fiber from the ieie vine, and lined with rootlets and some sheeps wool.
Fringillidae		Loxops		virens		Amakihi, honey creeper	
Fringillidae		Psittirostra		psittacea		O`u	Munro lists as Psittacirostra psittacea (Gmelin). Bishop lists as Psittirostra psittacea. Munro notes that Temminck, Rothschild and Henshaw all referred to it as Psittirostra. He seems to credit Temminch with the name, but states that Psittacirostra as used by Perkins is more grammatically correct. Munro states that the male was known as the O`u poolapalapa, or yellow-headed O`u; and the female as O`u laueo, or leaf green O`u. The bird has a bright green body, and the male of the species has a yellow head. The female and young did not have a yellow head, and the younger birds were not quite as bright. The bill was parrot-like and hooked, possibly facilitating scooping fleshy flower bracts and picking ripe fruit from the upright spadix of the ieie vine. The O`u had a beautiful voice, with clear whistling notes leading in to a plaintive call. Munro noted that the birds were common in 1923 and seemed to be doing well, but by 1944 he felt that they were near extinction. O`u naturally fed on the fruit and flowers of the ieie vine, and on the berries of arborescent lobelias, and other upland fruits but they were also seen feeding on guava and mulberries. Unfortunately, Munro believed this is part of the reason they became extinct. The O'u had a habit of coming to the low level areas for food, which exposed the species to introduced bird diseases which they could then carry back to their forest habitat. No nests were seen. Munro thought they were probably well hidden in staghorn ferms and ieie vines. O`u feathers were used in Hawai‘ian featherwork..

Fringillidae		Vestiaria		coccinea		I`iwi, honey creeper	Munro lists as Vestaria coccinea (Forster). Type of honey creeper. Bright scarlet wings and tail. Also black wings. Rose colored bill. 5.75" long. According to Munro, in 1891 the i`iwi and apapane were so numerous that they raised a continual buzz. Lived in `ohi`a and Pelea trees. Lived at all elevations from the seashore to the mountaintop, whereever flowering ohi`a forest reached. Munro noted, "It semed to me that the `ohi`a honey had a stimulating effect as these birds were full of life and gaiety when frequenting the profusely blooming ohi`a trees." I`iwi fed on nectar, caterpillars and insects. They flitted from flower to flower and hopped among twigs and leaves in search of caterpillars. The call apparently varied. When feeding it was a sharp chirp, at other times a longer call. Munro described it as "like the creaking of a wheelbarrow, but a little more musical". Apparently the call was more discordant in lower elevation trees, and more musical among the treetops. Munro also noted, "...in a great assembly of birds the medley of sounds produced by hundreds of apapane, i`iwi and other birds produced a pleasing chorus and cheerful effect." Although I`iwi liked `ohi`a nectar, the main food was thought to be caterpillars. Nests were built of dry stems, leaves and rootlets, and some skeletonized capsules of Poha. They were usually placed in tall ohi`a trees. The feathers were used in Hawai‘ian featherwork.
Muscicapidae		Myadestes		lanaiensis		Lana`i thrush, Amaui, (olomau - molokai species)	Munro lists as Phaeormis obscura lanaiensis. Bishop Museum and Ornithological Monographs list as Myadestes Lanaiensis (family Muscicapidae). Munro quotes Wilson as noting that the Lana`i Thrush "resembles P. obscura and P. myadestina, but is smaller than either while the bill is distinctly intermediate in size between those of the two species.". The outer pair of tail feathers have slight white markings at the tip, while the abdomen and undertail feathers are nearly pure white. Top was brown. Wing from carpal joint to tip was 3.65". Lana`i thrush differed from those of the other islands in its call. The other thrushes were great singers, but the Lana`i thrush had only 2 or 3 notes which it used constantly. It inhabited the forest and frequented the low trees and underbrush. It nested in the thickest underbrush amongst ‘ie‘ie vine and staghorn fern. It was a retiring species, more often heard than seen. It ate berries and insects. Munro also reported finding a small landshell in one. The thrush had the habit of trembling and quivering its wings when approached or excited. When disturbed, it flew upward into the trees. Munro believed the Hawai‘ian name for all of the thrushes was Amaui (from Manu a Maui?). The Hawai‘i thrush was called Omao or Amaui. The Molokai thrush was called Olomau or Amaui. Munro cites as his source "the very old Hawai‘ian whom Perkins consulted".

Procellarii-dae		Pterodroma		phaeopygia		U`au, dark-rumped petrol	Only remaining Munro lists as Pterodroma phaeopygia sandwichensis (Ridg-way). Hawai‘ian name was Uau, Uaau, or Uwau. The back was a brownish slate, with darker wings and tail. The forehead, cheeks and underparts were white, and the head was black. Length was about 15.5". The call was a long drawn out u-a-u. The flight was a darting zig zag, interspersed with sailing. It nested in the mountains of all the main islands, in holes under the roots of trees and stones at elevations ranging from 1,500' to 5,000' (the latter obvi-ously not on Lana`i.). It was killed off the mongoose in Hawai‘i, Maui and Molokai. Munro believed that cats and pigs killed it on Lana`i. The eggs were glossy white and laid in April - May. The young birds were considered a delicacy by Hawaiians, and were kapu to common people, reserved for chiefs. Older birds were eaten after they had been salted. By 1944 Munro commented that it was in danger of extinction, though it seemed from his text that it was already gone completely from Lana`i.

Recurviro-stridae		Himantopus		mexicanus		Hawai‘ian stilt	Listed by Munro as Himantopus himantopus knudseni. Listed by Bishop museumas Himantopus mexicanus. not listed in ornithological monograph. Hawai‘ian names `Ae`o, and also kukuluaeo (Kukuluaeo was the word for stilts, or for a person walking on stilts. it signifies one standing high or set up like an aeo). The back and upper body are blue-black, the underparts white, the tail smoky gray, with white markings over the forehead and around the eye and long thin pink legs. The young are brown/grey above and lighter below. The length is about 16.5". The flight is flapping with legs stretched out behind. Feeds on larvae of dragon flies, small fish, worms, seeds and roots of water plants. The cry is short and sharp. The nest is a hollow in dry mud bordering shore lagoons in summer. Eggs are laid in May with 8-12 in a clutch. Eggs brown with large black spots, 1.9"x1.36", thicker at the large end, pointed at the small end, and ovoid. Adult birds are very agressive at trying to lure intruders away from nest and young.
Strigidae		Asio		flammeus		Owl	Asio flammeus sandwichensis (Bloxam) per Munro. Hawai‘ian name Pueo, probably from one of its calls according to Munro. Tawny ocraceus to buffy white, plentifully striped with dark brown. Immature birds are much darker. The birds are about 15.25" long. The Hawai‘ian owl was spread through all the islands, and numerous in open grassy country. Though a day hunter, it is more active at dusk or in early morning. It was common in the late nine-teenth century on Lana`i, but by 1944 Munro commented that its territory had been so taken over by agriculture that numbers had decreased. Nests in grass tufts in a hollow in the earth. Eggs are white and almost round. The Hawai‘ian owl eats mostly mice, but it also eats smaller birds. On Lana`i some hunted over trees in the forests, searching for other bird nests. Most Lana`i species of birds hid their nests from owls. The owl has several cries. The cries of the yound sound something like hissing, and the cries of the old can sound like a muffled dog bark. The owl will spread its wings when approached in a threatening manner. It is fierce enough with its claws that it will fight off cats and dogs.
		Thambe-tochen					

Native Birds on Lana`ihale

FIGURE 6-17 Apapane

Sixteen species of native birds have been recorded in Lana`i, not including non-resident seabirds and seasonal migrants.

Of eight species of native forest birds once known to inhabit Lana`i, the only one known to remain is the apapane (*Himatone sanguinea*). The apapane eats both nectar and insects. Its primary food source is `ohi`a blossom. The amakihi is believed extinct, but a systematic survey should be undertaken to determine status.

Lana`i also has two native seabirds, the Newell's shearwater, and the endangered Dark-rumped petrol. Dr. Fern Duvall recently found a fresh-killed carcass (cat-kill) in Kaiolena gulch while looking for *Hedyotis schlechtendahliana var. remyi* with Bob Hobdy.

Many species casualties among native birds were associated with specific ecosystem niches. The o`u was closely tied with mesic `ie`ie (*Freycinetra arborea*) forest areas. (`ie`ie is a climbing pandanus found in mesic areas) The Lana`i hookbill and akialoa were once plentiful in lowland *akoko* forest (*Chamaesyce celastroides v. lorifolia*). The i`iwi, extinct from Lana`i, was associated with endangered lobeliads. These endangered, bird-pollinated lobeliads in turn were required food for the i`iwi.

The decline of visiting sea bird populations may also have adverse impacts to the Lana'ihale forest. With loss of native trees and habitat, visiting sea birds don't come to Lana`i as much. Bird guana from these birds was thought to once have been an important source of forest nutrients in the islands. Fewer visits by these birds in turn causes diminishing forest nutrients. With diminishing nutrients, forest maintenance and recovery become more difficult. (*Source: Personal communication, Dr. Fern Duvall, 2005.*)

Various species of birds known from fossil records or historical accounts are also gone from Lana`i. Lana`i once had a flightless Ibis species, believed to have lived in Lo`ulu palm habitat. It also had a Moa nalo, a large, flightless grazing bird with a turtle-like head. The extinct Lana`i Hookbill was so fantastic looking that when it was first discovered, its authenticity was questioned. Apparently at some point in history the Hawaiians developed a pastime of sewing skins of different birds together to make fantastic creatures, and upon first discovery, the Lana`i Hookbill was believed to have been one such creation. There were also two species of flightless rail, a flightless owl, a nene and two relatives of the nene. (*Source: Personal communication, Dr. Fern Duvall*)

A list of the bird species once found in Lana`i is found in Figure 6-18 This Figure contains observations by the naturalists of the time on possible causes of extinction.

Importance of Birds In Lana`ihale

Birds serve(d) several important & specific functions in the watershed on Lana`i, including:

- direct pollination of native plant species
- seed dispersal (ex: amakihi ate fruit and insects, spread seeds in feces)
- source of nutrients (especially from sea-bird feces)

Nutrient cycles, especially as affected by seabirds, are now being understood to effect soil and plant health more than previously recognized . It is believed that a contributing cause of progressive degradation of the forest is the loss of sea birds returning nutrients to the soil via guano (Dr. Fern Duvall, referring to research by Storrs Olsen of the Smithsonian Institute).

Birds were an integral part of the pristine ecosystem, so there may have been additional functions which we would not be able to study in the absence of the system intact.

Bird Species Descriptions

A list of native birds once found in Lana`i is provided in Figure 6-19. This list was compiled from the Bishop Museum Bird Checklist, Birds of Hawai‘i (George C. Munro, 1960, 1982), and communication with Dr. Fern Duvall of the State DLNR Division of Forestry & Wildlife.

Threats to Birds on Lana‘ihale

One of the primary threats to remaining birds on Lana`i is the loss of habitat. Although threats to birds are listed below, it should be noted that the threats to plant communities listed above are also among the key threats to bird populations.

FIGURE 6-18 Threats to Birds in Lana‘i Hale

Loss of habitat	Examples, akoko, lobeliads, etc. Direct loss of food source Inadequate space to support and sustain healthy breeding populations If `ohi`a is lost, apapane would probably be lost also
Loss of native pollinators	Loss of pollinators of habitat, (birds, insects) causes threats to remaining habitat. Introduction of pest birds that eat native insects that pollinate native plants.
Introduction of pest birds	Competition with native birds for food, nesting sites. Destruction of native pollinators Introduction of bird diseases including: avian malaria (protozoan), avian pox (virus) Direct agression Examples: White eye - competes for food, nesting sites Japanese bush warbler - compete for food, nesting sites Cardinals - feed on sandalwood fruits Java sparrow

Rats, Cats	Predation. Rats & mice also eat seeds of native habitat trees & plants.
Introduction of insects	Carry avian diseases, for example, mosquitoes carry avian malaria and avian pox. Compete with native insect pollinators.
Diminished population	Remaining population sizes may not be adequate to insure sustainability. It is estimated that in order to sustain a population, there should be a minimum “effective population” size of no less than 500 pairs. By “effective population” it is meant excluding juveniles, aged, or unpaired birds. There also needs to be adequate habitat extent to support such population. In 1980 it was estimated that there were: 540 ± 213 apapane in a transect area of 20 sq. kilometers on Lana`i 15,825 ± 1,129 in a transect area of 44 sq. kilometers on West Maui 94,000 ± in a transect area of 404 sq. kilometers on East Maui

FIGURE 6-19 Problem Birds on Lana‘i

Common Name	Latin Name	Comments
Japanese White Eye	Zosterops japonicus	Competes for food and nesting sites. Present on all main islands. Common.
Japanese Bush Warbler	Cerria diphone	Competes for food and nesting sites. First recorded on Lana‘i in 1980.
Northern Cardinal	Cardinalis cardinalis	Feeds on sandalwood fruits. Present on all main islands. Common.
Java Sparrow		
Erckel’s Francolin	Frncolinus erkelii	Common.
Gray Francolin	Francolinus pondicerianus	Very Common.
Spotted Dove	Streptopelia chinensis	May feed in native forest. Common.
Warbiling Silverbill	Lonchurra malabarica	Common. First recorded on Lana‘i in 1979.
Chukar	Alectoris chukar	Very common. Introduced in 1923.

Native Insects in Lana`ihale

The Bishop Museum arthropod list contains records of 472 endemic and indigenous arthropods from Lana`i. Even this number is thought not to be complete. Bishop Museum’s checklist lists 11 extinct species, 2 Candidate 1 level species, and 25 Candidate 2 level species. No species are listed as endangered or threatened. Hobdy (‘93) estimated that 30% of insect species on Lana`i were believed to be endemic, and that roughly 10% of the native insect species in Hawai‘i were on Lana`i. Even with so many species recorded, it is believed that records for insects are lacking. A partial list of arthropod species native to Lana`i follows in Figure 6-20. Rather than attempt to provide descriptions for all of over 400 species, only those listed as candidate species or species of concern are covered.

Insect endemism is not as high as plant endemism, in part because insects can fly and are able to move between the Maui Nui islands. However, in terms of numbers of species, the majority of native species were insects. There are or were native species of spiders, wasps, flies, fungus gnats, beetles, leaf hoppers and true bugs, among others. Endemic Lana`i insects include species of beetles *(Coleoptera)*, flies (*Diptera)*, bugs *(Hemiptera)*, true bugs (*Homoptera)*, bees & wasps (*Hymenoptera)*, moths and butterflies (*Lepidoptera*), and others.

Most Lana`i insect species are very host-specific in feeding & breeding requirements, and are closely interrelated to vegetation communities (Hobdy, 1993). This means they were likely to have fulfilled many key roles in ecosystem integrity, including pollination, etc. Insects also contributed to nutrient cycle, biomass, organic material, and litter component. Native insects were often important as pollinators of specific plants, or because they provided food for birds that were pollinators of specific plants. Insects were also predators, detritivores, soil processors and wood borers, contributing to the food cycle, the breakdown of dead trees and leaves, to soil nutrients, etc.

Examples of some interesting native Lana`i insects include the Nesoprosopis bees and Pomace flies. Over 50 species of Nesoprosopis bees have been found in the islands. Dr. Sam Gon III, of The Nature Conservancy, estimates that there were about 17 on Lana`i, several of which were only found on Lana`i. Nesoprosopis bees, also known as yellow-face bees are smaller and thinner than honeybees, and more solitary. They feed on tiny flowers.

Pomace flies are one of the best examples of adaptive radiation. Over 800 species of native Hawai‘ian pomace flies have been described, and almost all are host-specific. Pomace flies are often called fruit flies, but they are actually part of a different family of insects.

Threats to Lana‘i Hale Insects

Primary threats to remaining native insect populations in Lana`i include:

- Loss of habitat such as nesting sites or food sources necessary to maintain populations.
- Introduced insects may prey on or compete with other insects, damage plants, or carry disease A few of these problem insects are desribed in the Figure 6-21.
- Many insects were brought in with cane or pineapple crops to manage insect pests, but instead turned out to be generalist and fed on native insects and plants.
- Loss of native insects in turn can equate to loss of critical habitat elements, such as pollinators or food source, for other species.
- Introduced Pathogens.

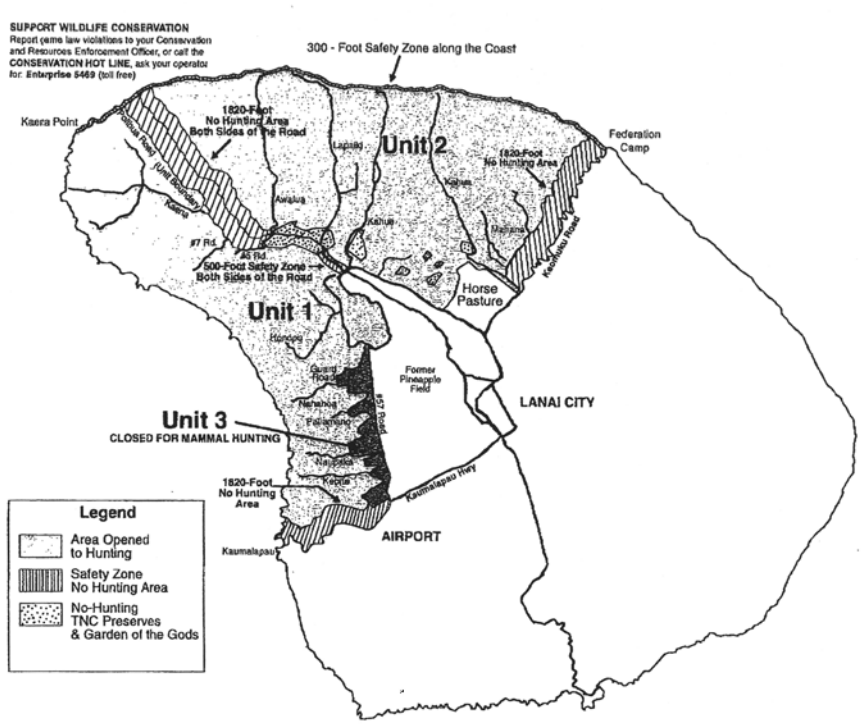
FIGURE 6-20 Lana`i Arthropods - Endangered, Proposed, Threatened, Candidate and Species of Concern

US FWS Status	Bishop L Status	Order	Family	Genus	# Spp in Genus	# Spp on Lana`i	# Lana`i Spp Listed	Species	Description
E		Heteroptera	Scutelleridae	Manduca				blackburniae	Blackburn's sphinx moth
C2	C1	Odonata	Coenagrionidae	Megalagrion	22	8	3	pacificum	damselfly - Pacific megalagrion
C8	C1	Odonata	Coenagrionidae	Megalagrion				xanthomelas	damselfly - orange-black megalagrion
SOC	C2	Archaeognatha	Machilidae	Neomachilis				heteropus	Hawai'ian long-palp bristletail
SOC		Coleoptera		Rhyncogonus				freycinetiae	Weevil, `Ie'ie rhyncogonus
SOC	C2	Coleoptera	Curculionidae	Rhyncogonus	34	3	2	lanaiensis	Lana`i rhyncogonus weevil
	C2	Coleoptera	Elateridae	Hyaleus				plebius	
SOC	C2	Coleoptera	Cerambycidae	Plagithmysus	139	4	2	lanaiensis	Long-horned beetle, Lana`i `Ohi`a beetle
SOC		Coleoptera		Plagithmysus				platydesmae	Long-horned beetle, Pilo Kea
SOC	C2	Coleoptera	Elateridae	Eopenthes	33	4	2	arduus	Click beetle , arduus eopenthes
SOC		Coleoptera		Eopenthes				plebius	Click beetle, common eopenthes
SOC		Coleoptera		Proterhinus	72				Hawai'ian Proterhinid beetles
SOC	C2	Diptera	Drosophilidae	Drosophila				lanaiensis	Lana`i pomace fly
SOC	C2	Heteroptera	Scutelleridae	Coleotichus	1	1	1	blackburniae	Koa bug
	C2	Heteroptera	Miridae	Kalania	1	1	1	hawaiiensis	
	C2	Heteroptera	Pentatomidae	Oechalia	14	2	1	grisea	
SOC	C2	Heteroptera	Rhopalidae	Ithamar	2	2	1	hawaiiensis	Hawai'ian rhopalid bug
SOC	C2	Homoptera	Psudococcidae	Phyllococcus	1	1	1	oahuensis	mealy bug - opuhe gall
SOC	C2	Hymenoptera	Colletidae	Hyaleus	60	15	11	anthracina	anthracinian yellow-faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				assimulans assimulans	assimulans yellow-faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				caeruleipennis	blue-wing yellow-faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				difficilus	difficult yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				facilis	easy yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				filicum	fern yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				laeta	laetan yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				longiceps	longhead yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				obscurata	obscuratan yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				satelles	satellus yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				volatilis	volatile yellow faced bee
SOC	C2	Hymenoptera	Vespidae	Odynerus	100	11	1	nigripennis	black-winged odynerus vespid wasp
SOC	C2	Lepidoptera	Crambidae	Omiodes	23	4	1	monogona	Hawai'ian bean leaf roller
SOC		Lepidoptera		Helicoverpa				confusa	Moth, confused helicoverpan noctuid
SOC		Neuroptera	Distolean	Eidolean				perjurus	Molokai Antlion
SOC	C2	Odonata	Coenagrionidae	Megalagrion				nigrohamatum nigrohamatum	damselfly - nigrohamatum megalagrion

FIGURE 6-21 Insect Pests in Lana`i

Genus	Species	Common Name	Description
Sophonia	rufofascia	Chinese leaf hopper, two-spotted leaf hopper	Destroys uluhe stands, `ohi`a lehua trees. Worse when plants are under stress from drought or etc. Suck the juices out of leaves, leaving yellow spots. Can stress trees to death. Typical scenario: deer move in, eat ferns and other understory, then plant is exposed and ground becomes dry. When drought hits, plants are more stressed and leaf hopper creates more damage.
Adoretus	sinicus	Chinese rose beetle	Feeds on leaves of native plants, incl. Abutilon menziesii. Affects mostly dryland and some mesic plants. Less of a problem than the leaf hopper.
		Hibiscus snow scale	Affects mostly dryland areas, and mostly Hibiscus, (including Abutilon and ilima).
		Mosquitoes	Introduce and carry avian malaria, avian pox and other diseases that destroy bird populations, some of which may have been pollinators.
		Ants	There are no native ants in Hawai`i. Ants prey on and compete with native insects for food, nest sites, etc. There have been many extinctions of native insect species due to ants.
		Yellow jackets, vespula wasps	Very predatory, and very disruptive to native ecosystems. Yellow jacket entry would be difficult to prevent, as a queen could make it from another island across to Lana`i, so measures need to include monitoring and removal.
		Small parasatoid wasps	Several types of small parasatoid wasps have been introduced. These lay their eggs in the eggs of spiders and other native insects, killing the young of native insects before they hatch.
		Black twig borer	Pest brought in with coffee. Attacks native plants. Affects dry areas and mesic areas surrounding Lana‘ihale.

FIGURE 6-22 Game Management Units on Lana'i



Existing Conservation Efforts

Existing conservation efforts include game management and monitoring efforts run by both Castle and Cooke Resorts, LLC and the State, volunteer planting efforts run mostly by the company, Rare plant exclosures supported by the Company and the US Fish & Wildlife Service, and ex situ collections of various species.

Game Management & Monitoring

The State DLNR runs hunting primarily on the north and western sides of the island, while CCR manages the south and east portions. Different hunting periods and areas are allotted for use of rifle, muzzle loader, and archery hunts. Success rates vary with animal populations, weather, hunter skill and etc. Company-run hunts include paid hunts by hotel guests, as well as resident damage control hunts on Lana'ihale, night hunts, and license hunts on former agricultural lands. Damage control hunting is sometimes undertaken around the resorts, golf courses and other infrequently hunted areas when complaints are raised. However, animal management that close to hotel grounds is generally restricted to hotel employees.

At one time, the Nature Conservancy also managed animal populations in its Kanepu'u preserve and nearby exclosures, in partnership with the State Department of Land & Natural Resources, Division of Forestry and Wildlife (DOFAW). The Nature Conservancy prepared and implemented six year management plans, funded by a TNC - State match. Management efforts included ungulate control (hunting and fencing), weed control, dry forest restoration, research and monitori ng, and fire control. Although most of these efforts did not take place on Lana‘i Hale, they did help to protect the Lana‘i Hale ecosystem.

The State Division of Forestry and Wildlife monitors animal head counts along established transects annually. These transects have been mapped using global positioning system(GPS) equipment .

State Game Management Area Units 1 & 2 are monitored together in 31 transects at half-mile intervals. CCR Management Units are monitored in 28 transects at half mile intervals. Transects taken at 40 mph along established transect routes at ½ mile intervals, flying at a relative altitude of 300 feet.

This flight path protocol provides coverage of over 1/3 of the area. Total estimated population numbers are extrapolated from these observations. Thirty percent coverage is quite good. Many U.S. mainland game management area monitoring operations are only able to fly about 1/10 of the area for their extrapolations.

Some uncertainty is inherent in any extrapolation method. However by repeating the census annually according to consistent methods and transects, this method yields fairly reliable population trend data, and may be considered a reliable indicator of whether deer and mouflon numbers are growing or decreasing.

Current Game Management Areas:

The areas outlined in green are managed by the State, and those in gold by the company. The purple and cyan areas indicate the Kanepu‘u preserve and more recent plant exclosures established by the company with funding assistance from the US Fish & Wildlife Service.

In providing information for the Tables 6-24through 6-30 on the following pages, DOFAW staff asked that the following caveat be given along with the data.. “The use of the term ‘estimated population’ is liberal. A more specific term utilized in wildlife management is “trend”, which reflects the upward or downward movement of the numbers of animals observed or projected to be observed over the given survey area. These trends, when used in conjunction with harvest data for the previous year, are invaluable in the setting of bag limits and seasons. Without prior harvest data to compare with the trends, no conclusion can be drawn as to future hunter success”.

FIGURE 6-23 Game Management Areas and Plant Exclosures on Lana‘i

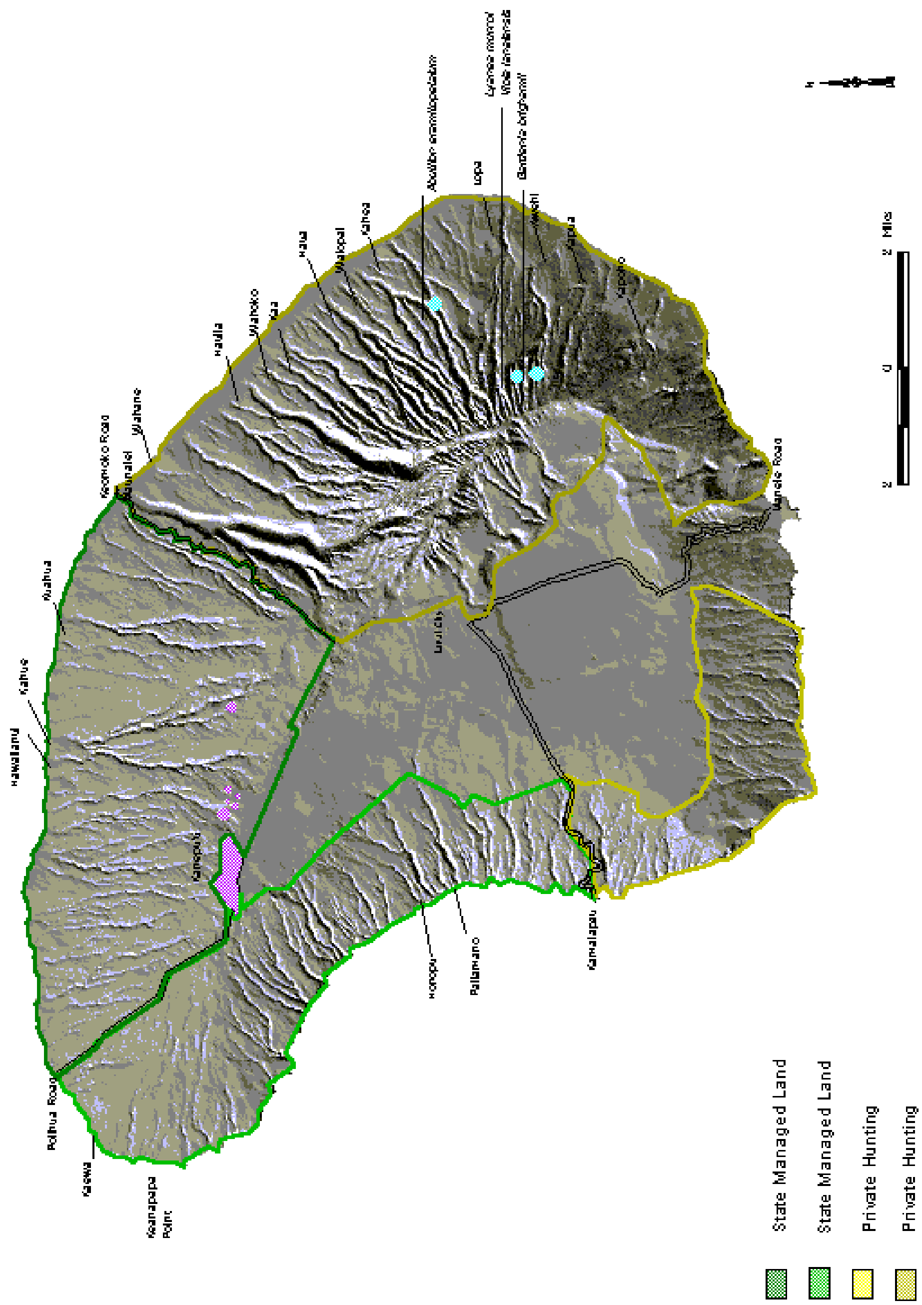


FIGURE 6-24 Lanaʻi Company Game Management Area - Deer Counts

	Buck	Doe	Fawn	Unclass	Total	Estimated Population*
1994	41	321	22	46	430	959
1995	34	323	19	60	436	972
1996	22	191	8	159	380	848
1997	39	260	9	91	399	890
1998	47	278	32	113	470	1048
1999	22	152	16	57	247	551
2000	14	134	9	71	228	508
2001	9	42	15	25	91	432
2002	9	93	7	11	120	268
2003	No Survey					
2004						
2005	38	164	13	28	243	654
2006	25	244	19	73	361	971
2007	61	351	23	136	571	1,536
2008						

(Projection Index = 2.23) Lanaʻi Company Area = 30,000 acres

FIGURE 6-25 Lana`i Game Management Area - Deer Counts in Lana`ihale

	Hale Count	General Habitat Conditions Over Entire Area
1994	55	66% increase over ‘93 Habitat dry & stressed
1995	46	Habitat dry & stressed
1996	21	Bad weather / flew 50 mph Habitat indicated mild summer
1997	28	Looked like start of drying period
1998	52	Extreme drought stress
1999	26	Moderate to severe drought
2000	34	Continued severe drought
2001	10	Prolonged severe drought
2002	17	No improvement from spring rain.
2003	No Separate Survey Data Available After 2002	
2004		
2005		
2006		
2007		
2008		

FIGURE 6-26 Lana'i Company Game Management Area - Mouflon Sheep Counts

Year	Mouflon Sheep Noted
1994	79
1995	16
1996	12
1997	51
1998	72
1999	10
2000	7
2001	11
2002	34
2003	No Survey
2004	
2005	69 Total / 186 Estimated
2006	120 Total / 323 Estimated
2007	186 Total / 500 Estimated
2008	N/A

FIGURE 6-27 Lana'i Cooperative Game Management Area - State Managed Area Counts

	Buck	Doe	Fawn	Unclass	Total	*Estimated Population
1994	111	567	59	176	913	2,438
1995	103	607	30	75	815	2,176
1996	104	537	24	116	781	2,085
1997	119	405	8	181	713	1,903
1998	108	561	101	75	845	2,256
1999	123	503	55	105	786	2,098
2001	87	363	52	174	676	1,805
2002	59	297	39	89	484	1,293
2003	51	261	30	32	374	1,006
2004	39	151	35	169	394	1,060
2005	74	359	42	84	559	1,504
2006	113	476	25	175	789	2,125
2007	93	545	20	273	931	2,512
2008						

Projection Factor: 2.67
Assumptions: buck to doe ratio applies for unclassified... but fawns are assumed equal boy/girl

FIGURE 6-28 State Managed Area - Axis Deer Hunt Statistics

	Estimated Population*	Total Harvest	Total Hunters
1994-1995	2,438	767	2,118
1995-1996	2,176	678	2,632
1996-1997	2,085	462	1,919
1997-1998	1,903	288	1,497
1998-1999	2,256	655	1,687
1999-2000	2,098	698	1,795
2000-2001	1,805	500	1,717
2001-2002	1,293	377	1,709
2002-2003	1,006	338	1,508
2003-2004	1,060	307	1,472
2004-2005	1,504	294	1,357
2005-2006	2,125	384	1,433
2006-2007	2,512	633	1,679
2007-2008		563	1,798
2008-2009		613	1,702

FIGURE 6-29 State Managed Lands - Mouflon Census

	Ram	Ewe	Lamb	Unclass	Total	Estimated*
1994	82	565	0	191	838	2,237
1995	74	617	0	57	748	1,997
1996	110	487	1	70	668	1,784
1997	156	450	1	76	683	1,823
1998	116	518	6	56	696	1,858
1999	110	525	1	6	642	1,714
2000	68	438	11	133	650	1,735
2001	68	371	15	48	502	1,340
2002	23	269	4	55	351	944
2003	50	367	5	36	458	1,232
2004	40	243	6	84	373	1,003
2005	119	535	2	56	712	1,915
2006	98	501	5	168	772	2,077
2007	189	898	1	315	1,403	3,774
2008						

FIGURE 6-30 State Managed Area - Mouflon Sheep Statistics

	Estimated Population*	Total Harvest	Total Hunters
1994-1995	2,237	722	1,727
1995-1996	1,997	435	1,192
1996-1997	1,784	293	944
1997-1998	1,823	640	1,496
1998-1999	1,858	641	1,351
1999-2000	1,714	455	1,298
2000-2001	1,735	445	1,148
2001-2002	944	396	1,115
2002-2003	1,232	441	1,108
2003-2004			
2004-2005	1,003	359	1,015
2005-2006	1,915	408	939
2006-2007	2,077	614	1,226
2007-2008	3,774	694	1,316
2008-2009		225	661

FIGURE 6-31 Observations on Habitat Conditions

	Habitat Condition
1994	Dry Summer effects showing but off-season rains helped
1995	Dry , stressed
1996	Mild summer w/off-season rains
1997	Looked like beginning of dry period
1998	Severe drought Vegetation dessicated
1999	Conditions indicated extremely dry weather
2000	Prolonged dry weather
2001	Conditions very dry
2002	Conditions same - dry with spring rains
2003	Dry range conditions
2004	
2005	Dry range conditions.
2006	Moderate drying of vegetation.
2007	Moderate drying of vegetation.
2008	Dry range conditions.

Existing Planting & Plant Exclosure Efforts

CCR runs periodic volunteer planting programs with volunteer groups and organizations such as the Lion's Club and the Boy Scouts. These are supported by the company's nursery. In recent years, the CCR Conservation Division has been expanded to include staff for regular forest management. This enables CCR to increase its efforts toward watershed preservation: weed removal, plantings, funding development and other functions above and beyond those already performed by its animal management crews.

Four exclosures exist in the Lana'i Hale and surrounding areas. These are indicated in Figure 6-9 above. The exclosures protect small populations of Gardenia brighamii, Abutilon eremitopetalum, Cyanea munroii and Viola lanaiensis. Two additional exclosures are proposed. The Puhielelu exclosure is sited to protect a variety of native plants in the Lana`ihale area, and an additional un-named exclosure is planned to protect critical wet forest habitat for certain snail communities.

Ex-Situ Collections & Reintroduction
Ex-situ collections of plants, plant tissue and seeds exist at various locations, including the National Tropical Botanical Garden & Center for Plant Conservation; the Waimea Arboretum & Botanical Garden, the Amy Greenwell Ethnobotanical Garden, the Honolulu Botanical Garden and others. Collections include Abutilon eremitopetalum, Abutilon menziesii, Cyanea macrostgia ssp gibsonii, Cyrtandra munroii, Gahnia lanaiensis, Phyllostegiat glabra var. lanaiensis, Santalum freycinetianum var. lanaiensis, and others.

The University of Hawai'i at Manoa is raising certain native snail species with the hopes that these can be re-released at some point. *(Sources: Thomas et al, Lana`i Plant Cluster Recovery Plan, 1995; and personal communication, Dr. Mike Hadfield, UH Professor of Zoology & Director of Kewalo Marine Laboratory)*

Necessary Actions

Fencing

If the Lana`i watershed is to have a realistic hope of recovery, there should be no herbivores within the protected area. This is the most important and highest priority management strategy. This has been supported as a priority, both by the peer review panel of resource managers, who reviewed various proposals and unanimously concluded that this was the most fundamental measure that needed to be taken, and by the advisory groups consulted.

Given the relative importance of this measure, several options were considered both within the Lana'i Water Advisory Committee, the Biodiversity Committee and with the public. A copy of presentation made to the public is included as an appendix in this plan. In general, options considered included fencing off either a large area of the island's northeast quarter, a somewhat smaller area encompassing the upper elevations of Lana'ihale, limiting fencing to small exclosures, or a combination of the above.

The larger fence was considered the most protective, and had various advantages such as being easier to maintain, since it was aligned along pre-existing roads on accessible, moderate terrain. This terrain would also limit fence wash-out problems. The larger fence also protected a larger slice of both biodiversity and potential recharge, benefitting more rare taxa. However, the larger fence was deemed unrealistic and overly drastic for a number of reasons. First, the community relies extensively on hunting in Lana`i, and it was thought that this fence would have an adverse impact on local residents. Also, some of the very advantages of the fence, were also disadvantages. Its accessibility would make it prone to vandalism and breakage, and its large extent would make it more of a monitoring and repair task. Finally, it was felt that the area to be enclosed was too large to realistically manage right from the beginning, and that if such a fence were ever to be built it would have to be with community support, built after time and a track record of success with a smaller project.

Exclosures and smaller fence areas were considered, but this postage-stamp model was rejected. While exclosures for enhanced protection of the most rare species may still be necessary outside or even inside a larger fence, exclosures alone would do little to protect the watershed. However, exclosure fences were still considered appropriate for certain areas. Where utilized, it is recommended that these be a mininimum of 50 meters (about 165') away from nearest target plant.

The selected fence was the one enclosing Lana‘ihale. This was selected because it both protected the key recharge area of Lana‘ihale as well as many of the more critical plant species, had lower impact on hunters, and achieved community buy-in more readily. The following pages further describe the fence options considered by the advisory group and the public.

Consideration was also given to survey of proposed fence lines to insure that no rare or endangered communities of insects, snails, plants or other native flora or fauna would be harmed. This was done for Increments I and II, although there was some discussion as to whether such surveys were sufficiently thorough. The same should be done for Increment III.

The fencing option chosen was option # 4 in Figure 6-23 and Figure 6- 10. This was subsequently modified to allow for construction in phases. A map of the current alighment is presented in Figure -6-11.

FIGURE 6-32 Fenceline Options Discussed with Panel of Experts and With Community

Option	Enclosed Acreage	Miles of Fence	Cost to Insstall Est.	Advantages	Disadvantages
1 - Keomoku	32,055	13.9	410,000	Protects largest area fastest, Protects more plant communities , Cheapest per area protected Easier maintenance on roads	Large impact on hunters, Exposure to vandalism
2 - Keomoku2	26,555	14.7	450,000	Protects large area more plant communities Cheap per area protected easier maintenance on roads	Large impact on hunters Exposure to vandalism?
3 - “Old Pipeline”	22,807	23	1,100,000	Pprotects large area more plant communities Cheap per area protected	Large impact on hunters, Exposure to vandalism, Low side expensive to maintain Cost per area higher
4 - “Fish”	3,588	12.1	680,000	Protects critical recharge area, Less impact on hunters	Cost per area a bit higher, Protects less plant communities
5 - “½ Fish”	1,835	11.5	400,000	Least impact on hunters	Will not protect key area Protects few plant communities Cost per area a bit higher
6 - No Fence - Eradicate	N/A	0	N/A	Most protective option Less on-going maintenance	Largest impact on hunters
7 - No Action	N/A	0	N/A	Least short-term investment	Loss of recharge Loss of Lana`i biodiversity
8 - Phased 1 -Exclosure 2 -Keomoku 3 -Makaiwa	Step 1 - depends Step 2 - Step 3 -			On second page of Figure 6-10. Protects largest area long term More plant communities protected.	Large impact on hunters Delays to step 2 could result in loss of everything beforefence is built Most expensive program
9- Modified Phased	1- “Fish” 2 - add selected gulch(es) / a’apuaa			Protects larger area than fish Protects down to sea along at least one or two gulches Less impact on hunting than larger options	Higher cost than most options Larger impact on hunters than fish or ½ fish
10 - “Big Fish”				Following road below bench field on SW for top of fish Would make that end less $ / / ft enlarging bottom somewhat wld include major snail and seabird colonies, still less impact on hunters than larger options.	High cost and difficult terrain on lower half. less protective than larger options. Still does not protect all ecosystems.

Source Water Protection

FIGURE 6-33 Fencing Options Considered - Presented Left to Right In Order of Figure Above

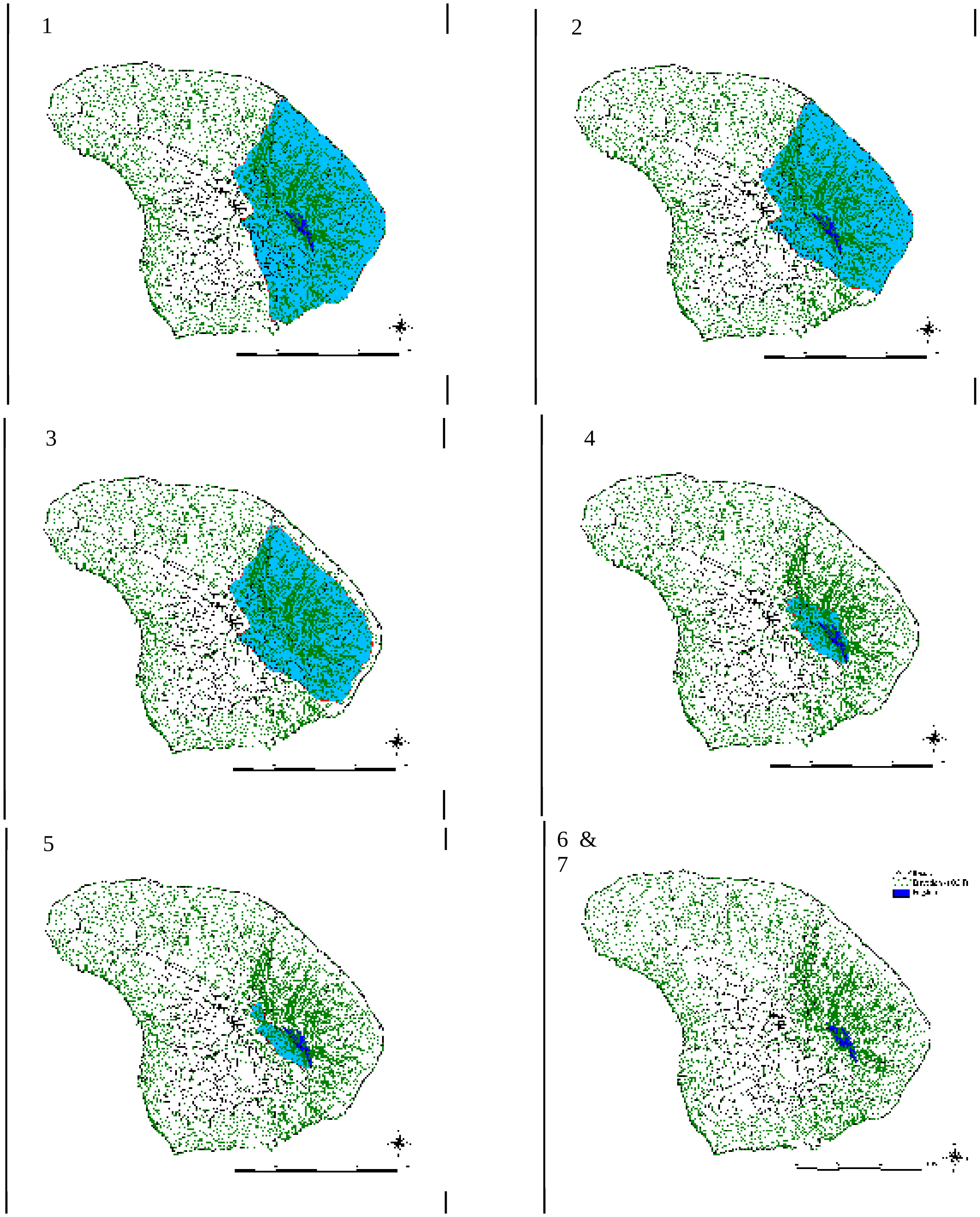
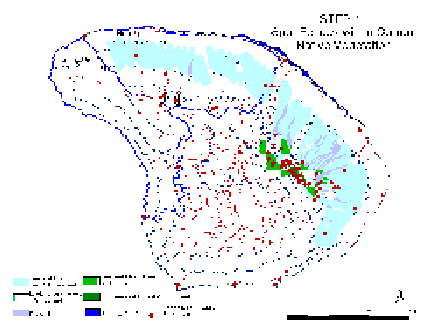


FIGURE 6-34 Fencing Options Considered - Continued

8 a



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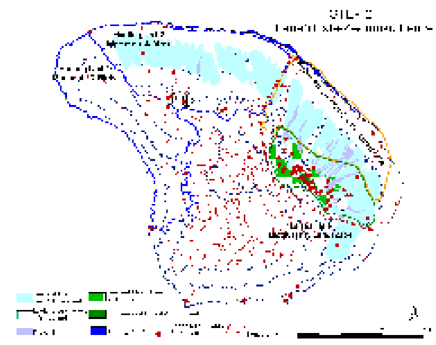

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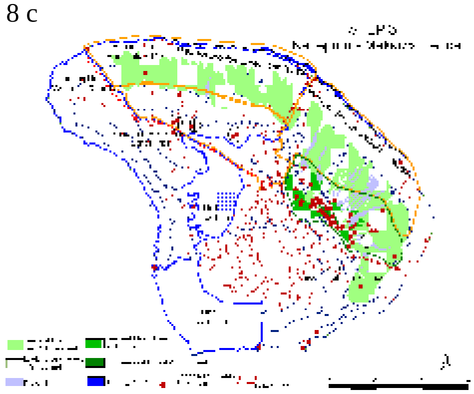

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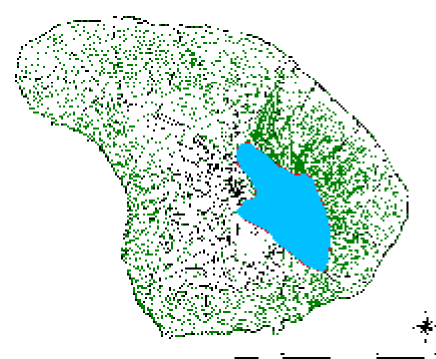

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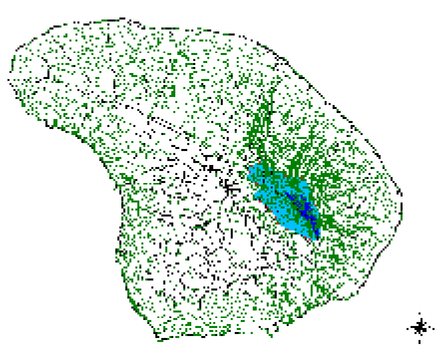


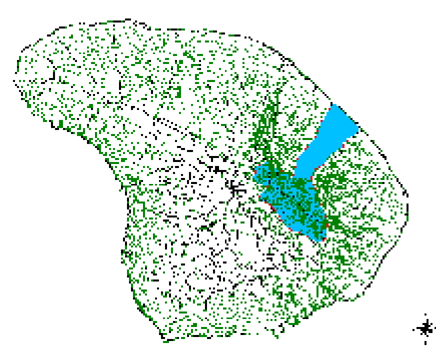
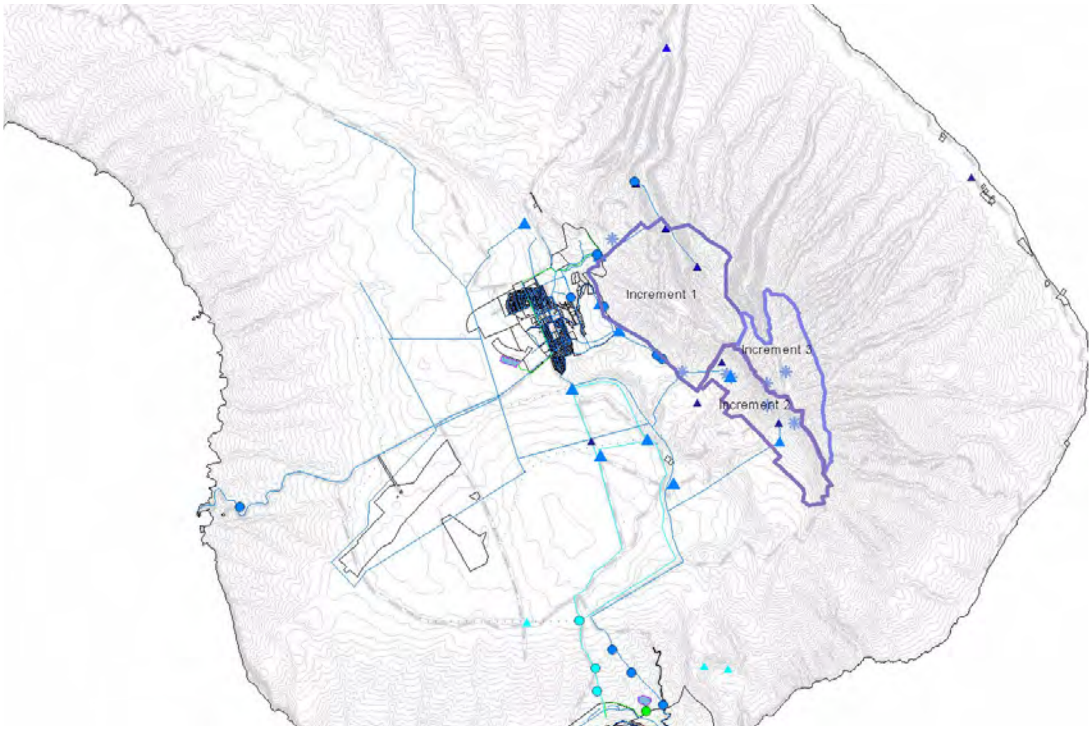


FIGURE 6-35 Current Alignment and Increments of Fence



Watershed Skybridge

Committee members received written testimony on watershed management considerations, and in response to certain unknowns and potential controversy, the committee also took the unusual step of convening a “skybridge” multi-island conference call between forest experts on Oahu, Maui, & Lana`i to receive further testimony and allow experts to discuss issues (One Big-Island expert was kind enough to be present in Oahu also) .

The results of this conference were unequivocal. Fencing was the measure of primary importance, without which all other measures were likely to fail. In further discussions, the Lana‘i Water Working Group / Lana‘i Water Advisory Committee determined that the issue was important enough and had enough potential to effect subsistence hunters and others, that a series of public informational meetings and discussions should be held.

The results of the public meetings were broad acceptance of the fence as a necessity. The community collectively has great concern for the health of its water systems.

Additional Measures

The Lana‘i Water Advisory Committee had many long discussions about how best to protect the watershed. Fencing was clearly considered the most important management measure, but it was not the only one deemed important. Additional measures are described below.

Fencing and other management must be performed in concert - i.e. fencing must be backed up with management of animal populations, appropriate weeding activity and so forth. The LWAC spent some time going over probable cost items, such as survey, herding hunting, ammunition, campsites, shelters, training, liability, and most importantly construction of the fence.

Removal of feral ungulates from inside fenced areas

LWAC agreed on the protocol of hunting to elimination within fence for protection of watershed, but maintaining managed populations outside of the fence for food and sport. Residents were to be the first allowed to hunt within the fence - followed by ongoing staffed hunts if needed. The possibliity of a non-kill herding effort, using men on foot, helicopters, spotlighting and so on to move deer out of the fenced area before it was sealed was also discussed. Once completed, if hunting proved unsuccesful in a given area within the fence, snares, traps or any other means necessary would be used to complete elimination, especially in remote areas. Other means discussed included repellants, non-forage distasteful plants, along buffer strips and other possible means to discourage deer or sterilization, capture and transport, or other non-lethal means of controlling them. At the time it was deemed that none of the alternate methods in literature had been sufficiently developed to be both practical and safe for consumers of hunted meat, nor would they have the necessary impact on populations in time to save the watershed.

Management of Feral Ungulates Outside Fenced Areas

Lana‘i has an unusually active contingent of subsistence and food hunters. In respect for these community values, consideration was given to possible enhancement of hunting outside of the fence to make up for opportunities that could be lost by elimination of deer within the fenced area. Provision of water or salt licks was discussed, but ultimately rejected as having the reverse effect on populations than was desired.

Fire Protection

Lana‘i Hale plants are not well adapted to fire. Some of the more prevalent and invasive weed species found on the hale are fire inducting. The Lana‘i Hale watershed is susceptible to fire, and fire could damage recharge on the island. For this reason, once the fence is in and animal management is showing results, it was deemed important to take certain precautionary measures:

- Survey susceptible areas, including lands taken out of pineapple to identify ways of minimizing fire risk
- Create firebreaks in key areas to prevent spread of fires.
- Create buffer zones to prevent spread of fires to important areas.
- Designate fire-free zones for human use to prevent indadvertent start of a fire.
- Remove, control and /or eradicate fire-inducing weed species as much as possible. At the very least, remove them from the most sensitive areas.
- Prioritize measures to protect areas where small populations mean that a single catastrophic fire could eliminate all remaining population of a species. (Ex. Tetramolopium remyi)
- Heighten public awareness of the dangers and implications of fire. Not just immediate destruction, but potential for longer term loss of recharge.
- Develop a prioritized species response plan, to mitigate damage in the event of a fire (protecting rarest species first).

- Inventory equipment necessary to protect the Lana‘ihale from fire and to protect it during a fire. Obtain necessary emergency equipment and /or seek funds to make this acquisition possible (helicopters/strategically placed reservoirs, water trucks, etc.).
- Provide training for Conservation staff and fire fighting staff on special needs within the Lana‘ihale area, and on response plan priorities.

Removal of Non-desirable Species

- Certain weeds diminish the forest’s ability to recover after disturbance. Identify and remove such weeds.
- Certain rodents and other small animals also impair the forest’s ability to recover from disturbance. This can be especially so during the fruiting or seeding time of threatened or endangered native plants. Remove rodent species likely to feed on native plants.

Protection of Sensitive Desirable Species

- Ferns, mosses, lichens, native birds, snails, and certain plants are very sensitive to disturbance. Communities and individuals of sensitive species should be identified and protected.
- Prevent trampling by spreading populations of feeding ungulates
- Prevent invasive weeds or remove them before they become established
- Take measures to reduce erosion.
- Develop a fire, prevention response and prioritization plan.
- Construct exclosures to protect sensitive species where approrpriate.

Monitoring, Mapping and Documentation

- Establish regular transects, using standard methods (point-line intercept or etc.) to monitor the status of target communities, and effectiveness of control measures.
- Perform scheduled field checks and document results.
- Perform additional checks after unusual events, catastrophes, etc. to see what changes have occured in target communities and identify mitigative measures necessary.
- Map monitoring plots, size and class of plants inside each plot (desirable and non-desirable).
- Maintain photographic documentation of plots - especially plant communities - to monitor recovery or loss.
- Establish water and soil moisture gauges to evaluate and track habitat characteristics and quality.

Control Incoming Species

- Establish adequate screening and quarantine for incoming agricultural goods and plants.
- Educate public, landowners, hunters and hotel guests about the dangers of exotic species, potential contaminants, etc.
- Set up procedures to avoid introduction of non-desirable plants and plant pathogens

- set up procedures to avoid introduction of non-desirable insects or insect pathogens

Eliminate or Mitigate Insect Pests

- Identify species to target for elimination, such as chinese rose beetle, chinese leaf hopper, and others.
- Determine protocols, spraying or other schedules, necessary equipment, etc.

Restore Native Populations of Insects, Forest Birds, Sea Birds, Snails, etc.

- Restoration of native species has several benefits for general forest health. Among these are the restoration and improvement of the natural nutrient cycle of the areas soils, establishment of a healthy litter layer, etc.
  - Native snails and insects evolved to be suitable with native plant communities. They also provided important quantities of biomass, nutrients to soils.
  - Sea-birds provided nutrients such as nitrogen, phosphorous, etc. in the form of guano.
  - Some native insects aid in decomposition and soil amendment.
- Restoration of native insects and birds helps to restore and improve pollination opportunities. Forest birds and insects provided important pollinators, the loss of which can exacerbate loss of forest plants.

Control Erosion

- Select realistic / effective areas for management
- Eliminate animal stresses that perpetuate the erosion cycle
- Establish strategic plantings to prevent soil loss
- Construct wattles or other soil trapping devices
- Establish native plants on newly trapped soil
  - Mycorrhizal inoculants can aid the establishment of outplanted seeds
  - Can outplant species grown ex situ.
  - Can broadcast seeds

Protect Species Prone to Gathering By Humans

- For example, sandalwood, due to its high economic value, was subject to removal by individuals seeking the heart wood. Identify species which are likely to be tampered with, and take effective measures to protect them.

Identify Plant Pathogens or Diseases of Concern and Take Measures To Protect Native Plants:

- Using the example of sandalwood
  - “Spike disease” - harmful to sandalwoods in India, believed to be in HI
  - Santalum seed fungus - destructive to viability of seeds (sandalwood)
  - Santalum heart rot

  - Possibly others
- Inventory disease problems affecting key species, as well as known management strategies.
- Enhance quarantine & inspection of carrier plants to prevent further introduction of problems.

Internal and Peer Review of Management Plans to Prevent Problems

- Even forest management experts can overlook protective measures or even adverse impacts of protective measures. Once a management plan is drafted, review it internally and invite outside experts to peer review, to eliminate possible ommissions or errors or identify necessary precautions.
- Examples of such errors can include:
  - fencing without adequate monitoring,
  - fencing without weed removal
  - over collection of seeds
  - damage or spread of pathogens by incorrect collection of tissue cultures,
  - careless management on part of humans (human trampling, unmonitored actions, etc.)
- Include proper forest entry practices in all management work.

Collection and Maintenance of Genetic Material

- Seeds, live plants, and plant tissue from threatened areas can be preserved and /or propagated in ex-situ populations. Curators of such collections should take care to avoid in-breeding or cross contamination of genetic material with other variations of a given species. Collectors of seeds or plant tissues should avoid the collection of genetically weakened specimens.
- Ex-Situ Collections - certain plant seeds and individuals exist in collections by
  - National Tropical Botanical Garden,
  - Waimea Arboretum & Botanical Garden
  - Amy Greenwell Ethnobotanical Garden
  - Hawai‘i Plant Conservation Center

Selective Augmentation and Re-introduction of Species from Existing Populations or Ex-situ Collections

- Avoid cross breeding or cross contamination of genetic material.
- Be sure plants have been properly collected, and seed sources appropriately identified.
- Be careful to avoid cross contamination in nurseries or germination media, and exposure to some plant materials.
- In preparation for outplanting, care must be given to proper handling, equpment and training.
- Once out-planted, care must be given to plant care and maintenance until established.

- Survey out-planting sites in advance.
- Prepare necessary protection, possible exclosures, monitoring & maintenance schedules and plans for out-planting sites.
- If necessary, construct camp sites or shelters in advance.

Additional Research on Targeted Plant Communities

The following additional research has been identified as desireable for target plant communities.

- Associated ecosystem components
- Relations between native plant communities / birds / insects (pollination, feeding, etc.)
- Critical habitat size / population size for species viability
- Growth and mortality at various stages of plant life, seasonal changes
- Optimum conditions for reproductive vitality, flowering/seeding conditions
- Light requirements at various stages of life
- Water, soil & nutrient requirements at various stages
- Pollination vectors, seed dispersal
- Means to compensate for missing pollination vectors or other keystone habitat concerns
- Minimum numbers needed for populations to be stable
- Susceptibility to inbreeding

Management Recommendations to Preserve Native Birds

- Protect habitat - including steps to preserve plant communities, snails, insects, etc.
- Prevent predator entry - adequate quarantine, fencing, baiting predators, etc.
- Remove rats and cats from native bird habitats - catch, bait, etc.
- Prevent entry of non-native birds - (avoid disease, competition)
- Prevent entry of mosquitoes and other problem insects
- Control mosquitoes at breeding sites - insecticides, sterilizers, introduction of sterile or non-carrier mosquitoes
- Specific strategic management of existing seabird colonies for enhanced protection.
- Construct feral ungulate fencing in such a way as to avoid harming native bird populations.
    - fence must be visible to prevent birds from crashing during night landing
    - white flagging or tape on top can help
- Establish rat, cat and other small mammal control within the watershed.
- Consider carefully managed re-introduction programs for amakihi, i`iwi, maui creeper, others
- Preserve Lana`i specific genetic material
- Consider minimum habitat size for sustainability of bird populations in deciding fence or othe rmanagement options

Benefits of Protecting Remaining Bird Species and/or Restoring Bird Populations:

- Birds serve(d) specific functions in the watershed on Lana`i
  - direct pollination of native plant species
  - seed dispersal (ex: amakihi ate fruit and insects, spread seeds in feces)
  - source of nutrients (esp from sea-bird feces)
  - possible additional non-identified roles, as birds were integral part of ecosystem
- Rare native plants would benefit from having native pollinators and spreaders of seeds restored.
- Nutrient cycles, especially as affected by seabirds, are now being understood to affect soil and plant health more than previously recognized (*Source: Personal communication with Dr. Fern Duvall descrbing paper by Storrs Olson of Smithsonian, indicating that one of the changes in the forest could have come about by loss of sea birds returning nutrients to soil.)*
- Encourage sea birds to return by establishing safe, predator-free sites for them
- In order to successfully maintain existing apapane and seabird populations, and /or to restore previously existing species with close approximations (Maui equivalents) - adequate disease free habitat extent will be required.

Management Recommendations to Preserve Native Snails

- Preserve native snail habitat, especially the upper elevation Lana‘i Hale forest.
- Encourage reforestation with native species, as many non-natives, including Cook pine and Eucalyptus, are not good hosts for native snails (although snails have been found on some non-native plants where they are intermixed with natives). (*Source: Personal communication, Mike Severns*)
- Establish and enforce a ban on collecting.
- Educate the public on damage caused by collecting.
- Eliminate predation by rats and other animals..
  - Construct exclosures to protect snails from predation.
  - Exclosures for snails are roughly waist high. They are constructed of painted, corrugated aluminum roofing. A trench is dug, and in that trench the fence is installed with its foot buried about 6" into the ground, at the top of the fence is a shed-like “roof” that protrudes to either side. Under that “roof” are two additional barriers, a trough of large crystal salt, and a 2-wire electric fence, constructed of two thin wires spaced 8mm apart. The electric wires are powered by solar panels mounted on the inside of the exclosure.
  - The largest such exclosure currently existing is about 40x25 meters.
  - Rat bait boxes may be placed on the outside of the exclosures for further protection
  - Tree limbs and other branches should be prevented from touching the fence exclosure structure , as they may provide a path for predators

- Prevent or eliminate predatory snails, as applicable
- Prevent entry of non-native snails & slugs to avoid possible introduction of diseases
- Snails may be subject to captive rearing and reintroduction as appropriate.
- CARE must be exercised in designing control of slugs.
  - Slugs don’t generally hurt snails, but there are no native slugs in Hawai‘i, and there is some chance that they could be a source of introduced disease. (Source, Personal Communication, Dr. Hadfield)
  - Any poisons designed to eliminate slugs would also be likely to affect snails.
  - If any poison or bait were used to control snails, it should be limited to extremely LOCAL applications in areas where it was fairly certain no native snails were present.
- Consider careful removal of non-native plant species where appropriate, and replacement with native species. (This measure requires exercise of care to insure that no snails are sitting on the plants to be removed).
- Some species of native snails seem to be adapting to certain introduced plants. In cases where this has occurred, consider selective use of non-native plants that the snails are adapting to.
  - Partulina variabilis
  - Partulina semicarinata

Management Recommendations to Preserve Native Insects

- Protect native habitat on which native insects rely, especially host plants.
- Eliminate non-native predator insects, especially yellow-jackets and ants.
  - Establish pheremone traps for predators.
  - Find and destroy nests with freezing or insecticides
  - Bait ?
- Develop improved quarantine measures and other controls to prevent entry of non-native insects
- Monitor native insect populations to determine species requirements, critical habitat, population size, etc.

Other Prevention Protocols

Through wind dispersion and other means, plants introduced in only a few sites well outside the watershed can and do spread to the watershed.

- A database of cultivated and naturalized non-native species on the island of Lana`i should be developed through survey of nurseries, botanical gardens, parks, hotel and other public landscape and other likely introduction sites.

- The best predictor of invasiveness for most taxonomic groups is a record of invasiveness in similar climates elsewhere in the world. The databases of historically invasive plants and non-native plants present in Lana`i should be cross-checked to identify species of concern.

- A series of species reports should be developed for targeted species, summarizing both literature and field research, and include results fromGPS data collection and distributional mapping, as well as information on attributes of other invaded ecosystems, control data, and so forth. A protocol for obtaining and structuring such information has been developed and implemented in Maui.
- Many of the key corridors by which invasive alien species are introduced are not the same areas where active management transects are located. Efforts need to be directed toward monitoring likely introductory routes such as roadsides, parks refuse sites, vacant lots, harbors, airports and residential areas.
- Through active identification efforts, plants may be detected at earlier stages of naturalization, or even prior to naturalization, avoiding widespread damage.

Education of Land Owners, Residents, Guests, Hunters

- Rare plants and their value
- Importance of watershed / importance of biodiversity
- Non-desirable plants and the threats posed by them
- How to enter the forest and other sensitive areas while causing minimal risk of doing harm
- Dangers of open flames, especially. in certain areas
- Plant walks outside critical areas

Legal & Regulatory Protections

- "It is illegal to remove, cut dig up, damage or destroy an endangered plant in an areas not under Federal jurisdiction in knowing violation of any State law or regulation or in the course of any violation of a State criminal trespass law (ESA §9(a)(2))
- Hawai`i State law prohibits taking of endangered flora aand encourages conservation by State governement agencies. "Take" means to harass, harm, collect, uproot, destroy, injure or possess endangered species of land plants, or to attempt to engage in any such conduct (HRS 195D-5(d))

Enforcement of Protective Measures

- Make effort to discourage and enforce prohibitions on collection of special species.
- Limit and or manage access to critical areas, as well as activities within those areas.
- Enforce proper forest entry practices for those who do enter.
- Ensure that any uses in sensitive areas are compatible with protecton goals .
- Maintain a regulatory presence in the watershed, manage public activities and education.
- Obtain assistance from agencies or other partnerships if needed.
- Develop a recreational use plan for guiding human activities in the watershed without damage to sensitive areas.

Community Outreach

- Educate the public regarding
  - Importance of watershed
  - Importance of Biodiversity
  - Plants of concern
  - Appropriate forest entry practices
  - Field volunteer training
- Establish a workshop and lecture series
  - Uses of plants in native culture
  - Value of native resources
  - Importance of watershed and connection with native vegetation
  - Plant, animal and bird identification
  - Threats and long term effects of unabated threats (Rapa Nui lesson)
- Solicit community input and partnering
  - Link w/ other environmental agencies and groups. Develop partnerships.
  - Create a pool of docents
  - Develop a guided hike program
  - Offer field trips to biological and cultural sites.
  - Utilize trained docents from partners as leaders.
  - Provide them with / partner to develop prepared informational materials
  - Partner to ensure adequate vehicles and logistical support
- Prepare interpretive materials for use in both community and by visitors
  - booklets, pamphlets
  - web sites
  - public access programs
  - develop native resources curriculum for the schools
- Identify and implement volunteer projects
  - Weed control
  - Restoration activities - outplanting, nursery, maintenance, erosion control
  - Fence building and repair
  - Hunting
  - Construction of wattles to retain soil
- Communicate progress
  - establish media contacts for coverage of projects both local and statewide dissemination

- regular means of communicating relevant information to the community
- utilize existing community special events as venue for promoting education and increasing viability of projects:
  - Aloha Festival
  - Health Fairs
  - Pineapple Festival
  - Other Cultural Events
- Develop and implement long-term alien species awareness and prevention program
- Seek grant funding to develop a video
- Develop a tie-in with the local business community

Coordination with Existing Conservation Efforts

- CCR
  - Some managed hunting and effort to reduce deer on the hale
  - committing funds and developing activities to manage invasive species on Hale
- USFWS
  - ecosystem conservation planning efforts / ongoing work projects
- DOFAW
  - game management areas
  - monitoring census
  - fencing projects on hale and elsewhere
  - endangered petrel project
  - helps to fund Kanepu‘u through NAPP
  - Considering re-intro of nene in conjunction with Hui Malama Pono O Lana`i?
- Kanepu‘u Volunteers
  - Community workdays and volunteer projects in Kanepu‘u
- Maui County BWS
  - WUDP, Lana‘i Water Advisory Committee process
- Certain plant seeds and individuals in collections by
  - National Tropical Botanical Garden,
  - Waimea Arboretum & Botanical Garden
  - Amy Greenwell Ethnobotanical Garden
  - Hawai‘i Plant Conservation Center

FIGURE 6-36 Partial Implementation Matrix - Watershed

Feral Animal Control -	Fence			
Action	Why	By When	By Whom	Cost Estimate
Obtain funding for fence Increment III, or establish rate structure to cover it.	Up-front capital expenditure too great for one entity	within next two years	CCR	$900,000
co-fund grant sources	up-front capital too great for one entity alone - but company will bear partial cost with help from public sector	within next two years	CCR	
Interim - determine whether / where exclosures need to be built while awaiting funds for fence	for some species, the time it takes to obtain public funding for large-scale fence may prove too long...this question needs to be examined and considered	begin immediately determination within 6 months - begin construction for key areas as soon as identified	CCR, DOFAW, LF&WP	Depends upon need.
Survey fence-line	identify best route, potentially affected communities, etc.	within 6 months of funding approvals	CCR in conjunction with DOFAW, US F&WS	Should be included in estimate above
Construct fence	major threat to remaining watershed and other ecosystems is deer	by schedule to be developed but w/in 2 yrs of funding	CCR with help from partners and agencies as needed.	Should be included in estimate above
Maintain Fence and surrounding buffers	without proper maintenance, fence will not work	entire fence perimeter should be checked ... (semi-annually?) to insure integrity	CCR crew	$100,000 per year crew to maintain materials for repairs vehicles, equipment, etc. should also cover some of related expenses
Small exclosures w/in fencelines for snails, seabirds, etc.	target specific areas: nesting sites, known communities, etc.	Can begin inventory of desired sites now, build as indicated	CCR with help from DOFAW, biodiversity committee, etc.	same public / private mix?
Feral Animal Control -	Animal Removal			
Manage Hunting inside and outside of fenced area	hunt to elimination inside fence. This may have to include judas-deer, night hunts, use of lights, use of snares or traps, etc. Manage hunting and access outside of fence	on-going elimination of deer inside fence to begin immediately upon completion of each fence increment.	CCR w/ help from DOFAW, public hunting groups, etc.	part of CCR budget (100,000 per year).
Determine whether deer repellant, non-invasive plant species that taste bad to deer, or other additional measures are desirable to add insurance to buffer zone along outside of fence	additional means of controlling deer may not be adequate by themselves, but may help to enhance the effectiveness of fencing	periodic update of recent research.	DOFAW, Lana`i Co., LWAC, Hui Malama Pono O Lana`i, etc.	Part of other proposed budgets? If desired, planting can be part of volunteer program ?

Determine & implement appropriate predator removal strategies, and implement on-going (rats, cats, etc. - prey on birds & seeds) baits, traps, buffer zones around exclosures, (for ex. see snail exclosure fence design in text)	rats and cats prey on native birds, rats also eat seeds of native plants this may involve controversial issues such as baiting, trapping, etc. Look for repellants too?	within 5 years	DOFAW, CCR. and LWAC	CCR. forest management budget..)
Feral Animal Control -	Monitoring			
Monitor deer & sheep populations maintain regular transects, scheduled field checks, additional checks after unusual events, etc.	determine effectiveness of measures	annually	DOFAW & CCR with enhanced communication with company.	DOFAW & CCR
Fire Protection				
establish fire protective measures:	fire is major threat to watershed and to habitat of all remaining species.	can be started immediately, regardless of fence status	DOFAW, Fire Dept., Company, LWAC, Kanepu'u group, Boy Scouts, others?	CCR. forest mangement budget...
Inventory worst risk areas				
Fire breaks & Buffer zones				
Remove fire-inducing weed species				
Inventory & obtain emergency equipment as needed				
Develop prioritized response plan				
Develop and implement education program			Volunteer Assistance?	
Weed Removal				
Selective removal of non-desirable plant species - prioritize & implement fire hazard weeds invasive weeds listed elsewhere in report	reduce threats of fire, habitat loss, erosion, etc.	immediately and on-going	CCR DOFAW Volunteers Assistance from LWAC? Assistance from Hui Malama Pono O Lana`i?	On-going CCR. annual budget? (part of $100,000 K annual?) Additional assistance to be sought from Fed, State agencies?
Insect Mitigation				
Mosquitoes identify promising methods (eg: enhanced quarantine measures, selective spraying at breeding sites, or selective intro of sterile or genetically non-avian-disease carrying mosquitoes to reduce threat of avian malaria, pox, etc.) -	reduce threats to pollinators, plant species	efforts can begin immediately & continue indefinitely	CCR. with assistance from DOFAW, Dep't of Ag, others?	ongoing budgets of listed agencies? additional assistance to be sought in over-all grant request?

Yellow jackets locate nests eliminate with freezing or insecticides	powerful predators on native insects	efforts can begin immediately and continue indefinitely	CCR. with assistance from DOFAW, others	ongoing budgets of CCR and DOFAW?
Mitigate Human Impact				

Enforce bans on collecting native species, snails, seeds, etc.	reduce loss of threatened species	immediately and on-going	CCR, DOFAW, others?	ongoing budgets of listed agencies?
Education on proper forest entry				
Education on Watershed values				
Improved Quarantine & Inspection Protocols	Prevent entry of birds, insects, pathogens, plants	Review can begin immediately Implementation depends upon review	Dep't of Ag, DOFAW, USGS-BRD can review	?
Erosion Control				
Strategic Planting				
Wattles, Other Soil Trapping				
Animal Mgmt				
Reintroduce/Augment	Selected Species			
Bird Pollinators				
Native Plants				
Others?				

CHAPTER 6-B

Wellhead Protection

Wellhead Protection Project Summary

The Maui County Department of Water Supply (DWS) is working with stakeholders, private water purveyors and land owners to develop a wellhead protection program for Maui County, which includes Moloka'i and Lana'i. The goal of this project is to establish effective wellhead protection through implementation of a local ordinance aimed at reducing` the risk of contamination in drinking water wells from potential contaminating activities (PCAs). The national Wellhead Protection Program was established under the 1986 Safe Drinking Water Act (SDWA) amendments. The law specified that certain program activities, such as delineation, contaminant source inventory, contingency planning and source management, be incorporated into state Wellhead Protection Programs, which are approved by EPA prior to implementation. State Wellhead Protection Programs vary greatly. Some states require municipal water systems to develop management plans. The State of Hawaii Wellhead Protection Program was approved by EPA-in 1995. The program provides guidance for development of protection measures but does not require local implementation. The SDWA Amendments of 1996 required states to develop and implement source water assessment programs (SWAPs) to analyze existing and potential threats to the quality of the public drinking water throughout the state. DOH has completed a SWAP report for Lanaʻi Company's wells. The report is still under revision. With the support from DOH, DWS continues to develop and implement a Wellhead Protection Program for the DWS water systems, and a protection incentive program. DWS has collected data followed by field surveys of wellhead protection areas (WHPAs) for Lanaʻi Company wells in preparation for future protection efforts. A first report was drafted for Lanaʻi in May 2004. This report serves as an update through addition of suggested protection strategies. DWS has drafted a county-wide ordinance based on strategy plans and input from stakeholders for continued review.

In summary, the Wellhead Protection Project consists of the following tasks:
Delineation of Wellhead Protection Areas (WHPAs). Land areas that could contribute water and pollutants to the water supply were mapped by University of Hawaii Water Resources Research Center as part of the State Source Water Assessment Program.

A review and documentation of the range in wellhead protection that is undertaken by utilities, counties, cities, districts and state agencies in the U.S. The research included the collection of 59 references and the preparation of an annotated bibliography. Programs and ordinances were reviewed and annotated, followed by a questionnaire to help evaluate the efficiency of each program.

Wellhead Protection

An inventory of land uses and PCAs in WHPAs. Land uses, facility type, nature of activities and site specific information were documented and mapped in GIS.

An inventory of contaminants typically associated with identified PCAs. Potential and confirmed contaminants are documented in databases, including descriptions of the environmental transport characteristics and toxicity.

Identification of best management practices for pollution prevention of PCAs, including checklists for public education

A review of the land use control structure and ground water protection programs in effect in Maui County.

With public participation, develop a wellhead protection strategy for Maui County. The Water Advisory Committees on Maui, Moloka'i and Lana'i have voiced support for an overlay zoning ordinance. DWS continues to solicit public input and participation throughout development of the Wellhead Protection Program.

Acronyms

AST	Above ground storage tank
BMP	Best Management Practice
CERCLA	Comprehensive Environmental Response, Compensation, And Liability Act
CWA	Clean Water Act
CWRM	Commission on Water Resource Management
DWS	Department of Water Supply
DOH	Department of Health
EPA	U.S. Environmental Protection Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HAR	Hawaii Administrative Rules
HISWAP	Hawaii Source Water Assessment Program
HRS	Hawaii Revised Statues
NPDES	National Pollution Discharge Elimination System
PCA	Potential Contaminating Activity
PUD	Planned Unit Development
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SDWB	Safe Drinking Water Branch
SHWB	Solid and Hazardous Waste Branch
SUP	Special Use Permit
SWAP	Source Water Assessment Program
TSRA	Toxic Substances Control Act
UIC	Underground Injection Control
USGS	United States Geological Survey
UST	Underground storage tank
WHPA	Wellhead Protection Area

Aquifers & Well Sites

The Lanaʻi Company wells delineated and GPSd in this project are described in Table 1. The table includes wells that are developed for current or potential future potable use. Well 1, 9 and 14 are currently for irrigation use. All wells are overlying the Leeward and the Windward aquifers in the Central Sector. Well 6 overlies the Windward aquifer and the remaining wells overly the Leeward aquifer. The aquifers are high level, where fresh water is not in contact with seawater. Both are unconfined aquifers in dike compartments. Salinity is considered fresh (<250 mg/l Cl-) except for the South leeward aquifer where the salinity is high (250 – 1,000 mg/l Cl-). Both aquifers are classified as high sensitivity. Aquifer sensitivity is defined by the U.S EPA as "the relative ease with which a contaminant applied on or near the land surface can migrate to the aquifer of interest". It is determined by the characteristics of the geologic materials of the aquifer. Aquifers in Hawaii are described by Mink and Lau as either vulnerable or not vulnerable to contamination, based on geographical limits of the resources, confining conditions and the relatively rapid time of groundwater travel. (Mink and Lau 1993: "Aquifer Identification and Classification for Lanaʻi: groundwater protection strategy for Hawaii", Technical Report No. 190) When combined with factors of land use and contaminant characteristics, the aquifer's vulnerability to contamination can be further evaluated. Well information about each delineated well was gathered from State databases and from visual survey of the well sites. An example of well information for Lanaʻi 8 well is documented in Figure 1.

Table 1 – Lanaʻi Company Wells Delineated in SWAP

Well Number	Well Name	Year Drilled	Well Type	Casing Diameter	Ground Elevation	Well Depth	Solid Case	Perf Case	Use	Use Year	Init Water	Init Cl	Pump_ GPM
4852-02	Lana'i 5	1950		18	2296	1122	630	1120	MUNPR		1548.0	0	900
4853-02	Well 1	1945		12	1265	1274			IRR		876.0	0	700
4854-01	Lana'i 9	1990	ROT	14	1411	1451	510	766	IRRGC	94	803.0	0	300
4854-02	Lana'i 14	1995	ROT	14	1193	950	650	950	IRRGC	95		700	0
4952-02	Well 4	1950		18	2327	1178	669	1170	MUNPR		1576.0	0	900
4953-01	Well 2	1946		18	1510	609			MUNPR			0	1400
4954-01	Lana'i 3	1950		18	1850	1199	442	1189	MUNPR		1078.0	0	300
4954-02	Lana'i 8	1990	ROT	14	1902	1490	942	1485	MUNPR	95	1014.0	0	800
5054-01	Kaiholena TH-3	1950									1064.0	0	0
5055-01	Lana'i 7	1987	PER	8	2100	1650			MUNPR			67	500

FIGURE 6-1. Well Information

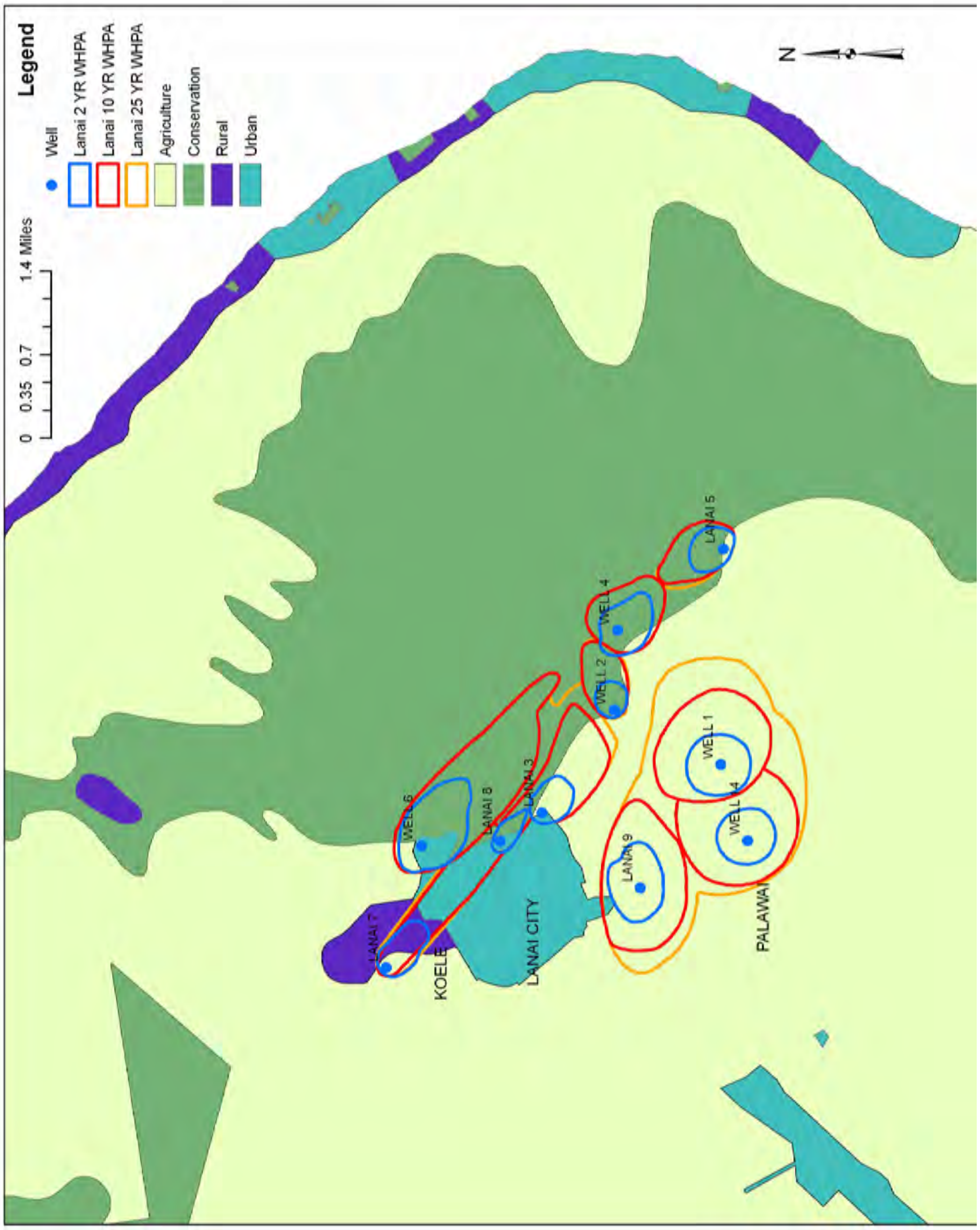
WELL NAME	Lanaʻi 8
WELL NUMBER	4954-02
OWNER/USER:	Lanaʻi Company
USE	Drinking water
AQUIFER SYSTEM	Leeward
AQUIFER HYDROLOGY	High Level : Fresh water not in contact with seawater
AQUIFER TYPE:	Unconfined
GEOLOGY:	Dike: Aquifers in dike compartments
DEVELOPMENTAL STAGE:	Currently used
UTILITY:	Drinking
SALINITY:	Fresh (<250 mg/l)

Wellhead Protection Area Modeling

Wellhead Protection Areas (WHPAs) for Lanaʻi Company wells were delineated by University of Hawaii Water Resources Research Center for the State SWAP. A WHPA is defined by the 1986 Amendments to the Safe Drinking Water Act as "the surface and subsurface area surrounding a water well or well field, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or well field". The SWAP modeling uses MODFLOW, a three-dimensional numerical groundwater model, and MODPATH, a particle tracking program. WHPAs were delineated for a 2-year, 5-year, 10-year, 15-year, 20-year and 25-year time of travel. SWAP designates a 50 feet fixed radius around each well to provide protection from direct contamination from vandalism or accidental spillage of chemicals or microbes. DWS added a 1,000 foot fixed radius to account for existing regulatory setback from wells for certain PCAs. The 2-year time of travel zone is intended to designate a conservative estimate of the surrounding area which may contribute bacteria and viruses to the wellhead, based on typical survival times for bacteria and viruses in soil and groundwater (HISWAP Report Volume I, November 2006). The 10-year and higher time of travel zones would allow protective measures in the event of a contaminant spill. Any land use management in this zone needs to address hazardous and persistent contaminants. However, bacterial and viral risks may still be a concern. MODFLOW is a reliable and well documented model that allows new sources to be added to the model fairly easily. MODFLOW WHPAs based on 2-, 5-, 10- and 25-year time of travel are illustrated in Figure 2.

Wellhead Protection

FIGURE 6-2. Delineated MODFLOW Wellhead Protection Areas



Potential Contaminating Activities Inventory

To identify the PCAs within the delineated areas, an in-office survey using public records and other information sources was completed, followed by field survey for visual inspection. Land uses considered PCAs are those facilities that typically use, produce, or store contaminants of concern, which, if managed improperly, could find their way to a drinking water source. Activities to be inventoried were selected referencing U.S. EPA and State WHP guidelines. Appendix A lists PCAs, categorized as Agricultural, Commercial – Industrial, Municipal or Residential. Contaminants of concern are chemicals and other material that can leach into and contaminate groundwater sources and that are commonly associated with PCAs. Those contaminants are in accordance with standard lists prepared by DOH and EPA. Less than half of these contaminants are regulated under State or Federal drinking water standards and monitored. Unregulated contaminants of concern include those on the EPA Drinking Water Contaminant Candidate List. Unregulated contaminants are known or anticipated to occur in public water systems, and may require regulation under the Safe Drinking Water Act, including so called emerging contaminants. Unregulated contaminants that are not subject to testing at the source can still be of concern if the PCAs they are commonly associated with are present, or could potentially be located within WHPAs. Contaminants of concern are listed in Appendix B.

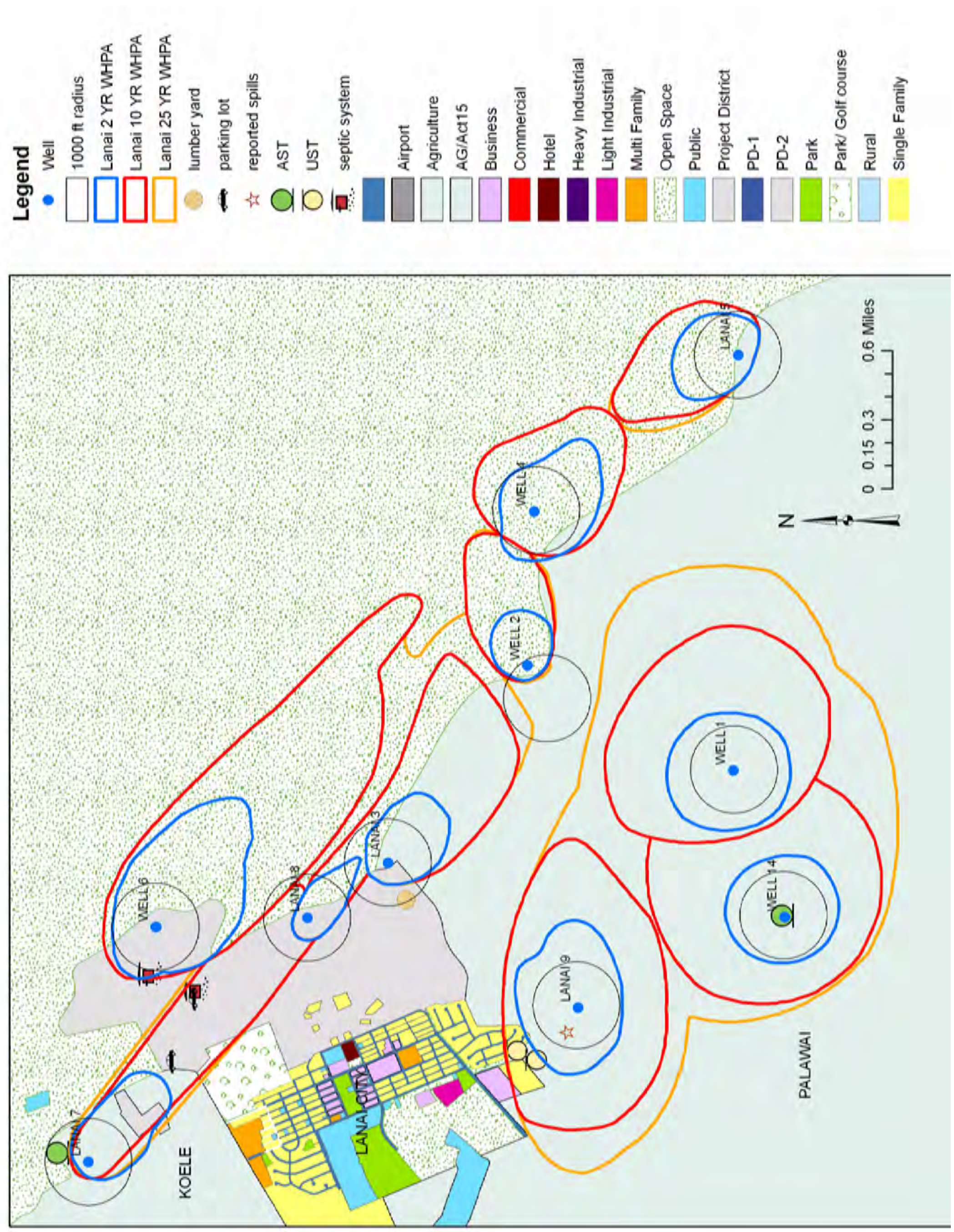
Staff performed field surveys with assistance from Lanaʻi Company to verify PCA locations and to identify any additional PCAs in 2004. DWS staff updated the PCA inventory in April 2010. Mapped PCAs are illustrated in Figures 3 – 4.

Pollution potential is based on, but not limited to, the type and quantity of chemicals used or wastes generated by an activity, and the behavior and mobility of the pollutants in the soils and groundwater. The characteristics of chemicals and the processes associated with the presence of PCAs were researched during data collection for the island of Maui, including mobility (solubility in water and potential for a contaminant to adsorb to soil), persistence (the time it takes to lose chemical potency by 50%) and rated leachability (ability to dissolve out into soil or water). The chemical and biological processes that control contaminant movement are a function of the contaminant composition, reaction with other compounds present in groundwater, and the conditions of the aquifer system. Examples of these processes are sorption (to take up and hold by either adsorption or absorption), biodegradation (capable of being broken down especially into harmless products by the action of living things), and volatilization (to cause to pass off in vapor). Organic contaminants that are discharged to groundwater may adsorb (to take up and hold) more or less to organic material present in the water, and affect the rate the contaminant moves through the aquifer and the amount of contaminants dissolved in the groundwater. Biodegradation can reduce contaminant concentrations and slow movement of contaminants through the aquifer. Volatilization is the migration of contaminants in the gas phase to the atmosphere and may reduce the volume of a contaminant reaching the aquifer. The inventoried data can in conjunction with site-specific factors such as soil type, amount of rainfall, water table level, and topography be used in the susceptibility analysis.

Known contaminant detections in delineated wells were inventoried and federal and state drinking water standards identified. The Maui data inventory also researched health effects resulting from exposure through drinking water to contaminants.

Wellhead Protection

FIGURE 6-3. Potential Contaminant Activitie



Lanaʻi 7

Lanaʻi 7 is a closed well not currently in use, but recommission of this well is an option included in the Water Use and Development Plan. It is located in brush area of a former pineapple field. Large-scale pineapple cultivation was largely phased out by the 1970s throughout the island. A rusting aboveground storage tank, likely formerly for fuel is within the 50 ft radius of the well. The entire 1,000 ft radius is former pineapple land, currently mowed pasture. PCAs at the Koele Lodge include: the golf course, commercial septic system, sewer lines, parking lot, and a horse stable. Reclaimed water irrigation of the golf course is R-1 quality, which is considered a medium risk PCA. The reclaimed water facility is located outside WHPAs. Roads and resort development are other PCAs. Historic applications of so called legacy pesticides on former pineapple fields in the immediate area surrounding the well should also be considered a PCA.

Lanaʻi 8

The well site is in a wooded area. The fixed 1,000 ft radius extends over portions of the Koele golf course. No other current PCAs were identified. However, former pineapple fields are in the 2 and 10 year WHPAs. The area may be subject to new residential development.

Kaiholena TH-3/Well 6

The well site is fenced and located in the wooded area. Portions of the Koele golf course are within the West section of the WHPA. A septic system located at the 7th tee is within the 2-year time of travel zone.

Lanaʻi 3

The well site is in a wooded area. No current PCAs were identified within any time of travel zone. A closed down lumber yard is found within the 1000 ft radius. Some metal and wood scrap remains at the site. The West portion of the WHPA was former pineapple cultivation and may be subject to future development.

Lanaʻi 9

The well is brackish, not used for potable consumption and is therefore not subject to wellhead protection under the proposed ordinance. The well is situated on a cement pad in a fenced grassed area. It sits below a former fill site. The South and West portions of the WHPA is former pineapple land. An underground storage tank in use for a wastewater pump station is located in the residential area within the 10-year time of travel zone. A permanently closed underground storage tank is located somewhere at field 5305, possibly within the WHPA. The tank was reported as leaking and site cleanup is completed. Alleged spills and/or dumping at former DDT storage tanks within the WHPA were reported to not require further action as DDT is known to degrade to the less toxic DDE, according to DOH Solid and Hazardous Waste Branch records. Other PCAs are retention ponds, roads, including Manele road, and a residential area with a sewer system.

Palawai Exploratory Well/Lanaʻi 14

The well is not used for potable supply. Surrounding land is former pineapple cultivation. The Western portions are possibly used for cattle grazing. There is a former hog farm located just outside the 25-year time of travel. The Manele road traverses the WHPA.

Well 1

Well 1 is a high-producing irrigation well, with chlorides in the 300 mg/l range. The well is not used for potable supply. Former pineapple cultivation is primarily at lower elevations than the well site. Historic water quality sampling data show Atrazine detected at 0.40 ppb in 1988, below the MCL set at 3 ppb (0.003 ppm). Current sampling does not show any contaminants detected at this site.

Well 4

This well is the primary source for Manele. The entire WHPA is in forested area. No PCAs were identified.

Well 2

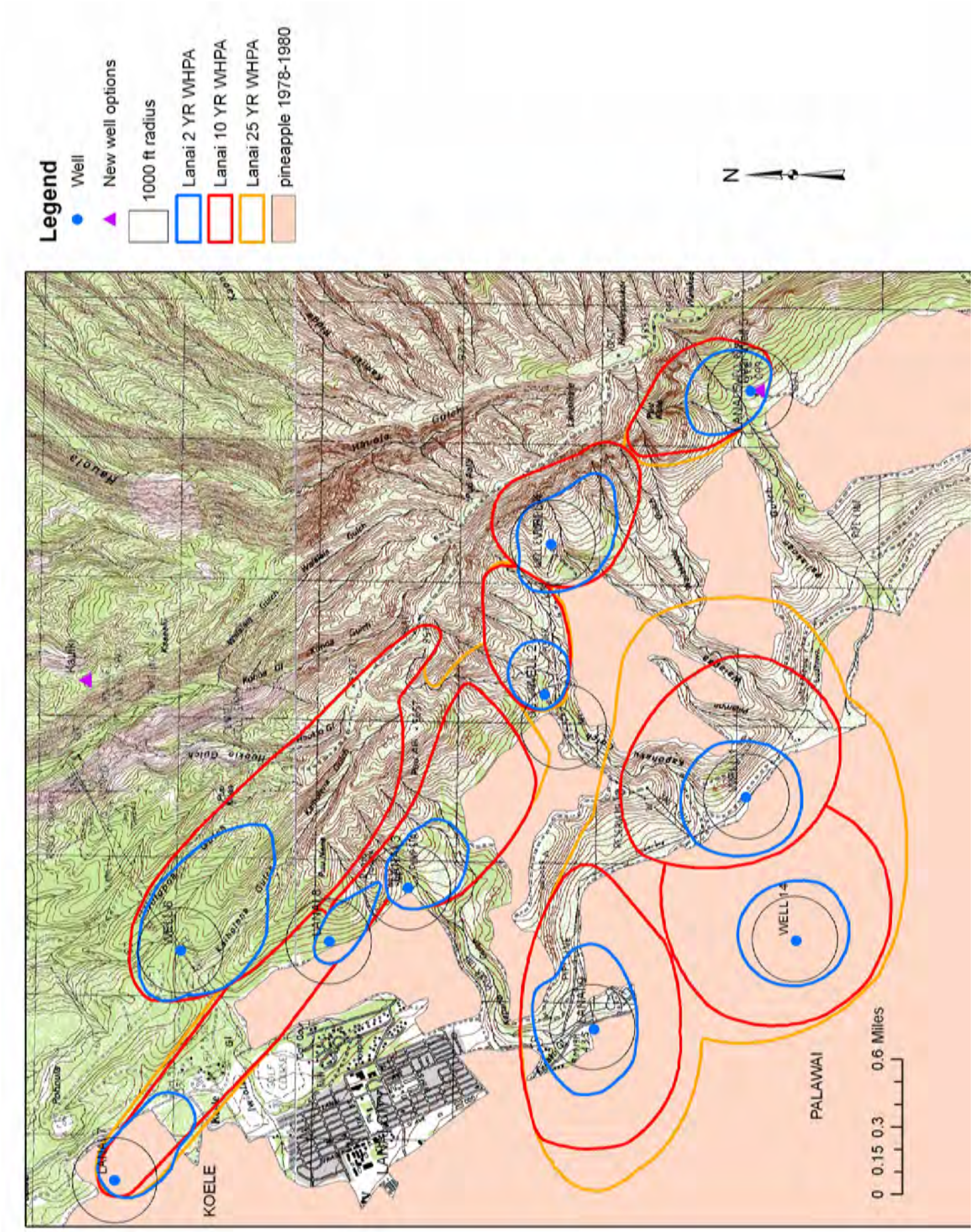
The well is currently in use and located in a wooded area. However, the site delineated for SWAP is the old well site up situated approximately 800 ft North East. Should the WHPA be extended further South, no current PCAs are likely to be found, but former pineapple cultivation is immediate upgradient of the new well site.

Lanaʻi 5

This is currently a monitoring well that collapsed and needs to be re-drilled. The Department was not able to GPS this location. It is situated in an area of overgrown pasture and forest. The WHPA mauka of the well is all forested.

Potential Contaminating Activities Inventory

FIGURE 6-4. Historic Pineapple Cultivation



Potential Future Well Sites

Potential new well sites were identified and characterized in Chapter 5 of the Water Use and Development Plan Lanaʻi Chapter. There are 10 wells at 7 different well fields identified for potential potable use, including: Leeward High Level Potable Well Development (near Hi'i Tank), Leeward High Level Potable Well Development (near Well 5), Well 2-B at Shaft 3 Site, Windward wells at Malau, Windward wells at Maunalei Shaft and Tunnel Sites, Windward wells at Kauiki, and Windward well at Kehewai Ridge. Eight alternative sites were also proposed by Lana'i Company in May 2010. WHPAs for all potential future well sites were delineated by the U.H. Department of Geology and Geophysics. DWS staff inventoried PCAs for the first 10 well candidate sites and intends to expand the inventory to all proposed well sites. None of the potential new sites are proposed on lands in former pineapple cultivation. WHPAs for proposed well sites and PCAs identified in the areas to date are illustrated in Figure 5 and 6. WHPAs for the 10 well sites originally proposed in the WUDP and sites B, C, D and E supplementing/amending these are shown in blue. WHPAs for the 8 well sites most recent proposed by Lanai Company are shown in red. The "composite capture zones" shown in purple were modeled with all of the wells pumping. Other WHPAs are modeled with only the subject well's assumed or actual pumpage. Roads extend through most of the WHPAs. At Malau Site Option B there were dump sites of vehicles and mopeds and other debris along the road. A septic system is located in the WHPA of Well Option D. The Koele Golf Course extends into the WHPAs of Well Option B, C and D. The exploratory well sites were difficult to GPS because of trees and ridges surrounding the sites. Most exploratory sites were not reachable and therefore not possible to GPS. Satellite accuracy was also low for those readings that did register. As these sites are further refined, additional GPS surveys are needed.

Potential Future Well Sites

FIGURE 6-5. Wellhead Protection Areas and Potential Contaminant Activities of Proposed Well Sites

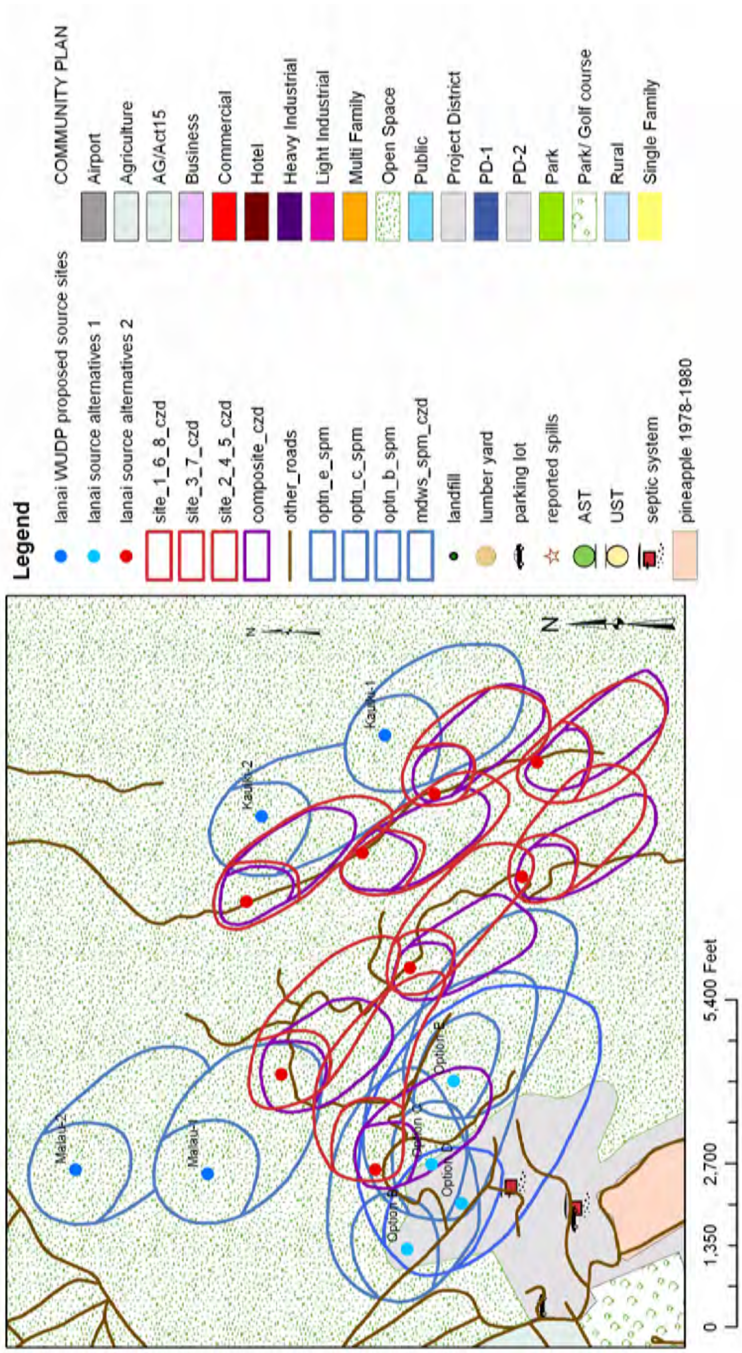
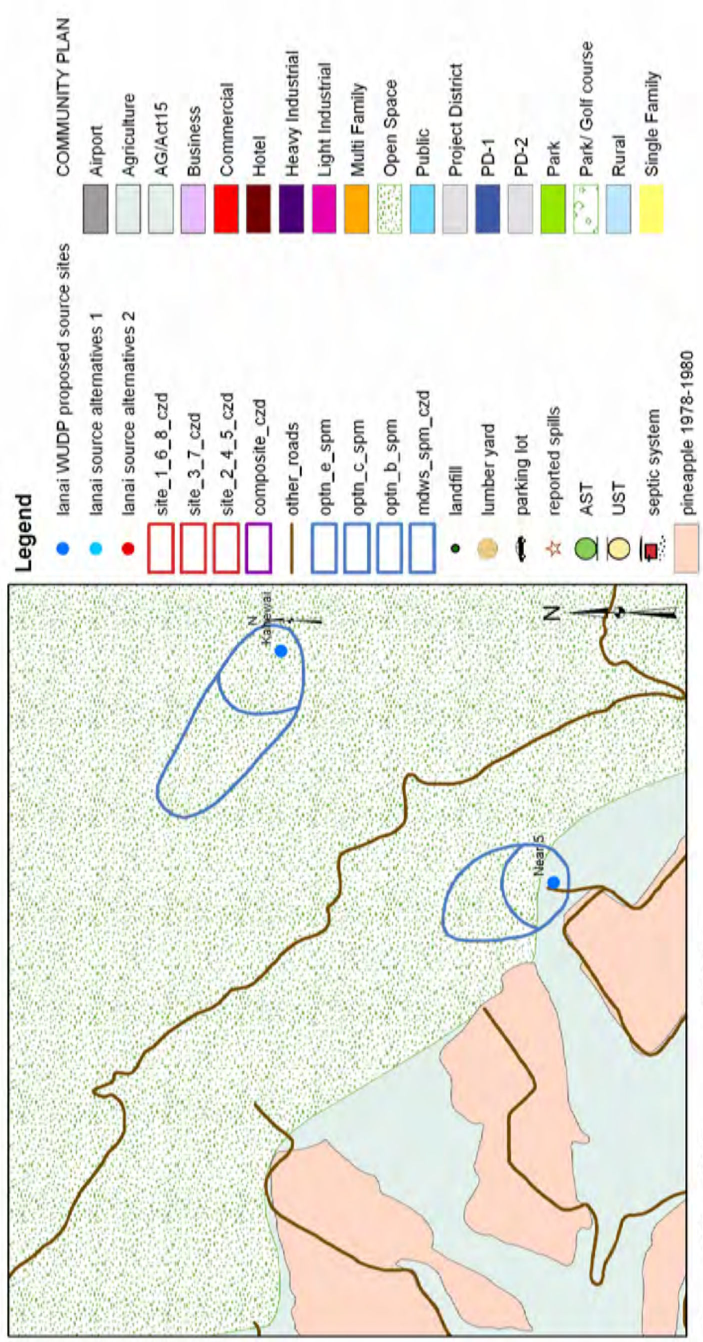


FIGURE 6-6. Wellhead Protection Areas and Potential Contaminant Activities of Proposed Well Sites "Kahewai" and "Near Well 5"



Land Use Changes

Land development must be consistent with the State Land Use Districts, the Community Plan and County zoning designations. The State Land Use districts are shown in Figure 2. The 2001 Lanaʻi Community Plan designations are depicted in Figure 3. Potential new residential development adjacent to the Koele golf course is shown in purple. Residential parcels are considered medium risk. Additional PCAs associated with residential development include vehicle parking, sewer systems, roads and storm drains.

Historic land use is primarily identified through land use GIS coverages from 1970s and 1980s, history recounts in the 1998 Lanaʻi Community Plan and personal communications. The phasing out of pineapple may be the major change potentially affecting water quality. The pineapple cultivation as of 1978-1980 is shown in Figure 4.

Potential Contaminating Activities Analysis

SWAP conducted a susceptibility analysis, defined by EPA guidance as "the potential for a Public Water System to draw water contaminated by inventoried PCAs at concentrations that pose concern." Susceptibility takes into account both site specific geologic/hydrogeologic factors (aquifer type) and characteristics of the PCA (e.g., nature of the activity, contaminants found in the well, distance from source, areal extent). The SWAP analysis incorporated five criteria in order to rank the potential of each PCA to adversely impact the water quality of each well:

1. Type of PCA: SWAP established PCA categories based on their potential to contaminate a drinking water source. A PCA was defined as very high, high, or medium risk based on specific characteristics of the PCA, namely, the nature of the activities, contaminants associated with the activities, and past history of contamination.
2. The distance of the PCA from the source: the closer a PCA is to the well, the higher the likelihood that a contaminant released would adversely impact the well.
3. The area occupied by the PCA: in general, the larger the spatial area that is impacted, the higher the potential for contamination. For PCAs such as cesspools, residential parcels, septic systems, sewer lines and parks, the scoring was assigned by the density.
4. Detection of potential contaminants commonly associated with PCA at the source: past detection demonstrates definite contamination risk. Scores were given on whether a contaminants is detected at concentrations above the MCL, detected at concentrations below the MCL (or has no MCL), not detected, or detection is unknown because contaminant is not monitored.
5. Aquifer sensitivity: The vulnerability of the geologic/hydrogeologic setting was discussed under the section "Aquifers and Well Sites". The aquifer sensitivity was rated as high, moderate and low. High sensitivity is characterized by basal and high level aquifers that are unconfined and may include aquifer types that are flank, dike, sedimentary, or a combination.

A numerical scoring system was used to relatively rank the susceptibility of the drinking water source to each PCA. The general concept is that the higher the score, the higher the potential for contamination from that particular PCA. (Hawaii Source Water Assessment Program Report Volume I, Approach Used

For the Hawaii Source Water Assessments. November 2006). The purpose of the analysis would be to indicate where source protection may be most needed and what PCAs should be targeted. The susceptibility analysis was included in Lanaʻi Company's SWAP report.

Protection Strategies

Lanaʻi has few current PCAs compared to more urban and developed areas. PCAs that are currently located in Lanaʻi WHPAs are discussed below. A regulatory approach can prevent undesirable and high risk PCAs from being located within WHPAs, while non-regulatory approaches may best address existing PCAs, such as best management practices education and agreements. Inventoried PCAs may in fact pose no or very little concern because of regulations and best management practices already in place. The regulatory framework of ground water protection was reviewed in the Maui process. State legislation and federal mandates provide for groundwater protection through land use and natural resource planning and programs specifically dealing with groundwater protection. A table of programs in place is provided as Appendix C. PCAs are administered by a range of state, federal and county regulations. Identified regulations of PCAs that directly or indirectly provide for ground water protection are described in Appendix D.

Cesspools and septic systems

Contaminants commonly associated with septic systems include nitrate, nitrite, viruses and bacteria as well as various household chemicals. Lanaʻi City is served by municipal and private sewer lines. HAR 11-62 regulates individual wastewater system siting, distance from groundwater table, design and installation. Septic tank effluent disposal systems must be located at least 1,000 feet from a drinking water well and at least 5 ft above groundwater table. Septic systems are allowed for new residential developments comprised of single-family dwelling units on a minimum lot size of 10,000 square feet, but hookup to sewer system is mandatory if available. Two septic tanks are located on parcels that could extend into the WHPAs of the Lanaʻi 7 and Lanaʻi 8 wells. Cesspools are used to receive untreated wastewater. Solids are retained in the cesspool and the liquid percolates into the surrounding soil. Virtually no treatment occurs that would protect the ground water. Installation of new cesspools is no longer permitted in unsewered areas. Large capacity cesspools – those designed to serve 20 or more people per day – have been banned. All WHPAs are in established Critical Wastewater Disposal Areas (CWDAs) where the director of DOH may impose more stringent requirements for individual disposal systems. Maintenance of the private wastewater systems are not monitored or enforced.

Suggested Protection Strategy:

In the event a cesspool would be identified within 1,000 ft of a drinking water well, an upgrade to septic tank would be required should a building permit be sought for the property. Development guidelines are proposed for all WHPAs that set a recommended minimum density of 1 septic unit/2 acres for new development in any unsewered areas. DWS could in cooperation with DOH Wastewater Branch distribute public education material to ensure proper maintenance and prevent use of improper septic tank cleaners.

Household hazardous products

Household chores involve a range of hazardous and non-hazardous products such as paints, solvents, synthetic detergents, pesticides, medicines, fuels, disinfectants, pool chemicals, oils, and batteries. These items can potentially enter groundwater sources when improperly stored through garage floor drains, spills and flooding, through disposal down household drains or through dumping and disposal on the ground. Pesticides, herbicides and fertilizers are sometimes over-applied on lawns and in flower and vegetable gardens and may infiltrate groundwater. Household hazardous products are exempt from hazardous waste and storage regulations, and can therefore be considered potentially significant PCAs.

Suggested Protection Strategy:
Public education for household practices should continue, including newspaper and radio advertisement, and public pollution prevention workshops. The potential contamination load would also be reduced with residential development density restrictions.

Pesticide application

There are no current large scale agricultural operations in WHPAs on Lana'i but pesticides are probably applied in small scale farming and home gardens. Applicators of registered pesticides must be licensed with DOA/EPA. The use of a pesticide can be cancelled, suspended, or restricted or limited to areas to protect groundwater, if it is determined that a particular pesticide or practice appears detrimental.

Suggested Protection Strategy:
Public education and workshops in coordination with the University of Hawaii College of Tropical Agriculture and Human Resources (CTAHR) or other appropriate agency can address Integrated Pest Management (IPM) practices. Application of pesticides and fumigants with high leachability should be avoided in the 2-year time of travel zone or, where no alternative pesticide is available, applied as part of an IPM program.

Pesticide storage and disposal

No pesticide storage was located within WHPAs, but storage could occur with small scale farming in agricultural and residential areas. Pesticides are commonly stored in above ground storage tanks. Unregulated tanks may pose a risk of contamination if not properly maintained. Tanks containing less than 660 gallons of non-hazardous chemicals are not regulated; therefore, the potential for greater hazards may exist. Larger storage must be labeled, and leak free containers and pesticides may not be disposed of except through regulated hazardous waste facilities. Pesticide wastes include leftover pesticides, unusable pesticides, pesticide containers, and rinse water Pesticide leftovers may not be accumulated by large quantity handler (>5000 kg/year) for more than one year. Empty containers must be triple rinsed and taken to landfill, or buried 1 ft deep in ground.

Suggested Protection Strategy:
Where possible, pesticide storage and mixing areas should be located outside WHPAs in order to prevent leaks and spills. Where location outside critical areas is not feasible, best management practices including a secondary containment system should be required.

Golf course

The Koele Golf Course extends into the WHPAs of Well 6 and Well 7. Contaminants commonly associated with golf courses are nutrients applied to the soil, primarily Nitrogen (N), Phosphorus (P) and Potassium (K) and pesticides, including herbicides, insecticides and fungicides. Without proper management, these contaminants may leach into groundwater. In a survey of 37 golf courses in Hawaii, researchers identified 30 different pesticides in use (Brennan et.al. 1992).

Suggested Protection Strategy:

Golf courses is a medium risk PCA. The Draft Wellhead Protection Ordinance prohibits new golf courses in the 2-year time of travel zone. Within the 10 year time of travel zone golf courses are prohibited unless they meet performance standards outlined in the ordinance. The existing golf course should meet "Golf Course Management Measure" outlined in Hawaii's Coastal Nonpoint Pollution Control Program Management Plan. Appropriate BMPs include:
Nutrient management:
Schedule fertilizer application so that the chance of leaching and run-off of soluble fertilizers is minimized
Apply slow release fertilizers that will release nitrogen at a rate comparable to the rate at which it is used by the turf
Apply slow release nitrogen fertilizer in an insoluble form. Calibrate fertilizer application equipment regularly.
Calibrate fertilizer application equipment regularly.
Implement an integrated pest management (IPM) plan that includes, among other things:
Emergency response procedures to be undertaken in the event of a spill or accident.
Avoid applying pesticides in areas where there is a high potential for leaching.
Avoid locating greens and tees that may require high amounts of pesticides within WHPAs
Avoid applying pesticides near well heads.
Apply pesticides when runoff losses are unlikely.
Ensure proper storage of pesticides, located away from wellheads, and if possible from WHPAs.

Well sites

Wells provide a pathway for contaminants associated with land uses around the well. Wells that are not serving a public water system are not subject to the same contaminant monitoring requirements or sanitary surveys as public water system wells. Private wells are often surrounded by farming and other business activities. Permit and registration with the Commission on Water Resource Management (CWRM) is required for new wells. Groundwater quality is not addressed through standard conditions but on a case-by-case basis. Abandoned wells require casing, plug back, cap, or cement fill and seal well in order to prevent seepage of contaminants directly into drinking water supplies. Abandoned or improperly sealed wells present a conduit effect for contaminants to enter an aquifer. DWS are investigating potential abandoned or unused wells during PCA field surveys. With the exception of Shaft 3, all delineated wells are owned by Lana'i Company.

Suggested Protection Strategy:
Siting of new wells should be preceded by delineation of a WHPA around the well, PCA identification and consultation of development plans in the WHPA to identify the impact of future land use and any need for land use controls to protect the well.

Overlay Zoning Regulation

Several existing PCAs may individually and cumulatively pose considerate threats to the underlying water supply. The Maui advisory committee suggested considering density of PCAs rather than individual sources. Clusters of small-scale businesses such as auto body shops and services, whose practices are not regulated by federal or state laws, use significant quantities of hazardous materials such as solvents. Lana'i fortunately has very few high risk PCAs. Although high risk PCAs are unlikely to locate in Lana'i WHPAs in the near future, prohibiting or restricting possible location of undesirable PCAs in WHPAs is recommended due to the nature of the activities, contaminants associated with them and past record of contamination elsewhere. Regulation by complete prohibition (no chemical use or storage in a WHPA) is consistent with most wellhead protection ordinances, regardless of site-specific history of contamination, to provide the greatest assurance that inadvertent discharge of pollutants into the groundwater supply will no occur. The prohibition list should represent changes in knowledge and technology so that as other polluting uses are discovered or as the employed technology reduces pollution potential, uses can be added or eliminated from the list.

There is currently merely a sliver of land zoned business within Well 9 WHPA. Business zoning could allow new establishments of automobile service businesses, printing shops, and other medium – to high risk uses, while light industrial zoned areas would potentially allow a range of high-risk uses. An overlay zoning district based on the delineated WHPAs could restrict uses that are incompatible with groundwater protection without changes to the underlying zoning districts. An overlay zoning ordinance would typically allow existing non-complying uses to continue operating, but subject to land use restrictions if any change in use is proposed. A Draft Wellhead Protection Ordinance for Maui County prepared in cooperation with the Maui Advisory Committee is attached in Appendix E. Regulatory and non-regulatory management approaches are illustrated in light of legal and administrative considerations in Appendix F.

Public Education

BMP education and compliance with applicable regulations in place should be further promoted. On Maui, DWS has distributed targeted pollution prevention material through direct mailings to businesses and residences, newspaper and radio advertising and workshops. A continued pollution prevention campaign in radio and newspaper media will continue that is expected to benefit the Lana'i water system as well. Targeted BMPs are recommended for identified PCAs such as integrated pest management for roadside weed control by Lana'i Company in WHPAs and by the County Department of Public Works.

Project district, mixed use & residential development design
While open space and low-intensity land uses are desirable in protection areas, these goals can pose conflicts with proposed land and resource use. Residential uses generally pose a low risk to water quality, but may not be desirable in protection areas unless appropriate sewer systems and design standards to minimize contamination are provided. Nitrates are commonly associated with septic systems and lawn fertil-

izing. An increase in residential density also brings along increased road runoff and use of household hazardous products.
The Lana'i Project District 2 (Koele) extends into the WHPA of Wells 6, 7 and 8. Permitted land uses in the project district include residential, multifamily, hotel, public use, park and golf course.

New development design could incorporate groundwater protection in the WHPAs in several ways, such as locations of park and storm water detention areas, as well as limiting residential densities. Low residential and commercial density in WHPAs is suggested to maintain groundwater recharge, prevent overloading of household hazardous products and septic systems and keep runoff basins outside WHPAs where feasible. Large-lot zoning is used to reduce the impacts from residential development by limiting number of units within WHPA. A minimum lot size of 2 acres for residential development has been reported to maintain compliance with nitrate standards (Stevens Point Whiting-Plover Wellhead Protection Program). On-site septic system density control should be provided at a minimum in the 2-year microbial contamination zone to prevent future contamination from viruses, bacteria and other contaminants typically associated with on-site septic systems. Maximum overall net density for single family development in the Koele Project District is two and one-half units per acre. Only un-sewered development would be subject to the density restrictions.

The following design guidelines are suggested for all new commercial, residential or mixed use development projects, excluding residential subdivisions of 2 lots or less, throughout the WHPAs:
2-year time of travel WHPA:
Commercial and high-density residential development should be minimized.
Appropriate uses are open space, parks, schools and low density residential (minimum 2-acre lots for septic systems)
Projects should be designed such that more intense uses are as far as possible from the wellhead while areas closer to the wellhead are reserved for less intensive uses.
Storm-water infiltration basins should be located outside the WHPA where feasible.

10-year time of travel WHPA:
High risk commercial and high-density residential development should be minimized.
Appropriate uses are open space, parks, schools, low risk commercial and low density residential (minimum 1-acre lots for septic systems)
Projects should be designed such that more intense uses are as far as possible from the wellhead while areas closer to the wellhead are reserved for less intensive uses.
Storm-water infiltration basins should be located outside the WHPA where feasible.

2-year and 10-year time of travel WHPA:
Proposed development entirely within the WHPA should be grouped and sited on the subject parcel at as far distance as possible from the wellhead.
Where development is proposed on property extending both inside and outside the WHPA, and where sufficient buildable land area exists on the portion of the property outside the WHPA boundary to accommodate the proposed development, and where applicable setbacks permit, that area in its entirety should be utilized before any land within the WHPA should be used. Where insufficient buildable land area exists on

the portion of the property outside the WHPA to accommodate the proposed development, as much of the development as possible should be sited outside the WHPA.

Expansions of existing uses should at least conform to these guidelines where the use is expanding beyond its property boundaries.

Vegetative cover should be provided on all disturbed land areas, excluding fallow agricultural fields, not covered by paving, stone or other solid material. The maintenance or use of native plant materials with lower water and nutrient requirements is encouraged.

Program Implementation

Legal Issues and Potential Conflicts

The Maui advisory committee discussed whether siting of new wells down-gradient of private land could potentially reduce land value and utilization due to land use restrictions. This also raised the issue of takings. Restrictive government decisions may constitute a taking in cases where the regulation interferes with reasonable investments made prior to general notice of the regulatory program, where the regulation deprives the landowner of all, or substantially all economically viable uses for the property with no offsetting reciprocal benefits. A regulatory approach would need to consider existing uses and proposed projects under current zoning to ensure that no restrictions will constitute a taking of private property. In prohibiting certain land uses, there is a potential impact on businesses, farms and “the little guy”. The Maui advisory committee commented that many land owners are already conscientiously implementing BMPs and are concerned that costly additional restrictions would be set. Technical and, where possible, financial assistance should be provided for implementation of BMPs so as not to overburden existing users. However, the overall impact and the benefits to the community must take precedence. The benefits of wellhead protection include public health, reducing liability from leaks and spills, decreasing emergency response costs, a safe and viable water supply, avoiding costly treatment systems to treat contaminated drinking water, replacing wells due to contamination and remediation costs to remove the source of contamination.

Administration & Financing

Implementation of an overlay zoning ordinance should rely on existing administration and staff for processing zoning requests. Non-regulatory management, such as BMPs and land use agreements requires coordination between DWS and the appropriate agencies for administration and technical assistance. Farming BMPs should be coordinated with the Natural Resource Conservation Service (NRCS); chemical use, handling and waste with the Department of Health offices and the County Department of Environmental Management; and individual PCAs with the appropriate agency as defined in the Appendix E. If an ordinance stipulates mandatory performance standards in addition to existing state and federal requirements, coordination and inspection by the approving agency will be necessary. An overlay zoning ordinance would be enforced, as other zoning, by the Police Department.

Wellhead Protection

CHAPTER 6-C

Well Operating Guidelines

On January 31, 1990 the Commission “authorized the Chairperson to reinstitute water management area proceedings and re-evaluation of groundwater status when: a. the static water level of any production well falls below one half of its original level above sea level, or b. any source or any alternative source of supply contained in the Company’s water development plan does not materialize and full land development continues.”

In 1996, voluntary well operating mangement guidelines (VWOMG)[1] were submitted by CCR to the State Commission on Water Resource Management. Based upon this review the Water Working Group at the time recommended revisions and further recommended that the guidelines, once revised, be made mandatory.

These guidelines set “action levels” as well as specified limits or “lowest allowable levels” of water for each well. When an action level is reached, data on pumping is to receive thorough public and scientific review, with the aim to evaluate whether new source should be developed and pumping on the well reduced.

When the lowest allowable level is reached, pumpage on a given source should stop altogether, pending new source development or recovery. In event that it is not possible to stay within the limitations set for potable wells, LCI will develop new wells and/or outfit Well 7, whichever is most hydrologically appropriate. [2]

1. Lana 'i Water Resources Management Plan, Prepared by Lana 'i Company, Inc., August 1996
2. Resolution 93-42. Relating to the use of non-potable water for the construction of the Manele Golf Course. County of Maui, 1993.

According to these guidelines, pumpage shall be distributed among well sources so as to maintain their water levels within the specified limits delineated in the table below:

TABLE 7-35 Action levels for groundwater sources.

Potable Well	Initial water level (ft elev)	2009 P7 Water level (ft elev)	Action Level* (ft elev)	Lowest allowable level (ft elev)	CWRM Trigger (Half Initial Head, Jan. 31, 1990)
2	1544	1,441	1050	750	772
3	1124	992	750	562	562
4	1589	1,495	1100	750	794.2
*5	1570	1,491	1100	750	735
6	1005	924	750	500	502.5
8	1014	944	750	500	507
Brackish Wells					
1	818	575	550	410	409
9	808	650	550	410	404
14	?	497	400	292	

*Requires public review of all pumpage, water level, and water quality data for possible changes in the resource management procedures, policies, and plans.

** Well 5 is not in operation

CHAPTER 7

Policy Issues

Sustainable Yield

Lana‘i has a very low sustainable yield. At 6 MGD, it is less than 1/10 that of any other major island. Unlike the other islands, Lana`i also has no flowing streams or utilizable surface water. Figure 7-3, below, shows the relative sustainable yields of the main inhabited Hawaiian Islands for comparison. Note that the recent update of the State Water Resources Protection Plan reduced sustainable yields from the 1990 estimates on virtually every island but Lana‘i, although these reductions were less than initially proposed. In many cases, such decisions resulted from pumpage beginning to approach initial sustainable yield estimates, only to find that such estimates were either overly optimistic, or that distributions of withdrawals had to be increased substantially to realize them. It is not unreasonable to posit that Lana‘i might one day find itself in a similar situation.

FIGURE 7-1. **Sustainable Yields of Hawaiian Islands**

Island	1990 WRPP Sustainable Yield MGD	2007 Draft WRPP Update Sustainable Yield MGD	June 2008 Final WRPP Sustainable Yield MGD
Hawaii	2,431	2,175	2,410
Kauai	388	306	310
Lana‘i	6	6	6
Maui	476	386	427
Molokai	81 / 38 Dev	71	79
Oahu	446	419	407

<u>Need for Improved Distribution of Withdrawals</u>

Policy Issues

The document *A Numerical Groundwater Model for the Island of Lana'i, Hawaii* (CWRM-1, Hardy, 1996, pg. 126), "shows that **many more wells** would be necessary to achieve pumpages near the current CWRM sustainable yield estimate of 6 MGD, assuming that long term recharge conditions in the regions above 2,000' remain stable" [emphasis added].

This model assumed withdrawal of water was distributed between thirteen sources, of which two, the Upper and Lower Maunalei Tunnels were passive. Pumping was distributed among eleven sources, as shown in Figure 7-4. Pumping is currently distributed primarily among only six sources, with a seventh contributing an average of only 2,418 GPD.

More than 85% of 2008 water withdrawals on Lana'i, 1,913,310 GPD out of 2,241,222 GPD, came from the Leeward aquifer. All near term plans of LWCI or LHI to develop water are also in the Leeward aquifer. The only pumping well in Windward aquifer is Well 6, with an average 2008 withdrawal of 328,000 GPD. It is unlikely that more pumpage could be distributed to this well, because its water levels are already declining.

FIGURE 7-2. Modeled Distribution of Pumping Versus Present Distribution of Pumping

	AS MODELED IN 1996 CWRM MODEL	CWRM MODEL WELLS IN USE NOW	2008 MAV	* MOST RECENT ACTUAL MAV	* OTHER RECENT ACTUAL MAV	AVG OF NON-ZERO MAVS OVER PUMP RECORD	Comments
Maunalei Shaft 2	500,000	0	0	0	557,385	525,980	*MAV period 13 1994. In the late 1980s, more than 600 KGal came from Maunalei sources. Shaft 2 operated until 1995 with a running MAV of around 526 KGal. Stopped in early 1995.
Well 1	270,000	270,000	393,981	378,074		291,173	*MAV period 7, 2009. Water levels appear to be declining at current pumping rates.
Well 2 / Shaft 3 future "2-A"	300,000		2,418	0	302,468	228,523	*302,468 was MAV period 13, 2006. However, there have not been 13 straight periods of pumping since 1997. Period 8, 1997 MAV was 157,140 GPD.
Well 3	300,000	0	0	0	233,991	191,281	*MAV period 6, 2006. Last 13 period with continuous non-zero pumpage.
Well 4	400,000	400,000	683,867	598,677		532,729	MAV period 7, 2009.
Well 5	400,000	0	0	0	120,030	153,557	*MAV period 12, 1992. This well started in the 200-300 KGal range for 2 years, and then dropped steadily. Period shown is last continuous non-zero MAV use.
Well 6	300,000	300,000	327,912	303,118		432,557	MAV period 7, 2009.
Well 7	200,000	0	0	0			No continuous pumpage record. One monthly number in 1992.
Well 8	300,000	300,000	276,890	255,469		121,459	*MAV period 7, 2009.
Well 9	270,000	270,000	151,440	127,851		224,302	*MAV period 7, 2009.
Well 12	0	0	0	0	14,305	10,316	*MAV period 13, 1995. Started at 17.8 KGal & declined continously. Use stopped in 1997.
Well 14	280,000	280,000	404,714	323,302		336,913	*MAV period 7, 2009.
	------------	------------	------------	------------	------------	------------	
	3,520,000	1,820,000	2,241,222	1,986,491	1,228,179	3,048,790	Average over pump record is high. These wells have not pumped at same time. Difference between 2,238,804 and 2,241,222 is less than 1%, and results from different averaging method.

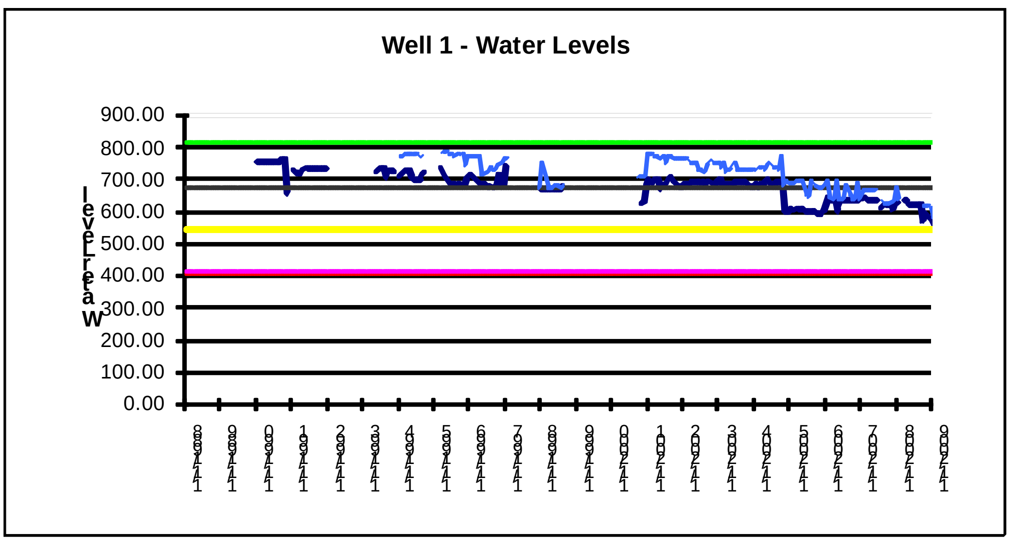
As modeled in CWRM-1, Hardy, 1996. Modeled scenarios were based on pumpage at the time and various pumpage scenarios that had been proposed at the time.

Declining Water Levels

At 2008 pumpage rates, water levels in several wells are declining (Wells 1, 9, 14, 6 and 8). Pumps have been lowered recently in several wells with Well 9 showing particular stress. Since 2003, the pump in Well 9 has been lowered 442 feet. Water levels are within 48 feet of the "Action Level" in CCR's proposed operating guidelines, and continue to decline. Chlorides have also been rising in the 15 MG reservoir. This is not due to rising chlorides in the wells, but rather to increased use of the higher chloride Well 14 to supplement Wells 1 and 9. However, it does affect the amount of salt that is introduced in irrigation at Manele. LHI is taking action on this situation, by drilling an additional well, Well 15, to distribute withdrawals. How much water and at what quality this well will produce remains an open question. While a certain amount of decline in water levels is to be expected, caution and circumspection would still seem warranted.

Water levels in the wells mentioned are plotted below. In each of these graphs, the green line represents the initial water level. The yellow line is the action level set in the LWCI operating guidelines. The red line is the lowest allowable level in the LWCI operating guidelines. A pink line is plotted, and is the CWRM trigger for designation proceedings, but it is so close to the red line that the two are not distinguishable. The dotted black line is the pump level. The thick blue line is the low water level and the thin blue line is the high water level.

FIGURE 7-3. Water Levels - Well 1



Policy Issues

FIGURE 7-4. **Water Levels - Well 9**

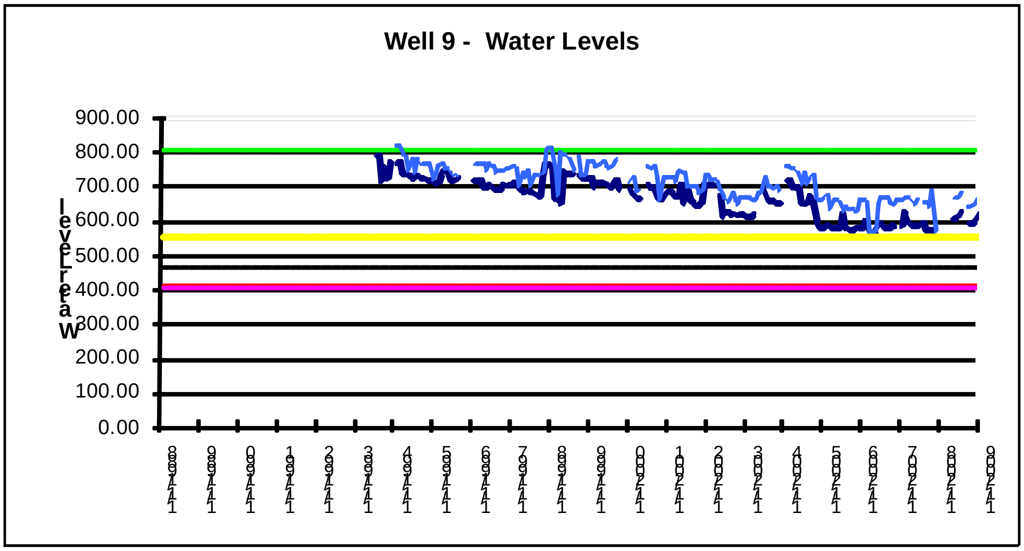
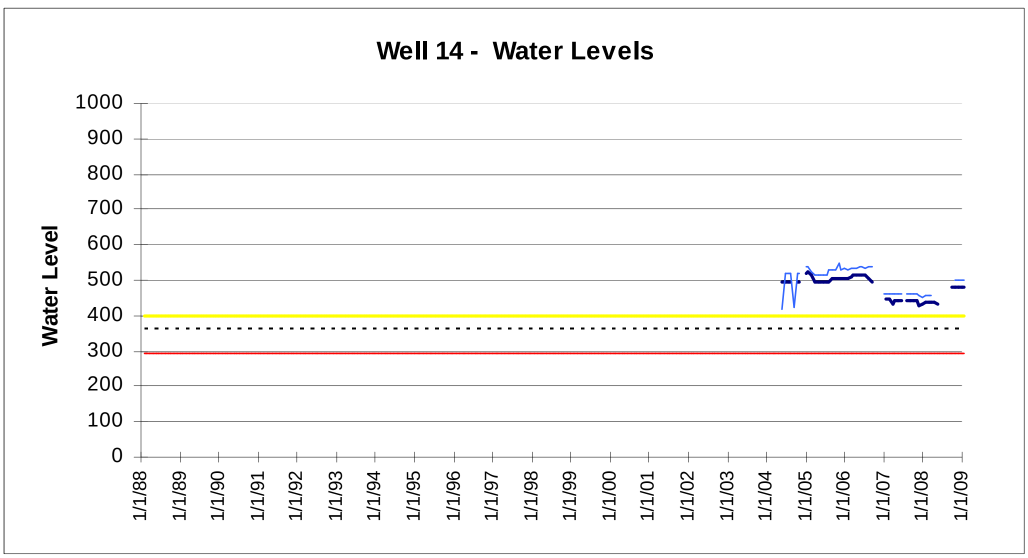


FIGURE 7-5. **Water Levels - Well 14**



Declining Water Levels

FIGURE 7-6. 15 MG Brackish Reservoir - Chloride Levels

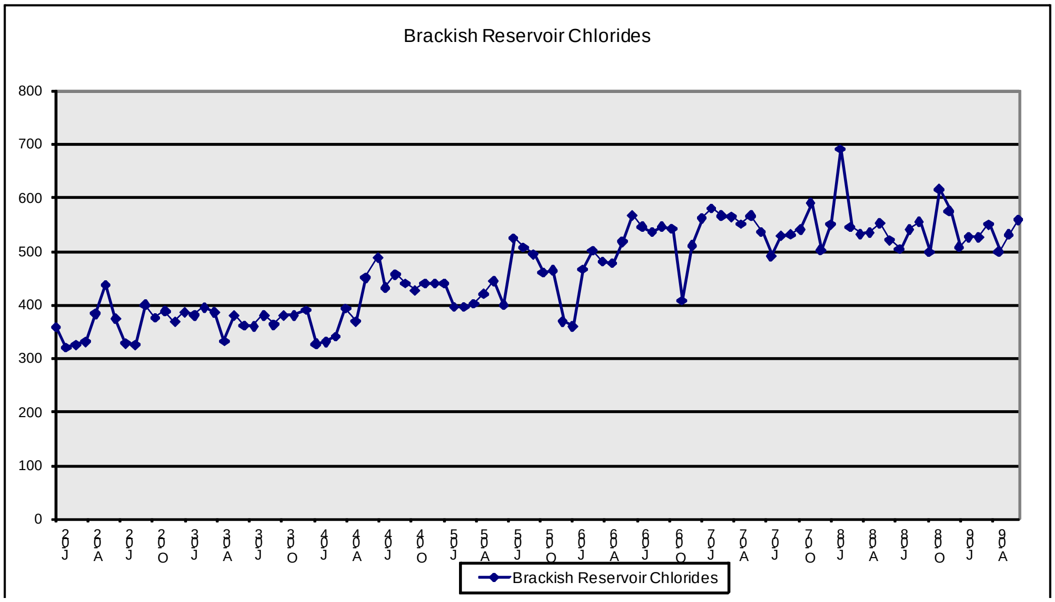


FIGURE 7-7. Well 6 Water Levels

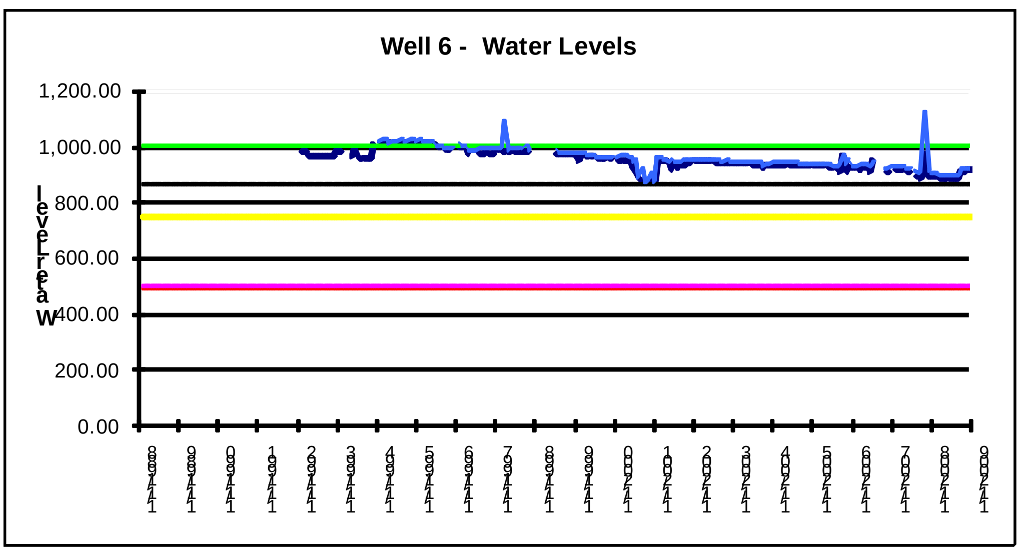
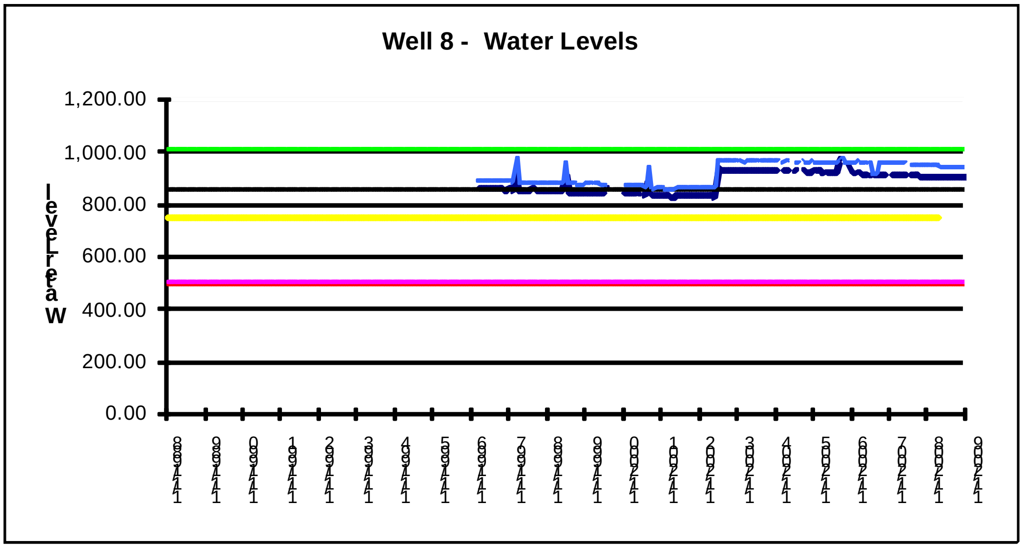


FIGURE 7-8. Well 8 Water Levels



Green - Initial Water Level; Yellow - Action Level; Red - Lowest Allowable Level; Pink - Trigger for Designation Proceedings; Dotted - Pump Level, Thick Blue - Low Water Level; Thin Blue - High Water Level

Importance and Condition of the Mauka Watershed Forest

The *Numerical Groundwater Model for the Island of Lana'i Hawaii* (CWRM-1, Hardy, 1996) "...predicts that the reduction of forest cover would affect ground water levels drastically." (pg. 126) The model indicates that fog drip is a major contributor of recharge to the primary high level aquifer. Fog drip is estimated to contribute 8.87 MGD of a total 13.5 MGD in estimated recharge (65.7%). Loss of fog drip from the forest, even with zero pumpage, would result in a severe drop in water levels, on the order of 25% to 30%. With 6 MGD pumpage, that drop would be even more severe, with water levels dropping 50% within the modeled period. (CWRM-1, Hardy, 1996, pgs. 44, 105 & 112 - described in Chapter 3 of this document).

The mauka watershed forest is exceedingly compromised. By 1993, two thirds of cloud forest vegetation had been lost. (Hobdy, 1993). Despite efforts to install fencing and manage feral ungulates, the Lana'ihale watershed continues to decline. (Hobdy and Penniman, minutes of 5/30/2008 meeting). Increment I of a three-phase project has been completed. However, fencing for the most critical habitat area must wait for Increment III. This is still years away, and funding is uncertain. Whether or not cost recovery for this increment is folded into the final rates of the LWCI, additional major entitlements for CCR should be conditioned upon continuing watershed protection, and most especially upon construction of Increment III of the fence.

Historical Water Allocations

Hawaii Revised Statutes (HRS) §174-C-31 (a)(2) states that the Water Use and Development Plans for each county shall set forth the allocation of water to land use in that county. However, the statute is not prescriptive about how such allocations should be made. Conceivably, allocations could be made in any number of ways, from broad-brush statements about general priorities for each type of water, to accommodating land use forecasts for each sector, to specific and explicit review of every planned use and source. Similarly, such allocations could address the "bottom line" at the end of the planning period and ignore timing, or could address the pace and schedule of resource use.

Regardless of the manner in which allocations are set, they must be set within certain parameters. They must be consistent with Community and General Plans. They must incorporate the current and foreseeable development and use needs of the Department of Hawaiian Homelands. They must reflect the responsibility of the counties set forth in Article XI of the constitution that the State *and its political subdivisions* have the responsibility to protect and conserve resources. In other words, protection of resources is a public trust obligation for which the State has primacy, but from which the counties are not exempt. Given a public trust obligation, a precautionary principle is warranted where applicable in setting water allocations.

1997 Allocation Agreement

Source water use estimates from the 1997 Water Working Group Report are presented in Figure 7-1. These were the starting point for allocation discussions by the Water Advisory Committee for this update. Two key points of the 1997 consensus were:

- Total potable and brackish water use for the Manele Project District should be limited to 1.03 MGD, regardless of any approvals that would result in a higher build-out. High level brackish water use is limited to 650,000 GPD, to be decreased as increasing reclaimed water becomes available. Use of reclaimed water for irrigation should be maximized.

- No high-level water should be utilized to irrigate the Koele Golf Course, with the exception of the special conditions provided for in Ordinances 2515 and 2516, described in Appendix B.

The 1997 allocation agreement remained the consensus agreement of the LWAC until 2002.

Island-wide water use, at 2.24 MGD in 2008, was considerably less than the projected 3.72 for 2010.

Consumption for the Manele Project District area reached 1,082,999 GPD in 2008. Only a small portion of the Project District has been built. Of 282 Single Family units permitted under the Project District Ordinance, only 17 units have been built. Half the hotel units have been built. The project is not even close to full build-out. Similarly, in Koele Project District, only 13 of 535 eventual single family units have been built.

FIGURE 7-9. **Water Use Allocations from 1997 Water Working Group Report**

LAND USE CATEGORY	Present (97) mgd	2010 mgd	Future mgd	Source of Wate
Residential	0.274	0.414	0.494	Primary
Agriculture	0.219	0.50	1.50	Primary
Commercial & Institutional (10 addditional acres)	0.379	0.439	0.439	Primary
Light Industrial (15 acres)	0	0.09	0.09	Primary
Kaumalapau Harbor	0.009	0.01	0.01	Primary
Lanai Airport	0.004	0.005	0.005	Primary
Manele Project District	0.078	0.68	1.03	Primary & Seco
Manele Golf Course	0.51	0.65	0.65	Secondary
Manele Effluent	0.05*	0.07*	0.14*	Effluent
Koele Project District	0.096	0.20	0.42	Primary
Koele Golf Course	0.25*	0.25*	0.25*	Effluent
Subtotal Groundwater	1.569	2.99	4.64	Primary & Seco
System losses 12% future	0.134	0.41	0.63	
Subotal Groundwater	1.703	3.40	5.28	
Total Effluent	0.3	0.32	0.44	
Total Water Demand	1.73	3.72	5.72	

*Reclaimed wastewater effluent

**Sources of Water:
Primary= Wells 2,3,4,5,6,8, Maunalei

Secondary=Palawai (Wells 1,7,9,10) and beyond

Effluent=reclaimed water

Water Demand Associated with Build-out of Entitled Projects

Build-out of Existing Approvals / Partial Entitlements Could Create Demands Exceeding Sustainable Yields

Absent measures to mitigate withdrawals, existing partial entitlements in the form of Project District approvals, could cause demands to meet or exceed the sustainable yield of one or both aquifers. This is shown in Figures 4-59 and 4-60 of the *Demand Analysis* Chapter. Project Districts plus additional entitlements requested in the CCR proposals, plus non-company projects, would lead total demands to exceed the sustainable yield of the aquifer, as shown in Figures of the *Demand Analysis* Chapter. Build-out of the portions of Project Districts which already have Phase II approvals will lead to a total withdrawal of about 3.66 MGD. This assumes unaccounted-for water could be cut to 15% in the Manele Project District and Palawai Grid areas. At current island-wide unaccounted-for water rates, build out of the Phase II entitled portions of the Project Districts, without additional development in the Windward aquifer, could lead to exceedence of sustainable yield in the Leeward aquifer. These estimates are tallied in Figure 4-76 of the *Demand Analysis* Chapter.

CCR Proposals Include Project Elements Beyond Those In The Approved Project Districts

The CCR proposals indicate additional project elements beyond those already entitled or partially entitled. It also does not include all of the partially entitled project elements in the PD. Differences between build-out of proposals and project district entitlements are delineated in Figure 4-75 of the *Demand Analysis* Chapter. The 2006 proposal for Koele includes 90 Multi-Family units, 425 Single-Family units and 250 Hotel units, while the PD allows for 156 Multi-Family, 535 Single-Family and 253 Hotel units. In Manele, the proposal calls for 200 Single-Family units, 300 Multi-Family, 400 Hotel units, and 10 acres of Commercial area, while the PD allows for 282 Single-Family units, 184 Multi-Family units, 500 Hotel units, and 5.25 acres of commercial. CCR was asked in discussions whether it would be willing to trade additional elements noted above for project elements not included in its proposal. CCR personnel responded that they preferred to reserve the full PD approvals, even though these may not be built-out within the planning time frame. For example, the 2006 proposal raises the count of MF units in the Manele Project District from 184 to 300. At the same time, it omits 82 of the SF units allowed in the Project District. In this scenario, the full count of 200 single family units would still be built, so the net effect would be the addition of 116 MF units. The problem with this logic for Lanaʻi is that the existing approvals and the proposed approvals both have the ability to render demand higher than sustainable yield. Adding additional entitlement without benefit of clearly identified source raises concerns regarding sustainability of the aquifer. While it is understandable that any business would want to maximize the flexibility of its options, in this case it is recommended that such flexibility be obtained by trading some entitlements for others, rather than by adding more, until more is known about the response of the aquifer to build-out of existing entitlements. This will require interagency coordination. Figure 4-61 is a table of current Project District build-out status. Figures 4-65 and 4-66 are attempts to map this status into Phase I, Phase II and Phase III approvals. Some difficulty was encountered in mapping, as certain unit counts were not tied to specific counts on Project District maps. It is both recommended that this be addressed, and hoped that it may be already being addressed in preparation for the Community Plan process. In any case, discrepancies between proposals and Project Districts as approved, plus the addition of other projects not part of the Project Districts point to the need for both clear allocations and for convenient tracking mechanisms such as the maps described.

<u>Demand Generated From Project Approvals Is Not Immediately Apparent</u>

There is a time lag between when projects are approved and when their full water consumption is reached. Even once projects have been built, there is a time between construction and full occupancy. Therefore, it is possible that additional approvals could be issued before the full impact of already-approved developments is accurately known and gauged. A reviewing governmental body may ask for a comparison of present consumption figures, and incremental additional use represented by the project, without being fully aware of or able to visualize the magnitude of demand still pending. One way to limit the probability of this becoming an issue is to identify sources for each approval, including all existing and planned project elements anticipated to rely on those sources, and to proceed slowly and deliberately with regard to build-out.

<u>Econometric Trends from General Plan Update Data and Time Trends Both Indicate that the Natural Pace of Growth Would Be Slower Than That Proposed</u>

Forecasts range from 2.43 MG to 5.03 MGD, with the base case between 2.6 and 3.5 MGD. Build-out analysis, on the other hand, ranges from 6.08 to 7.13 MGD, or 5.66 MGD for Phase II. The recommended allocation is consistent with the SMS base case forecast at an elasticity of 1.5, allowing slightly more consumption than the base case and elasticity calculated for other communities on Maui, but not so much as full build-out.

Proposed and Empirical Unit Consumption Are Considerably Higher Than Standards

Both proposed and actual demands in the hot, dry Manele area exceed *System Standard* guidelines. However, in some cases hundreds or even thousands of gallons per day of brackish water are used, even when potable consumption is at or near zero. This and other observations led to the impression that occupancies of these single and multi-family residences can be low, while most of the water goes to irrigation. In turn, this would lead to a lower available return of reclaimed water per unit of build-out. The question was raised by LWAC and discussed at length as to whether per-unit consumption rates exhibited and proposed were reasonable. Water consumption by single family lots in Manele Project District averaged 3,700 GPD in 2008, with a high of over 9,000 GPD. Most of these are half-acre lots. Among the recommended measures are a tiered rate structure and a landscape conservation program with the objective of reducing per-unit consumption.

Conservation Potential

System wide unaccounted-for water averages about 0.633 MGD, or 28.36% of total production. There are several potential sources of such unaccounted-for water. Pipelines in the Palawai Irrigation Grid are old, deteriorated, and subject to high pressures. Leak detection has been performed by visual inspection, “walking the lines”, for years. This generally indicates an old system in poor repair. A leak has to be either quite large, or to continue for a long time, or both, before visible signs reach the surface. Other lines are old and sub-standard as well, such as the Kaumalapau line. There is a 15 MG uncovered reservoir where evaporation and other losses are suspected to be high. Also on the brackish system, some unmetered uses were found during the drafting of this document. There is a 1.5 MG covered reservoir which is over fifty years old but lined at the bottom only with old concrete. In addition, end uses demonstrate high per unit consumption, most of which is attributed to landscape. Landscape use is estimated at 1.1 MGD. Per unit consumption rates are high, with much of this going to the landscape. Hotel uses are about 0.27 MGD, roughly half of which is presumed to be outdoor use and included in the 1.1 MGD total. About 485,000 gallons of target savings have been identified in the Supply Options chapter of this document, and are included in the allocation proposal.

Green - Initial Water Level; Yellow - Action Level; Red - Lowest Allowable Level; Pink - Trigger for Designation Proceedings; Dotted - Pump Level, Thick Blue - Low Water Level; Thin Blue - High Water Level

Forest Management and Watershed Protection

Over 65% of the recharge in the primary high level aquifer is attributable to fog drip (Hardy, CWRM, 1996). Forested watershed is critical to maintaining water availability on Lanaʻi and yet the native forest on Lanaʻihale is diminishing.

The Lanaʻi Water Advisory Committee deemed watershed protection important enough to warrant an entire section of the Water Use and Development Plan. Through several community meetings, a fence alignment and plan to protect the watershed were agreed upon. Other protective recommendations are delineated in the *Source Water Protection* chapter and in the *Implementation Matrix*.

Aside from protective measures identified in that chapter, several policy questions relating to watershed protection were raised in the course of Water Advisory Committee discussions.

<u>Relationship of Forest Protection to Build-out of Entitlements</u>

Continued protection of the watershed, and most particularly construction of Increment III of the Lanaʻihale Fence, were deemed of utmost importance. One way to ensure that such protection continues is to tie continued protection of the watershed forest, and /or specific protective measures, to entitlements. Due to uncertainties as to the timing of construction of Increment III, the enclosure for the best remaining native watershed on the island, it was decided that construction of this fence should be linked to allocation table triggers.

<u>Provision for Forest Protection In Water Utility Rates</u>

Statewide, many utilities have objected to a mandatory provision to address watershed protection in the rates. However, one of the primary reasons has been that drinking water utilities throughout most of the Hawaiʻi are not the only, nor even the major users of water, and as such it seemed to be placing an unfair burden on utility customers. On Lanaʻi, there are no such complications. All drink from the same source and that source is dependent on the forest. Therefore, the financing plan proposed included watershed protection, specifically construction of the Increment III Fence, deemed crucial to the viability of remaining native watershed.

Aquifer Monitoring and Protection

With a low sustainable yield, declining forest cover, declining water levels and an ambitious build-out proposal, several members of the LWAC expressed concern about extending the life of the aquifer. Such concerns gave rise to the concept of the allocation plan discussed earlier.

In addition to recommended limitations on withdrawals, LWAC members discussed the idea that an allocation plan should include triggers of actions to be taken when pumpage reached certain levels. For instance, total island-wide withdrawals should not exceed those modeled in scenario 6 of Hardy's numerical groundwater model, without additional distribution of withdrawals or other actions.

The results of Hardy's numerical groundwater model indicated that the 13 sources modeled should be able to yield 3.52 MGD from the aquifer, without severe water level declines. However, pumpage is currently distributed between only 6 or 7 sources (one source pumps only 2,000 GPD), and, as noted elsewhere, water levels are declining. Some LWAC members have expressed some concerns about adequate distribution of withdrawals. The implementation chapter lists a schedule of near term, mid term and long term source improvements.

For the planning period, or until new sources can be brought on line to better distribute withdrawals, it is recommended that a minimum 10% resource reserve be maintained in each aquifer. This would enable pumpage impacts on the aquifer to be better evaluated before the full yield is utilized. This recommendation is consistent with other criteria used by the State, such as the criteria for designation of a groundwater management area in §13-171-7 of the State Water Code, which reads, "whether an increase in water use or authorized planned use may cause the maximum withdrawal from the groundwater source to reach ninety percent of the sustainable yield of the proposed water management area." It is also consistent with other CWRM actions, such as the 90% sustainable yield trigger that was set for Iao aquifer. This would limit pumped water to a total of 5.4 MGD, and water pumped from each aquifer to a total of 2.7 MGD during the planning period. A total of 600,000 gallons in resource reserve is included in the allocation plan. However, this amount does not affect other uses within the allocation plan, as each use was escalated separately with the planning time frame.

Key recommendations with regard to source development include:

- New source development should commence at or before the point total pumpage reaches 3 MGD (At current Well 6 pumping rates, this would be 2.7 MGD in the Leeward aquifer).
- Project build-out should take place at a pace that enables continued monitoring of the status of the aquifer and watershed.
- Build-out approvals should be contingent upon continued efforts to protect and preserve the watershed in Lana'ihale.
- Operational guidelines should be followed to avoid over-pumping and ensure adequate distribution of withdrawals.

Wellhead protection was also discussed. Protection of wellheads or potential future wellheads from potential contaminant sources is an important source protection measure. A wellhead protection strategy is presented in Chapter 6 of this document, as well as in Appendix F.

Operational Guidelines

Early LWAC discussions stressed the need for guideposts to help Committee members and water managers know when action must be taken to prevent over pumpage. Guidelines were proposed by CCR and reviewed by CWRM. These are described briefly in the *Source Water Protection* chapter. As stated above, it is recommended that these be followed.

System Monitoring & Maintenance

System monitoring and maintenance was at times a heated topic within the Lana'i Water Advisory Committee. The recommendations here are not strictly policy matters, but arise from the community's desire to have adequate information about the status and condition of the water system.

Maintenance

As demand for water and cost of electricity increase, maintenance will become increasingly important. Unaccounted-for water on Lana‘i presents opportunities to provide for demand while still extending the life of the aquifer. Replacement of old degraded pipe, leak detection equipment, pipe repairs, annual unaccounted-for water analysis and other measures are recommended to provide for source availability as well as to save money and resources. These are described in the Supply Options chapter.

Metering and Monitoring

Metering and monitoring have improved in recent years. Previously unmetered uses are now metered, and other improvements have been made. However, LWAC members have raised concerns regarding the Periodic Water Report

Maui County Ordinance 2408 stipulated that the total amount of non-potable water drawn from the high level aquifer that may be used for irrigation of the golf course, driving range, and other associated land-scaping, shall not exceed an average of 650,000 gallons per day, expressed as a moving annualized average using 13-28 day periods rather than 12 calendar months, or such other reasonable method as may be determined by the Maui County Council upon advice from its standing committee on water use. This was likely written to enable the company at the time to continue its 28 day reporting without disruption. Since that time the question of monthly reporting has come up repeatedly. The pumpage record goes back to 1926. For most of that record, either reporting was in fact on a monthly basis, or whoever maintained the data at the State reconciled it back to a monthly basis. In any case, the majority of the available record is recorded on a monthly basis. The system of thirteen 28 day periods started in 1981, continued to 1986, stopped for a time, and then resumed from 1987 to the present. Depending on how this is accomplished, there are some advantages to reporting both pumpage and withdrawals on a monthly basis. Today's meters are capable of recording historical flows, such that the flow at any chosen period can be derived. Unaccounted-for water analysis now requires that billing and pumping records be broken down and re-apportioned to the number of days in a month or period, in order to ensure that pumping and billing are examined for the same period. If flows from the same periods were utilized, then this process would be streamlined. However, there appears to be some hesitancy to make this change, because of the outstanding ordinance.

Another issue raised with the Periodic Water Report has been the break down of water service areas. As discussed in the *Demand Analysis* chapter, the periodic water report has a service area subtotal called "Manele, Aoki Diversified, Agriculture and Ag Activities near the Airport." This was apparently intended to maintain consistent data breakdown, but more accurately re-name what was once simply called "Irrigation" (in the days of pineapple). Based upon today's uses and service areas, this breakdown makes little sense. In terms of pumped water, there are two public water systems on Lana‘i, and essentially 5 service district areas, distinguished by sources and tanks serving them and by pressure zones. These are the Koele Project District Area, Lana‘i City, Kaumalapau, the Palawai Irrigation Grid, and the Manele Project District Area. The Manele Project District Area is further broken into fresh and brackish service. It would seem that the reports could be clarified by distinguishing these areas. Another item repeatedly desired by the committee was a more discernible breakdown of what amount of brackish water goes to the golf course vs. other irrigation, and what amount of potable water goes to irrigation vs. other uses, most especially in Manele.

Current billing user types maintained in the LWCI data base are shown in Figure 7-13.

FIGURE 7-10. **Use Types in Current CCR Database**

R. Residential						
C-Commercial						
G-Government						
Z-Community Gardens						
L-Non Resorts (Central, Plantation Homes, Iwiole, Commercial Homes, etc.)						
P-Four Seasons						
V-Development						

A further breakdown of residential multi vs. single family use is provided for Manele and Koele in the district code, but no such breakdown is provided for Lana‘i City. Current utility personnel are sufficiently familiar with the system to know which meters are which. The data system is clearly useful for internal accounting and operations, which would naturally be of highest concern to the utility. However, an additional field might be useful for auditing and reporting, as well as for rate-setting. Certain meters are classed in ways that are non-intuitive to an outsider - not incorrectly, but based as much on internal company operations as on the actual use class. For an outside analyst, or even an internal one, to go through and reclass each meter, even based upon personal familiarity with each, is a time consuming effort. For purposes of water audit, data reporting and other uses, it may be beneficial to add a field to the data base that breaks user classes out by more conventional use types. This could be done without any change to the primary breakdown and functioning of the database and may prove to be a useful option. It would be especially so, in fact maybe even necessary, if the proposed rate structure, or one like it, were established. Another value of such a change would be the ability to report more clearly on the status of build-out versus any agreed upon allocation. A more practical breakdown for planning purposes might be:

Single Family
Multi-Family
Commercial
Industrial
Hotel
Government
AgriculturalIrrigation
Other Irrigation

Rate Equity

While LWAC members had no objection to the use of desalinization as a major water source, some expressed concern that the expense of new source development to accommodate project district build-outs not burden the existing residents of Lana‘i, or that long-time residents not have to experience fees raised to a level to accommodate build-out growth.

The rate and fee structures proposed in the Supply Options chapter are designed to keep rates low for low water users, and to encourage conservation by sending a pricing signal to high water users. New source would be paid for by new meters or by the company.

Conservation Measures and Milestones

The Lana‘i Water Advisory Committee spent much time discussing high consumption rates per unit, system losses, unaccounted-for water, and the need for conservation. A few iterations of a draft conservation ordinance have also been presented to the LWAC. The most recent of these is attached as Appendix I. System wide unaccounted-for water in 2008 was roughly 28%, with about 13.5% in Lana'i City, 45% on the potable Manele / Palawai Irrigation Grid system, and 19% on the Brackish system. A target program was developed that included the following measures and targeted savings:

FIGURE 7-11. **Targeted Conservation Savings**

	Manele & Grid Fresh	Manele Brackish	Lanai City Koele & Kaumalapau	
Palawai Grid	200,000.0			200,000
Landscape	50,000.0	50,000.0	11,000.0	111,000
Fixture Replacement	20,000.0		80,000.0	100,000
Leak Detection & Repair	15,000.0	13,000.0	12,000.0	40,000
Hypalon Cover		14,000.0		14,000
Hotel & Landscape Incentives	12,000.0	6,000.0	2,000.0	20,000
Rate Structure				0

These measures may still fall short of achieving targeted unaccounted for water rates in one or more areas, particularly in the service area of Wells 1, 9 & 14. Additional reductions should be possible through additional landscape savings beyond the modest 10% prescribed or additional leak identification. Metering of previously unmetered services will also help to reduce UAFW, though it may not help to reduce pumpage.

Agricultural Reserve

There is strong conviction among certain community members that preservation of agricultural opportunities should not be lost. LWAC members expressed concern that build-out of the project proposals by CCR could preclude there being enough water for the planned Agricultural Park. Agricultural lands offer many benefits, including increased food security, and economic development opportunities. The recommended allocation plan includes a 500,000 GPD agricultural reserve, which is assumed to be actually withdrawn from the aquifer, as opposed to the resource reserve, which is not assumed to be pumped. Neither reserve affects water allocations to other uses within the planning time frame, as each class of use was escalated separately, and there was adequate water to cover uses and reserves based on the forecast coefficients used.

Issues Pertaining to Specific Supply Options

Selecting new source options always involves some trade-offs. Lana‘i is no exception.

Several good Leeward locations have been identified for new source, but at some point, these will start to provide only distribution of withdrawals, rather than additional source.

Development of a windward well is recommended, but this is not without challenges either. On the windward side, whether Maunalei or Kehewai are chosen, the transmission route will be long and expensive. The transmission route to Kehewai was designed in such a way to avoid damage to crucial habitat.

On the other hand, both the Maunalei and Kauiki options are in the greater ahupua‘a of Maunalei. During the Mahele of 1848, 19 individuals made 20 claims for property rights in the ahupua‘a of Maunalei. The entire ahupuaa was granted to Pane Kekelaokalani, a chiefly awardee (who filed two separate claims). At the close of the Mahele in 1855, at least 11 commoners claims were also granted. The clustering of kuleana lands deep in the valley of Maunalei include the claims for lo`i kalo (taro pond fields) and the associated water rights as protected by the Kuleana Act of 1850. At the time of this writing, it is unclear if any native claims remain to kuleana lands and water resources in Maunalei. It is noted that company maps dating from 1929 to 1993 still identify possible lots in the valley to which such water rights might appertain. It is suggested that a definitive study on the native tenant rights and disposition of land ownership be determined prior to final settling of water usage in Maunalei.

Desalinization is still expensive, and proper disposal of brines can prove difficult. CCR will need to accommodate the fact that marine waters surrounding Lana‘i are Classed AA under HAR §11-54-3. The objective of Class AA waters is that they remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused sources or actions. To the extent practicable, the wilderness character of these areas must be protected. No zones of mixing are permitted in this class.

Community Plan Consistency

The Maui County Charter, §8-11.2(3) requires that the Water Department’s Long Range Plan conform with the County’s general and community plans. The last version of the Lana`i Community Plan was adopted by the Maui County Council on December 8th, 1998. An update of the plan is expected shortly, However, some of the goals, objectives, policies and implementing actions that pertain to water issues within the old plan are attached as an Appendix J, with comments as to how this WUDP addresses those items.

CHAPTER 8

Implementation

The Matrix below identifies a categorized list of impelementing actions that could further the intent of the Lana‘i Water Use and Development Plan

Abbreviations used in the Implemenation Matrix are as follows:

CCR	Castle & Cooke Resorts, LLC.
DOE	Department of Education
DOFAW	DLNR - Division of Forestry and Wildlife
DOT	State Department of Transportation
DWS	Department of Water Supply
LF&WP	Lana‘i Forest and Watershed Partnership
LWAC	Lana‘i Water Advisory Committee
LWCI	Lana‘i Water Company Inc
MCC	Maui Community College
USDA	United States Department of Agriculture
US F&WS	United States Fish & Wildlife Service

FIGURE 8-1. Implementation Matrix

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
I. INFRASTRUCTUREMAINTENANCE, OPTIMIZATION & SUPPLY-SIDE MANAGEMENT STEPS			
	Develop or update storage inventory. Size, volume, geometry, age, materials, condition, fill cycle issues, leaks, estimated remaining useful life, potable or reclaimed, service zones, controls and call levels, inside lining, existing maintenance schedules, etc.	LWCI	Annual Update
	Evaluate costs and create or update ongoing tank and reservoir refurbishment schedule -annual, 5 year, Longer. 5 year storage CIP.	LWCI	Annual Update
	Develop or Update Pump Facilities Inventory. Model, Speed, Rated Head, Motor HP, Performance against manufacturers curves (efficiency), Control Configurations, Well or Booster, On-Off calls, Chemical Feeds (chlorine, corrosion control, other), Backup Power source, land use for source pumps, chlorides, water level fluctuations, etc. Last Replacement, Next scheduled maintenance, etc.	LWCI	Annual Update
	Compile 5 year pump maintenance & replacement schedule, including updated pump efficiency curves and calibrated efficiencies.	LWCI	Annual Update.
	Develop and /or update inventory of transmission and distribution lines in the system; from and to points, diameter, material, install dates, leakage or breakage problems, pressure and flow status, etc. leak or breakage history, etc.	LWCI	Near. Ongoing.
	Identify replacement and upgrade priorities for line repair and replacement and compile 5 year schedule	LWCI	Regular Updates

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Implement hydrant maintenance program: operate, flush periodically, check drain rate, lubricate when needed, check, pressure, replace older hydrants as needed	LWCI	Annual Update.
	Perform or maintain similar inventory and maintenance schedule development for all system elements as well: valves, meters, treatment facilities, generators, etc.	LWCI	Annual Update
	Acquire leak detection equipment and or borrow/ rent same. Perform& document regular leak detection on system.	LWCI	Near
	Perform annual unaccounted-for water audit.	LWCI / Possibly help from DWS.	Near
II. INFRASTRUCTURE & CAPITAL & MAINTENANCE PROJECTS			
	Replace Deteriorated Palawai Grid Pipeline	LWCI	Near
	Install Floating or Hypalon Ball Cover on 15 MG Brackish Reservoir	LWCI	Near
	Replace old asbestos segments in Lanaʻi City	LWCI	Near to Mid
	Replace deteriorated Hiʻi Tank and 50 year old concrete lined Hiʻi Reservoir with new 2 MG Tank	LWCI	Near to Mid
	Replace Old Substandard Pipeline to Kaumalapau	LWCI	Mid
	Replace Old Steel Line Segments in Lanaʻi City	LWCI	Mid
	Drill Well 15 to distribute brackish withdrawals	LWCI	Near term
	Replace Well 2-A to increase ease of operability and for better reliability.	LWCI	Near to Mid

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Replace Well 3 or drill new well that will serve same purpose for improved reliability and distribution of withdrawals.	LWCI / LHI	Near Term
	Replace Old Line Segments in Northwest End of Irrigation Grid	LWCI	Mid-Long
	Improve pump system to reclaimed reservoir especially around lower 9 at Koele. (can't pump out of reservoir as needed)	CCR	Mid
	Evaluate possible improvements to reclaimed water treatment facility and storage. Make any necessary improvements	CCR	Mid to Long
	Install additional wells for distribution to prevent declining water levels or over-use of either aquifer. Options identified in Chap 5.	LHI	Near, Mid & Ongoing
III. DEMAND-SIDE MANAGEMENT STEPS			
	Retrofit indoor fixtures including but not limited to 1.28 GPF toilets, showerheads, faucets, efficient clothes washers.	LWCI	Replacement in Proposed rate structure. Near to Mid term.
	Implement water conservation measures aimed at reducing outdoor usage (Conservation measures are more cost effective the earlier they get done.)	CCR; LWAC	Near and Ongoing
	Establish additional ET/weather stations for improved drought prediction, fire prevention and conservation.	LWCI, CCR, DLNR	Some existing. Additions Near and Mid.
	Review & update design guidelines and plant list	CCR; Planning Dept.	Near to Mid term
	Support establishment of certification program, and of certified source of native stock to protect existing communities of appropriate plants	CCR LWCI;	As Appropriate

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Identify and map areas where turf or other high-water-use plants are featured, and prioritizing them for retrofit - i.e. seeking places that can be converted to less thirsty plants.	CCR; Hotels, LWCI,	Near to Mid term included in rates
	Maintain and expand native plant nurseries; possibly with grant funding assistance -also establish or help other "certified" nurseries - as may be established, for example by Hui Malama, MCC or others.	CCR, LFWSP, DLNR, FWS	Increase focus on native & drought-tolerant non-invasive plants. Near to Mid term.
	Annually examine "per-unit" water use information; by customer class, location, size of meter, end uses; etc. Develop targets for reduction.	CCR;	Near to Long
	Develop tiered rate structure to encourage conservation, leave rates low for base "life-line" amount; increased rates for excessive use.	LWCI, LHI, CCR, PUC, Public	Proposed in Plan, PUC case in Near term.
	Revisit and consider conservation ordinance; including county-wide public review;	LWAC, LWCI, Public, Council	Near to Mid term
	Offer incentives and assistance to local hotels and businesses. Assist with pre-rinse spray nozzles, incentives for cooling efficiency improvements, efficient laundries, and other measures mentioned in Chapter 5.	LWCI	Included in proposed rate structure. Near to Mid term.
IV. WATER CONSERVATION OUTREACH & EDUCATION			
	Develop a "walking tour" of native/demonstration landscapes: identifying projects that have been well-landscaped with native plants;	Cultural Center, Conservation Dept., Community Groups, possibly Hotels, Schools	Mid

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Partner with other Community Resources to provide well-rounded education and outreach for landscape and other conservation opportunities.	Conservation, Cultural Center, MCC, Hui Malama and others.	Near Term and Ongoing
	For new developments, utilize native or non-invasive non-native plants to the maximum extent possible in landscaping	CCR other developers incl. government	Near, Mid and Long, Ongoing
	Re-plant selected hotel properties with native plants - secondary to restoring natives on the hale	CCR; Hotels, LWCI assistance program, Conservation Dept., help from Community Groups & Cultural Center as applicable.	Near to Mid and Long term. (should commence near term, and continue).
	Demonstration projects: community gardens, plantings etc. establish demonstration gardens at various sites. Note that the last community plan also stated that this be should done at government sites.	CCR; Conservation Dept., DOE County/State govt., Cultural Center, Community Groups as applicable.	Near and continuing
	Establish set of qualified speakers on various conservation topics. Visit schools & community groups, offer classes.	LWCI; CCR, MCC, Conservation Dept. Partner with others as applicable.	Near
	Conservation ads in Lana‘i newspaper(s).	LWCI, CCR, Other co-sponsors as available.	Near

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Ads for radio, movie screen, other venues	LWCI, DWS	Near. DWS has Many Ads, can share.
	Ads for movie-screen	DWS; CCR	Optional
	Posters	DWS; CCR	Mid
	Information on and periodic distribution of appropriate plant types	CCR, BWS	ongoing arbor day upgrade with nursery Near to Mid & ongoing
	Maintain list of appropriate plant species. Review and update Urban Design Guidelines accordingly.	DWS; Planning Department; DLNR, HEAR Lana`i Planning Commission	Ongoing. Needs improvement. Near
V. SOURCE WATER PROTECTION			
	Conduct additional fog drip studies in order to refine recharge estimates. Update Lana`i Water Model accordingly.	CWRM; UH; USGS; CCR, DWS?	Study on Cooke Pine throughfall completed. No review of native forest.
	Adopt the well operating management guidelines in the plan; monitor performance against same.	CWRM, LWCI CCR	Included in Plan. Implementation Near, Mid & Long.
	Draft wellhead protection strategy and ordinance discussed with LWAC, needs broader community presentation and discussion.	DWS, LWCI, CCR, Public	Near
	Distribute withdrawals such that no more than 2.7 MGD each are pumped from Leeward and Windward Aquifers during plan period.	LWCI, LHI	Near to Long Term

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Establish an ongoing watershed management program with special emphasis on preserving native ecosystems and maximizing the fog drip component of the watershed	LFWP, DWS, US F&WS, DOFAW, County CCR, CWRM, NRCS,	Ongoing Long-term
	Continue to Identify Potential Sources of Funding, Including Appropriations, Assessments, Contributions, Grants, Donations from Public and Private Sources, and Recommend Funding Sources	CCR Conservation, LF&WP	Near term and Ongoing
FENCING			
	Monitor the integrity of existing fences	CCR, LF&WP, USF&WS	Ongoing and Near
	Select appropriate fence materials for new fences or fence segment replacements, such as triple dip galvanized with welded seams, treated against corrosion, alloy, even plastic fence, consider fence materials researched at Kalaupapa, consider increase in height or visual barrier to deter deer	CCR; LF&WP, USF&W	Increment 1 Completed Increment II in Progress Increment III still pending.
	Ground and aerial survey of new Increment III alignment & surrounding areas; set proper alignment vis a vis terrain and rare species communities; survey area to insure that populations of important snail, insect or plant species are not disturbed, or that such disturbance is minimal & mitigated	CCR; LF&WP, USF&W	Increment I completed Increment II Near Increment III Near.
	Resolve access issues. Additional gates needed. Gates at Hi‘i Bench, East and West Hauola. Koolanai and Waiwaiku need gates. Vandalism could lead to more animals in Hale.	CCR; Community	Mid Term.

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Maintain fence regularly	CCR Conservation, with help from other forest partnerships as needed.	Mid to ongoing
	Maintain buffer zones around fence	CCR	Mid to ongoing
FERAL UNGULATE MANAGEMENT			
	Inside Fence		
	Herding effort to move deer out of each new increment of fenced area - foot, helicopter, etc.	CCR, DOFAW	Increment I - Done. Increment II - Near Increment III Near.
	Allow residents to hunt within fence first - ongoing staffed hunts if needed	CCR, DOFAW	Increment I - Done Increment II - Near Increment III - Near to Mid
	Hunting to elimination within fence for protection of watershed,	CCR, DOFAW, LFWP, Community	Mid to ongoing
	IF NECESSARY - Aerial hunts, spotlighting, snares, or traps if necessary in designated elimination areas -esp. remote areas, or where animal numbers are not dropping	CCR, DLNR	last resort only
	Outside Fence		
	Manage populations outside of fence	CCR, DLNR	Near term & continuing
	Investigate use of repellents, non-forage distasteful plants, other methods along buffer strip / corridor on outside of fence to discourage deer from approaching or trying fence	DLNR, USF&WS, CCR Conservation	Mid to Long

	Continue to investigate other "non-kill" options that may be used with hunting: catch & transport; repellents, sterilizers, habitat alteration, etc.	DLNR, USF&WS CCR Conservation	Mid & continuing
	Provide training or review, as appropriate and necessary for certified volunteer hunters.	DLNR - license CCR - forest entry etc.	ongoing & continue
	Improve harvest reporting protocols and data. Harvest report should go to one central repository, such as DLNR-DOFAW	DLNR, Hunter Advisory Group, CCR	Near
OTHER ANIMAL MANAGEMENT			
RODENTS			
	Survey area to determine priority locations for treatments highly susceptible plant, bird or snail communities signs of excessive rodent activity	DLNR, USF&WS; LF&WP, CCR	Ongoing DLNR Conservation as needed
	Determine appropriate treatment schedule all year, or at least during fruiting/seeding of target native plants?	DLNR, USF&WS; LF&WP, CCR	As appropriate
	Eliminate rodents using traps, bait, other methods	DLNR, USF&WS; LF&WP; CCR	As needed
	Perform follow-up documentation and monitoring to evaluate usefulness	DLNR, USF&WS; LF&WP; CCR	Mid & continue as needed
INSECTS			
	Survey as needed to determine priority pests for removal based on threat to remaining target communities: mosquitoes, chinese rose beetle, chinese leaf hopper, others	DLNR, USF&WS; LF&WP; CCR	Mid & continue
	Research other removal experience with target insect pests determine protocols, spraying, equip needed, etc.	DLNR, USF&WS; LF&WP; CCR	Mid & continue as needed

	Implement removal protocols	DLNR, USF&WS; LF&WP; CCR	Mid & continue as needed
	Perform follow-up documentation and monitoring to evaluate usefulness	DLNR, USF&WS; LF&WP; CCR	Mid & continue as needed

FIRE PROTECTION

	This is especially. important on Lana`ihale, since the native Hale plants are not well adapted to fire. Efforts should also address management of surrounding lands, including those taken out of pineapple.		
	Consult with other fire management agencies to review existing fire plan as related to Lana‘i Hale protection.	DLNR, Fire Dept.; CCR	ongoing, re-evaluate Near to Mid
	Survey plant communities in pristine areas, fire prone areas	CCR	Mid
	Map & prioritize fire prone areas.	DLNR, Fire Dept.; CCR	ongoing, re-evaluate Near to Mid
	Inventory response crews, response times, etc.	DLNR, Fire Dept.; CCR	ongoing, re-evaluate Near to Mid
	Inventory/ obtain as needed emergency equip (helicopters/strategically placed reservoirs, water trucks, etc.)	DLNR, Fire Dept.; CCR	ongoing? re-evaluate? Near to Mid?
	Develop improved access as necessary (careful not to spread weeds).	DLNR, Fire Dept.; CCR	Mid
	Develop and conduct regular training, and/or joint training programs for fire fighting crews.	DLNR, Fire Dept.; CCR	ongoing & continue? or Mid?
	Review and update prioritized response plan as appropriate.	DLNR, Fire Dept.; CCR	ongoing, re-evaluate Near to Mid

Implementation

	Construct fire breaks or buffer zones as appropriate	CCR	Mid to Long
	Remove/ eradicate fire-inducing or fire-carrying weed species, especially in areas where small populations mean that a single catastrophic fire could eliminate the entire remaining population of a species. (Ex. Tetramolopium remyi)	CCR	Mid to Long
	Establish “fire-free” use zones	CCR	Mid to Long
	Heighten public awareness of dangers	CCR	Mid

REMOVAL OF NON-DESIRABLE PLANT SPECIES

	Survey area to locate and prioritize weeds for removal, based on aggressiveness of weed species; extent of spread; proximity to rare species; etc. - (ex.guava, eucalyptus, christmas berry, ironwood)	LF&WP; CCR; DLNR	Mid (after fence Phase I completion)
	Remove target weeds from selected areas by hand or mechanical removal; possibly with selective use of herbicides or bio-controls where appropriate	LF&WP; CCR; DLNR	Mid (after fence Phase I completion) to Long & continue
	Follow/up to remove re-germination	LF&WP; CCR; DLNR	Mid to Long and continue

PROTECTION FROM PATHOGENS, DISEASES

	Identify pathogens of concern to Lana`i watershed species communities. Possible examples include but are not limited to: _“Spike disease”- harmful to sandalwoods in India, believed to be in HI _Santalum seed fungus - destructive to viability of seeds (sandalwood) _Santalum heart rot _Others~~?~~	LF&WP; DLNR US F&W	Mid to Long term and continue

	inventory disease problems affecting key species, known management strategies	LF&WP; CCR; DLNR	Long
	enhance quarantine & inspection to prevent further introduction	LF&WP; CCR; DLNR, DOT	Long
	implement treatment options where identified	LF&WP; CCR; DLNR	Long

EROSION MANAGEMENT & REFORESTATION

	Survey & select realistic / effective areas for management	CCR; LF&WP	Mid & continue
	Eliminate animal stresses that perpetuate erosion cycle	CCR; LF&WP	Mid & continue
	Strategic planting	CCR; LF&WP	Mid & continue
	Mycorrhizal inoculants can aid the establishment of outplanted seeds (down side?)	CCR; LF&WP	Mid to Long as appropriate
	Wattles and other soil trapping devices. silt basins?	CCR; LF&WP	Long
	Establish native plants on newly trapped soil	CCR; LF&WP	Long
	Outplant species grown ex situ.	CCR; LF&WP	Mid
	Seed broadcast	CCR; LF&WP	Mid to Long as appropriate

	Perform complimentary actions aimed at restoration of native populations of insects, forest birds, sea birds, snails, etc. These will also help to restore and improve the nutrient cycle of the soil, healthy litter layer, etc. For example, Snails and insects provided important quantities of biomass & nutrients; Sea-birds provided nutrients such as nitrogen, phosphorous, etc. Insects helped to break down fallen trees, aided in decomposition and soil amendment. and provided biomass. restoration of these populations will also improve the health of the soil.		
MONITORING AND EVALUATION			
	Establish & Maintain Monitoring Transects Using Standard Accepted Methodologies (point-line intercept or etc.)	CCR; with help from LF&WP	Mid to Long as appropriate
	Collect Data on Soils, Stream Flows, Rainfall & Other parameters	CCR; with help from LF&WP	Long & continue as appropriate
	Perform aerial and field survey, photography and mapping to inventory and characterize resource health	CCR; with help from LF&WP	ongoing & continue periodically
	Monitor, map and inventory on a regular basis to keep track of changes in plant communities, animal communities, ungulate activity, erosion, etc.	CCR; with help from LF&WP	Mid to Long & continue
	Survey and map major communities, threats, measures	CCR; with help from LF&WP	Mid to Long & continue
	Map monitoring plots, size and class of plants inside (desirable and non-desirable)	CCR	Mid to Long & continue
	Perform scheduled field checks	CCR	Mid & continue
	Perform additional checks after unusual events, catastrophes, etc.	CCR	Mid & continue
	Photo plots - especially plant communities - to monitor recovery / loss	CCR	Mid for baseline & continue

	Water / soil gauges other special equipment for monitoring fog drip, etc.	CCR, LHFWP DLNR/ CWRM, USGS. UH	Mid to Long
	Provide report of quantitative and qualitative data w/ photos and maps	CCR	Mid for base-line & continue

CONTROL OF INCOMING SPECIES

	Adequate screening and quarantine for incoming agricultural goods and plants	DOT, DLNR, USDA; CCR	Long
	Education of public / landowners on dangers of bringing in exotic species, potential contaminants	LF&WP; CCR; DLNR, DOT, USDA	Mid to Long
	Set up procedures to avoid introduction of non-desirable plants OR plant pathogens	LF&WP; USDA CCR; DLNR, DOT	Long
	Set up procedures to avoid introduction of non-desirable insects or insect pathogens	LF&WP; CCR; DLNR, DOT	Long

PROTECTION FROM HUMAN ACTIVITY

	Protect species prone to gathering by humans. For example, Sandal-wood has been subject to removal by individuals seeking the heart wood, due to its high economic value.	CCR LFF	Long
	Develop and enforce protective measures: no collection of special species limit forest entry in selected areas such as exclosures, etc. proper forest entry practices, maintain a regulatory presence in the watershed, post signs for limited entry or special access concerns manage public activities and education interagency cooperation for these	CCR with help from members of LF&WP	Long
	Develop a recreational use plan for human activities in the watershed	CCR with help from members of LF&WP	Long

Implementation Matrix

	Insure that existing protections are followed, and continue to evaluate the need for and support additional measures as appropriate Existing Legal & Regulatory Protections include the following: "It is illegal to remove, cut dig up, damage or destroy an endangered plant in areas not under Federal jurisdiction in knowing violation of any State law or regulation or in the course of any violation of a State criminal trespass law. (ESA §9(a)(2)) Hawaii State Law prohibits taking of endangered flora and encourages conservation by State government agencies. "Take" means to harass, harm, collect, uproot, destroy, injure or possess endangered species of land plants, or to attempt to engage in any such conduct (HRS 195D-5(d))	CCR with help from members of LF&WP DLNR	Long

PEER REVIEW MANAGEMENT PLANS & IMPLEMENTATION TO AVOID MANAGEMENT ERRORS

	Establish a regular system of inter-agency review to help avoid and /or correct errors such as the following: fencing without adequate monitoring, fencing without weed removal over-collection of seeds damage or spread of pathogens by incorrect collection of tissue cultures, careless management on part of humans (human trampling, unmonitored actions, etc.)	LF&WP	ongoing and continue

MANAGEMENT RECOMMENDATIONS TO PRESERVE NATIVE BIRDS

Benefits of protecting remaining bird species and possibly restoring bird populations:
Birds serve(d) various beneficial functions in the watershed, including:
direct pollination of native plant species
seed dispersal (ex: amakihi ate fruit and insects, spread seeds in feces)
source of nutrients (esp from sea-bird feces)
possible additional non-identified roles, as birds were integral part of ecosystem
rare native plants may benefit from having native birds that served to pollinate and spread seeds restored.
nutrient cycles, as affected by seabirds may effect soil and plant health by returning nutrients to soil

	Protect habitat - including steps to preserve plant communities, snails, insects, etc.	CCR with help from members of LF&WP	ongoing as part of other plan elements.
	Prevent predator entry - fencing (*fencing will not keep out chief bird predators, but may reduce spread of weeds that attract them, reduce disruption of habitat, etc.*) adequate quarantine baiting predators	; LF&WP CCR	fence ongoing quarantine, Long term baiting, Long term
	Remove rats and cats from native bird habitats - catch, bait, etc.	CCR; LF&WP	Long

	Prevent entry of non-native birds - (avoid disease, competition)	CCR; DLNR, DOT	Long
	Prevent entry of mosquitoes and other problem insects	CCR; DLNR; DOAg; DOT	Long
	Control mosquitoes at breeding sites - insecticides, sterilizers, introduction of sterile or non-carrier mosquitoes	CCR; DLNR, Dof Ag; DOT	Long
	Specific strategic management of existing seabird colonies for enhanced protection	CCR; DLNR, DOT	Long
	Appropriate adjustments to fencing, such as flagging or etc. Fence must be visible to prevent birds from crashing during night landing. white flagging on top can help.	CCR; LFWP DLNR	Mid to Long
	Intensive rat & cat control	CCR; DLNR,	Long
	Consider carefully managed re-introduction programs for amakihi, i`iwi, maui creeper, others	CCR; DLNR, USF&WS	Long
	Preserve Lana`i specific genetic material.	CCR; DLNR, Bishop, NTBG, USF&WS	ongoing, continue and Long
	Consider minimum habitat size for sustainability of bird populations in deciding on deer fence option	CCR; DLNR, USF&WS	Mid to Long with Phases II and III
	Encourage sea birds to return by establishing safe, predator-free sites for them	CCR; DLNR, USF&WS	Long - as part of general plan elements

	In order to successfully maintain existing apapane and seabird populations, and /or to restore previously existing species with close approximations (Maui equivalents) - adequate disease free habitat extent will be required.		
MANAGEMENT RECOMMENDATIONS TO PRESERVE NATIVE SNAILS			
	Preserve habitat, esp. upper elevation wet forest.	CCR with help from members of LF&WP	ongoing as part of other plan elements.
	Encourage reforestation with native species. Many non-natives, including Cook Pines and Eucalyptus, are not good hosts for native snails...(although snails have been found on some non-native plants where they are intermixed with natives).	CCR with help from members of LF&WP	ongoing as part of other plan elements Cook Pine area will be preserved, but extent of Cook Pine area will not be extended
	Enforce ban on collecting	CCR w/ LF&WP members	Long
	Educate public on damage caused by collecting	CCR w/ LF&WP members	Long
	Eliminate rat predation *(see also rodent control section)*	CCR w/ LF&WP members	Long
	Eliminate predatory snails, if applicable	CCR w/ LF&WP members	Long

	Prevent entry of non-native snails & slugs to avoid possible intro of diseases. CARE MUST BE EXERCISED in designing control of slugs. poisons designed to eliminate slugs would also be likely to affect snails. Slugs don't generally hurt snails, but there are no native slugs in Hawaii, and there is some chance that they could be a source of introduced disease, competition or habitat loss. slugs do appear to damage certain native plants If any poison or bait were used to control snails, it should be limited to extremely LOCAL applications in areas where it was fairly certain no native snails were present.	CCR w/ LF&WP members	Long
	Captive rearing and reintroduction as appropriate	DLNR, Bishop, USF&WS,	Long
	Construct and maintain exclosures for snails There are various means of constructing snail exclosures. one example is described here, but the design would be selected by the UH, USF&WS, DLNR or others as appropriate. this exclosure is roughly waist high. they are constructed of painted, corrugated aluminum roofing. a trench is dug, and in that trench the fence is installed with its foot buried about 6" into the ground, at the top of the fence is a shed-like "roof" that protrudes to either side. under that "roof" are two additional barriers, a trough of large crystal salt, and a 2-wire electric fence, constructed of two thin wires spaced 8mm apart. The electric wires are powered by solar panels mounted on the inside of the exclosure. the largest such exclosure currently existing is about 40x25 meters. Rat bait boxes may be placed on the outside of the exclosures for further protection. Tree limbs and other branches should be prevented from touching the fence exclosure structure, as they may provide a path for predators.	DLNR, Bishop, USF&WS, UH, others	Long
	Consider careful removal of non-native plant species where appropriate, and replacement with native species. (again, this measure requires exercise of care to insure that no snails are sitting on the plants to be removed)	CCR with help from members of LF&WP	ongoing

	In cases where native snails seem to be adapting to introduced plants, selective use of these non-native plants may be considered. Snails that seem to be exhibiting adaptation according to Severns (conversation) include: Partulina variabilis, and Partulina semicarinata		
MANAGEMENT RECOMMENDATIONS TO PRESERVE NATIVE INSECTS			
	Protect native habitat on which native insects rely, especially host plants	CCR with help from members of LF&WP	ongoing as part of other plan elements.
	Eliminate non-native predator insects, especially yellow-jackets and ants. Possible methods include: pheromone traps; find and destroy nests with freezing or insecticides; bait as appropriate	CCR w/ LF&WP members	Long
	Develop improved quarantine measures and other controls to prevent entry of non-native insects	CCR; DLNR, Dof Ag; DOT	Long
	Monitor native insect populations to determine species requirements, critical habitat, population size, etc.	CCR; DLNR, USF&WS, others	Long
COLLECTION AND MAINTENANCE OF GENETIC MATERIAL			

	Inventory existing ex-situ populations & identify needs for more, if any	CCR; DLNR, USF&WS, others	Mid to Long
	Involve experts in collection of seeds, live plants, plant tissue	DLNR, Bishop, USF&WS, UH, others	Long
	Maintain ex-situ seeds, live plants, plant tissue, plant populations	DLNR, Bishop, USF&WS, UH, others	Long

	Note: Ex situ collections must be managed with care to avoid in-breeding, collection of genetically weakened specimens, cross-contamination of genetic material with other variations of the species Should be handled by outside experts such as NTBG, Bishop Museum, University, or other qualified organizations.

SELECTIVE AUGMENTATION / RE-INTRODUCTION OF SPECIES

	See cautions above. It is important that such projects be carried out with close attention to proper collection and identification of appropriate seed sources, as well as care to avoid contamination in nurseries, germination media, plant materials		
	Identify priorities for restoration efforts. Rare species, important species, etc. Restoration of certain plant, bird and insect species may help to restore and improve pollination opportunities. plants provided food for birds and insects, forest birds and insects provided important pollinators. Restoration of these components will help support a healthy ecosystem.	DLNR, Bishop, USF&WS, UH, others	Mid to Long
	Identify appropriate sources (seed collection, ex-situ collections, etc.)	DLNR, Bishop, USF&WS, UH, others	Long
	Identify and obtain necessary equipment	DLNR, Bishop, USF&WS, UH, others	Long
	Survey and prepare out-planting sites	CCR w / DLNR, LFWP Bishop, USF&WS, UH, others	Long
	Protect, monitor and maintain out-plantings. (consider smaller exclosures)	CCR w / DLNR, LFWP Bishop, USF&WS, UH, others	Long

PREVENTION & EARLY DETECTION

	Through wind dispersion and other means, plants introduced in only a few sites well outside the watershed can and do spread to the watershed. Through active identification efforts, plants may be detected at earlier stages of naturalization, or even prior to naturalization, avoiding widespread damage.		
	Develop a database of cultivated and naturalized non-native species on the island of Lana`i through survey of nurseries, botanical gardens, parks, hotel and other public landscape and other likely introduction sites.	CCR w / DLNR, LF&WP DOT	Long
	Cross check data on naturalized species in Lana‘i with databases of historically invasive plants in similar climates elsewhere. The best predictor of invasiveness for most taxonomic groups is a record of invasiveness in similar climates elsewhere in the world. Cross-checking these lists may help to identify species of concern.	CCR w / DLNR, LF&WP DOT	Long
	Develop and/or refer to existing species reports for targeted species, summarizing both literature and field research, and include results from gps data collection and distributional mapping, as well as information on attributes of other invaded ecosystems, control data, and so forth. A potential protocol for obtaining and structuring such information has been developed and implemented in Maui.	CCR w / DLNR, LF&WP DOT	Long
	Monitor likely routes of introduction, such as roadsides, parks, refuse sites, vacant lots, harbors, airports and residential areas for new communities of potentially invasive species. Many of the key corridors by which invasive alien species are introduced are not the same areas where active management transects are located.	CCR w / DLNR, LF&WP DOT	Long

ADDITIONAL RESEARCH ON TARGETED PLANT COMMUNITIES
The following have been identified as research items which may help the project over the Longer term. This research may not be performed as part of Lana‘ihale management. However, funding of such research would be consistent with WUDP watershed goals.

	Associated ecosystem components	DLNR, Bishop, USF&WS, UH, others?	Long
	Relations between native plant communities / birds / insects (pollination, feeding, etc.)	DLNR, Bishop, USF&WS, UH, others	Long
	Critical habitat size / population size for species viability	DLNR, Bishop, USF&WS, UH, others	Long
	Growth and mortality at various stages of plant life, seasonal changes	DLNR, Bishop, USF&WS, UH, others	Long
	Optimum conditions for reproductive vitality, flowering/seeding conditions	DLNR, Bishop, USF&WS, UH, others	Long
	Light requirements at various stages of life	DLNR, Bishop, USF&WS, UH, others	Long
	Water, soil & nutrient requirements at various stages	DLNR, Bishop, USF&WS, UH, others	Long

	Pollination vectors, seed dispersal	DLNR, Bishop, USF&WS, UH, others	Long
	Means to compensate for missing pollination vectors or other key-stone habitat concerns	DLNR, Bishop, USF&WS, UH, others	Long
	Minimum numbers needed for populations to be stable susceptibility to inbreeding	DLNR, Bishop, USF&WS, UH, others	Long
EDUCATION AND COMMUNITY OUTREACH			
	Rare plants and their value Importance of watershed / importance of biodiversity Non-desirable plants and the threats posed by them How to enter forest / other areas while causing minimal risk of doing harm Dangers of open flames, esp. in certain areas Plant walks outside critical areas Deer impacts to environment / water resource Importance of watershed / biodiversity Plants of concern Appropriate forest entry practices	CCR w / DLNR, LF&WP members	Near & continuing upgrade
	Create pool of docents Field volunteer training Recruiting Reporting	CCR w / DLNR, LF&WP members	Near & continuing upgrade
	Workshop and lecture series Uses of plants in native culture Value of native resources Importance of watershed and connection with native vegetation Plant, animal and bird identification Threats & Long term effects of unabated threats (Rapa Nui lesson)	CCR w / DLNR, LF&WP members	Near & continuing upgrade

	Solicit community input and contributions to educational efforts Link w/ other environmental agencies / develop partnerships	CCR w / DLNR, LF&WP members	Near & continuing upgrade
	Develop guided hike program / field trips to biological and cultural sites Trained docents as leaders Prepared informational materials Vehicles and logistical support	CCR w / DLNR, LF&WP members	Long
	Prepare interpretive materials for use in both community and by visitors Booklets, pamphlets Web sites Public access programs	CCR w / DLNR, LF&WP members	Mid & continuing upgrade
	Identify and implement volunteer projects Weed control Restoration activities - outplanting, nursery, maintenance, erosion control Fence building and repair Hunting	CCR w / DLNR, LF&WP members	Mid to Long
	Develop native resources curriculum for the schools	CCR w / DLNR, LF&WP members	Near & continuing upgrade
	Develop and implement Long-term alien species awareness and prevention program Seek grant funding to develop a video Develop a tie-in with the local business community	CCR w / DLNR, LF&WP members	Long
	Establish media contacts for coverage of projects both local and statewide dissemination Regular means of communicating relevant information to the community	CCR w / DLNR, LF&WP members	as appropriate

	Utilize existing community special events as venue for promoting education and increasing viability of projects: Aloha Festival Health Fairs Pineapple Festival Other Cultural Events	CCR w / DLNR, LF&WP members	Long
	Provide update on status of watershed and protection activities to LWAC and or to the Lana‘i Planning Commission twice per year.	CCR Con-servation	Near and Ongoing

February 25, 2011 DWS Amended Draft

LANA‘I ISLAND WATER USE & DEVELOPMENT PLAN

APPENDICES

Appendices

APPENDIX A

Final Report of the Lana'i Water Working Group

The *Final Report of the Lana'i Water Working Group*, also known as the *1997 Draft Water Use & Development Plan for Lana'i* is attached and incorporated in its entirety.

DRAFT
WATER USE
AND
DEVELOPMENT PLAN
FOR
LANA'I

Prepared by:
Lana'i Water Working Group
P.O. Box 86
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February 1997

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The Group also expresses its appreciation to Ms. Rae Loui, Deputy Director, Commission on Water Resource Management for the assistance and encouragement given to the group to pursue the work for updating the Water Use and Development Plan for Lana 'i.

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2/10/97

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List of Acronyms

BWS	Board of Water Supply, County of Maui
CWRM	Commission on Water Resource Management, State of Hawaii
DHHL	Department of Hawaiian Home Lands, State of Hawaii
DOA	Department of Agriculture, State of Hawaii
ET	Evapotranspiration
LCI	Lana'i Company, Inc.
LEGS	Lanaians for Economic Growth and Stability
LSG	Lanaians for Sensible Growth
LWG	Lana'i Water Working Group. Includes LWS members and additional members from the community. Members are listed as authors of this report.
LWS	Lana'i Water Subcommittee. First established by Council Resolution 93-42, May 7, 1993.
MG/L, mg/l	Milligrams per liter. In water supply, this is equivalent to ppm, parts per million.
MGD, mgd	Million Gallons per Day
MSL	Mean sea level. Reference point used for groundwater levels.
SFR	Single Family Residential. Term used in county zoning actions.
USGS	United States Geological Survey, Department of Interior
VWOMG	Voluntary Well Operating Management Guideline. Part of the procedures proposed by Lana'i Company to monitor performance of groundwater aquifer.
WUDP	Water Use and Development Plan. Part of the State Water Code.

Introduction

Lana'i has been in transition from pineapple to resort economy for several years. The demographics and land use pattern of the island have been changing. While actual use has declined in the short term, the projected water demand for the resort economy exceeds what was experienced in the pineapple economy. Lana'i's officially recognized sustainable yield of 6 million gallons per day (mgd) is much smaller than any other inhabited island, and the anticipated demand of the resort economy presses closer to the sustainable yield than any other island.

Because the island's water resource planning must be more precise, the community has little tolerance for uncertainty. The adequacy of the water resources of the island is a concern for both company and community leaders. In addition, they are beginning to recognize the importance of a sound watershed management program to protect their groundwater resource.

Planning History of the Lana'i WUDP

This planning effort is the third iteration under the state water code. Two Water Use and Development Plans (WUDP) have been prepared before. The 1990 plan was completed by the Maui BWS and adopted by county ordinance. That plan was subsequently adopted by the Commission on Water Resource Management (CWRM) as part of the Hawaii Water Plan. The plan was revised in 1992, but it remained in draft form with no further action by the BWS, the County Council, and the CWRM. Lana'i Company disagreed with the projections of the task force utilized in the plan and opposed its adoption despite the participation of company officials in the process.

Moloka'i started revising its plan in 1993. Moloka'i has been designated as a water management area by the CWRM, and Lana'i is currently under consideration for designation. The proposed community plan update is incomplete for both Lana'i and Moloka'i.

The 1990 WUDP dealt with the critical issue of resort development competing with pineapple for the limited water resources of the island. The WUDP recommended a strategy of developing alternate sources of water outside the high level aquifer as it was defined at that time. However, the company decided to phase out pineapple altogether and focus its effort entirely to developing the Koele and Manele Hotels and the two golf courses, thus avoiding that competition.

In 1992, the draft WUDP identified the major issue as water supply management and control. Construction was booming and resort was starting up operations. The plan recommended a strategy of a tighter organizational control and the use of dual systems in Manele for potable and nonpotable water.

The projections of future demand for water made in the 1990 and in 1992 plan are different, and both projections are substantially different from the demand experienced in the pineapple economy. Water use in the previous pineapple economy on Lana'i is shown in Table 1.

Table 1. Water consumption in a pineapple economy.

Water Use	Annual average* (mgd)	% of total
Domestic and Commercial	0.38	13.7
Pineapple irrigation	2.40	86.3
Total	2.78	100.0

***The peak demand periods are in the summer months when daily averages were often greater than 6 mgd and as high as 8 mgd. Domestic and Commercial consumption is the average over 1950 to 1988. Pineapple irrigation is the average over 1983 to 1987.**

The prospect of resort development and the added demand especially during the summer months was a serious concern to the plantation. The strategy of alternate sources of water for golf course irrigation was proposed in the 1990 WUDP to alleviate demand on the high level water resource.

The future demand projected in the 1990 and 1992 planning projects are compared in Table 2 below. Projections were made using different assumptions for the same category and new categories of use were added in the 1992 WUDP.

In the 12-month period of 1990-1991, the average annual consumption was 3.01 mgd. Koele golf course used 0.49 mgd of that amount in its start-up phase with wide swings in consumption over the year. The range was 0.15 mgd to 0.78 mgd as 4-week averages with standard deviation of 0.18 mgd, or 37 percent of the average.

The 1992 plan addressed management issues. There were wide swings in water consumption without explanation. Water losses were high, on the order of 23 percent. Consumers were drawing water without being billed for it. Faucets were leaking without any effort to repair them. Landscaping was irrigated in the rain. Conservation measures were not evident in the community. The 1992 WUDP concluded that tighter management control and a strong conservation ethic were needed to minimize the risk of over-extending the limited water resource on the island. The WUDP recommended a tighter organization and management of the water supply. The WUDP also recommended dual water systems for potable and nonpotable supply for Manele, including the reuse of water.

In summary, the 1990 issue was the competing economic interests. The 1992 issue was management.

Table 2. Summary of projected demand from the 1990 and 1992 WUDP for Lana'i. Note the difference between pineapple and resort economy versus resort only. Note also the difference in terminology which reflects changing description of the water resource.

	Projected Demand (mgd) 1990 WUDP with Pineapple		Projected Demand (mgd) 1992 WUDP without Pineapple	
	High Level	Alternate	Potable	Non-potable
Domestic and Commercial	1.25		1.869	
Pineapple	1.80		0	
Koele Hotel	0.18			
Koele Golf Course	0.25			0.4
Koele Project District			0.255	
Manele Golf Course		0.8		0.8
Manele Hotel & Hulupoe	0.38		0.405	0.1
Manele Project district			0.338	0.3
Community gardens and landscape		0.4		
Agricultural Park			0.5	
Diversified Agriculture			1.0	
Total	3.86	1.2	4.4	1.6

Scope of this report

This report is intended to provide consensus recommendations for a new draft of the WUDP. The Water Code requires the County to prepare the WUDP and adopt it by ordinance. Once adopted by the CWRM as part of the Hawaii Water Plan, the Code specifies that the WUDP shall serve as a continuing long-range guide for water resource management. The Lana'i Water Group is also considering recommendations for the implementing ordinance itself.

The Lana'i Water Working Group (LWG) was formed from the Water Subcommittee of the County Council's Committee on Human Services, Water, and Agriculture, with the addition of two Lana'i residents. The CWRM provided the facilitator and technical support.

The Group addressed various issues that have been the subject of conflicting views, and proceeded by consensus to recommendations intended to resolve those issues where possible, and to lay the groundwork for future discussions of the more complex issues.

The specific parameters and actions undertaken by the Working Group are as follows:

1. Develop data on present water use according to land use categories.
2. Evaluate system losses through an input-output model.
3. Develop projections of future water demand by identifying specific projects affecting future land use.
4. Identify issues in water use and development and recommend alternative strategies for resolving conflicts and disputes.
5. Prepare draft WUDP for adoption by the county council and the CWRM.

Summary and Recommendations

RECOMMENDED LANAI WATER PLAN ACTION ITEMS			
	ACTION ITEM	KEY AGENCIES	TIME FRAME
LEGISLATIVE MANDATE AND FORMULATION OF ADMINISTRATIVE POLICY	Create a permanent Lanai Water Committee by ordinance. Define its makeup.	County Council	1997
	Appoint and confirm members of the committee.	Mayor's Office; County Council	1997
	~~Designate a lead agency~~ and define its role in staffing the Lanai Water Committee and in the development, monitoring and implementation of the Lanai Water Use and Development Plan (WUDP).	County Council	1997
	Provide appropriate levels of staffing and funding.	County Council; Mayor's Office	1997
	Develop, adopt, and update the WUDP on a regular planning cycle.	LWG; Lead agency; County Council	1997
	Establish rules for the operation of the committee.	LWG; Lead agency	1997
MONITORING AND ENFORCEMENT	Requirements and Conditions of WUDP.	Lead agency CWRM	1998

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Recommended Lanai Water Plan Action Items (Cont'd)			
Infrastructure	Implement and maintain a dual water system at Manele.	LCI	1997
	Submit to County Council comprehensive storage plan for Koele Golf Course. Pursue action to cover open reservoirs for Manele golf course and landscape.	LCI	1999
Community Education and Outreach	Water conservation and education program.	LWG; Lead agency; LCI	1998
	Distribution of low flow devices.	LCI; Lead agency	1999
	Information and distribution of appropriate plant types.	LCI; Lead agency	1997
Supply-side Resource Management	Establish a watershed management program as an on-going program with special emphasis on preserving native ecosystems and maximizing the fog drip component of recharge in the watershed.	LCI; DLNR;	1998
	Consider desalination when necessary to meet future demand for new hotels and resort facilities at no cost to the residents.	LCI	
Resource Planning, Research and Modeling	Link Community Plan and WUDP review processes.	Lead agency	1998
	Conduct fog drip studies in order to refine recharge estimates. Update Lana'i Water Model.	LCI; CWRM; Lead agency	1999

RECOMMENDED LANAI WATER PLAN ACTION ITEMS (CONT'D)			
DEMAND-SIDE RESOURCE MANAGEMENT	Adopt the revised well operating management guidelines as mandatory.	LCI	1998
	Implement water conservation measures aimed at reducing outdoor usage as the strategy for meeting future demand.	LCI; LWG; Lead agency	1998
	Retrofit and plan for recycling and reusing water from water features within the resort complex, particularly for landscape irrigation.	LCI	1998
	Establish inventory of all irrigated acreage and monitor appropriate irrigation standards and practices.	LCI; Lead agency	1998
	Maintain list of appropriate plant species.	LWG; LCI; Lead agency	1998
	Continue to reduce system losses.	LCI	1997
	Establish "per unit" water use targets and pricing structure.	LWG; Lead agency; LCI	1998

Present water demand

The base year selected for evaluation is calendar year 1995. It is the latest complete year of record available at the time of this report preparation. Data on present water use are shown in Table 3.

The 1995 consumption determined from billing records was 1.57 mgd. The corresponding pumping (supply) rate was 1.70 mgd. System loss is the amount unaccounted. This was 7.89 percent of the pumping rate. This is a significant improvement over the 23 percent loss in 1993. Lana'i Water Company improved its management of the water system.

The unit consumption for residential units in Lana'i City averages 316 gpd/unit. The unit consumption rate is equivalent to Paia, Maui. This rate appears to be normal for this community that is predominantly of old plantation architecture without extensive landscape development. (See Appendix for typical unit consumption rates for Maui County.)

Koele and Manele Hotel water usage appear low compared to projections, but essential information is not available to fully evaluate demand. The occupancy rates for the year are not available. The hotels will not release that information. Instead, occupancy rates are available for specific periods. They are evaluated and extrapolated over the year.

Manele golf course consumption shown in Table 3 does not include the reuse of wastewater effluent. Manele golf course used less water in 1995 than projected in earlier plans. The long term rate is the key, and it has not been yet been demonstrated by experience.

Koele golf course is currently irrigating with reclaimed water only. However, potable water usage may be allowed under unanticipated conditions defined in ordinance 2515.[1] The director of the Department of Public Works and Waste Management reviews requests and authorizes usage according to law. Ordinance 2516[2] also provides for potable water usage for re-seeding and re-grassing fairways. The maximum allowed is 27,000 gallons per day per fairway. The County Council approves by council resolution. Ordinance 2514[3] requires Lana'i Company to present to the Maui County Council within two years of the effective date, a report detailing the following:

1. a comprehensive plan to develop additional storage of water for Koele golf course irrigation;
2. the time frame within which the plan will be implemented; and
3. steps taken to implement the plan at the time the plan is submitted.

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[1] Effective date: October 17, 1996

[2] Same effective date.

[3] Same effective date.

While ordinances allow potable water usage under prescribed conditions, but they require a plan for additional water storage which serves to minimize reliance on potable water.

Projected Water Demand

The water demand for the future is shown in Table 4. The derivation of the demand figures is given in Appendix A. Line item quantities for the Manele and Koele project districts are combined into one figure. This report is not intended to show approval or disapproval of specific projects within the project districts listed for future development. However, it is expected that adjustments will be allowed within the line item categories shown in Table 4.

Residential water demand.

The present population of Lana'i is 2,800 residents. Population growth on Lana 'i is expected to be driven by the two resort developments. Secondary jobs will be created in the service sector as a result of the resort growth. Population projection in the draft community plan indicates a population of 4,968 by the year 2010, a 77 percent increase averaging 5 to 6 percent per year. This increase of 2,168 residents would require approximately 1,019 additional housing units. It was the consensus of the working group that the population projected by the draft community plan is too high. The projection in the draft plan came from the socio-economic forecast model done in 1992[4] and has not been formally adopted as policy by the Council.

The various population projections reviewed by the group are presented in Appendix A. From 1980 to 1990, the population growth rate was approximately one percent per year. From 1990 to 1996, the growth rate was approximately two percent per year. The Working Group concluded that a growth rate of two percent per year until the year 2010 is the most realistic estimate. This results in a total population of 3,695 in the 2010, representing an increase of approximately 407 additional housing units.

It is very difficult to determine several years in advance where the additional housing will be constructed and what form it will take. The Working Group agrees that new housing should include a mix of multi-family and single family units. At present, there are several potential projects which may arise for the residents of Lana'i. The potential projects include the affordable housing property (115 acres), Department of Hawaiian Home Lands (DHHL) property (50 acres), Kaumalapau Subdivision (45 units), and the redevelopment portion of the Koele Project District (75 acres or 280 units). Assuming a density of 4.5 units per acre, the total number of housing units that can be constructed is more than 1000 units which is far more than needed for the year 2010.

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[4] Community Resources, Inc., Maui Community Plan Update Program. Socio-Economic Forecast Report, August 1992.

Table 3. Present water demand (1995 data).

Category	Present demand gpd	Number of Meters	gpd/unit	Remarks
Residential	274,200	867	316	Predominantly Lana'i City
Commercial	91,695	46	1993	Inventory irrigated acreage
Government	58,600	20	2930	Inventory irrigated acreage
Lana'i Company	229,015	86	2663	Inventory irrigated acreage
Koele Hotel	37,754	4	*	102 units. 1995 occupancy unknown.
Koele Hotel landscape	48,646	1	*	
Cavendish	9,393	1	*	
Manele maintenance	8,279	2	*	
Manele Hotel	39,847	2	*	250 units, 1995 occupancy unknown. Refer to calculations in appendix.
Manele Landscape	30,227	1	*	
Kaumalapau	9,223	1	*	Meter at reservoir
Lana'i airport	4,239	1	*	
Diversified Agr	219,123	32	*	Approximate number of meters
Manele Golf	505,710	1	*	Does not include effluent reuse: 49,737 gpd ave for 1995.
Total consumption	1,565,949			
Total Pumped	1,700,000			
System Loss	134,051			
Percent	7.89%			Improvement. System loss was 23% in 1993.

*This report recommends that all irrigated acreage associated with existing uses be inventoried and evaluated in the water conservation program described later in this report.

Table 4. Present and Projected Water Demand for Lana'i. Manele and Koele Project Districts include all water demand within those boundaries.

(Refer to Appendices for assumptions and details)

CATEGORY	Present mgd	2010 mgd	Total Future mgd	Source of Water**
Residential	0.274	0.414	0.494	Groundwater
Agriculture	0.219	0.5	1.5	Groundwater
Commercial & Institutional	0.379	0.439	0.439	Groundwater
Light Industrial	0	0.09	0.09	Groundwater
Kaumalapau Harbor	0.009	0.01	0.01	Groundwater
Lanai Airport	0.004	0.005	0.005	Groundwater
Manele Project District	0.078	0.68	1.03	Groundwater
Manele Golf Course	0.51	0.65	0.65	Groundwater
Manele Effluent	0.05*	0.07*	0.14*	Effluent
Koele Project District	0.096	0.20	0.42	Groundwater
Koele Golf Course	0.17*	0.25*	0.25*	Effluent
Subtotal Groundwater	1.569	2.99	4.64	Groundwater
System losses***	0.134	0.41	0.63	
Total Groundwater	1.703	3.40	5.28	
Total Effluent	0.22	0.32	0.44	
Total Water Demand	1.92	3.72	5.72	

*Reclaimed wastewater effluent
**Sources of Water:
Groundwater=all wells
Secondary=Palawai (Wells 1,7,9,10) and beyond
Effluent=reclaimed water
***System losses=7.89% for 1995, 12% for future years

The housing requirement for the DHHL shown in the Appendices is based on an assumption of residential development density. It is possible that the property would instead be developed as agricultural homesteads. DHHL has no plans at this time. The agricultural alternative could result in a smaller domestic water demand. Potential agricultural demand has been included in the overall agricultural allotment in this plan.

Plans for the future housing are uncertain at this time. Lana 'i Company, the major landowner, is concentrating its housing efforts on the Lana 'i City Redevelopment Project. State and County agencies are currently waiting to gain a better understanding of the need for future housing prior to proceeding with development of their projects. Therefore, housing densities are flexible and may change. Attention should be given to providing the residents different types of housing.

Rather than attempt to allocate water to each of the potential projects, the working group agreed to provide an allocation of water for the increased population in general. The future homes for these residents will be built on one or more of these potential projects, depending upon the home purchase preference of the community at the time.

The key variable in the population projections is the timing of projected expansion of the hotels allowed under current zoning. The expansion of the hotels will have an impact on the job growth on the Island and will affect the population figures accordingly. The group agreed that the long term average population growth estimate of two percent per year is sufficient including the future of the hotel expansion impact.

Agriculture

Agriculture as defined in this WUDP is all activities including corporate farming, farming in the 100-acre state agricultural park, and subsistence farming that DHHL residents might undertake. The water set aside in this plan for agriculture is 1.5 mgd.

The Lana'i Water Working Group invited the Chair[5], State Board of Agriculture to brief the group on the potential for agriculture on the island. A briefing paper was prepared for the Chair prior to his visit (Appendix B). His comments and conclusions given orally to the working group are summarized as follows:

1. DOA has received no requests from members of the community for land in the 100-acre agricultural park. The high cost of water on Lana 'i compared to other parts of the state is a disadvantage.

[5] James Nakatani, Chair of State Board of Agriculture and Director, Department of Agriculture, State of Hawaii. August 1, 1996.

2. DOA does not intend to develop the park unless there is community interest.
3. The economically viable options include high value niche crops, for example, for the hotels and for papaya in a fruit-fly free zone. Papaya is also disease free.
4. Focus efforts on supplying on-island demand for fresh produce.
5. Consumptive uses depend on the crop, but 3500 gpd/ac can be an average.

While there is no specific proposal for agriculture on Lana'i, the working group agreed that 1.5 mgd should be set aside for agriculture. Allocating water for agriculture is also a specific recommendation of the draft community plan for Lana'i.

Strategy for water use and development

Supply-side Factors

The protection of the island's water resources is a principal concern of the WUDP. The Working Group reviewed background information shown in Figures 1 to 6 and Table 5.

Watershed Management

Watershed management is critical to assure continued recharge of the aquifers. The Working Group has expressed concern for two major issues: fog drip and protection of the native ecosystem.

Fog drip is a particularly sensitive element in recharging the aquifer on Lana 'i, due to limited rainfall and the low sustainable yield. The Group is very concerned that loss of fog-drip vegetation could reduce the available groundwater. The focus of attention is the high elevation area recharging the potable aquifer. Fog-drip first came to the attention of the Lana 'i Ranch manager in 1927, as the ranch sought ways to maximize its land use activities, and subsequent studies have confirmed its significance in augmenting rainfall.

The introduction of pigs, goats, axis deer, and mouflon sheep in successive periods has been detrimental to the vegetation. Pigs and goats have been eradicated and sheep seem to be self-limiting, but the deer population has expanded significantly, contributing to vegetative damage and erosion that has undermined the health of the high elevation native habitat that contributes to recharge of the aquifer. Trees that were planted in the 1920s and 1930s and that contribute to the recharge capacity are reaching old age and are susceptible to the current long-term period of low rainfall. Invasive plant and insect species are adversely affecting native species that are significant in retaining moisture. As elsewhere in the islands, native species have been exterminated or are in retreat.

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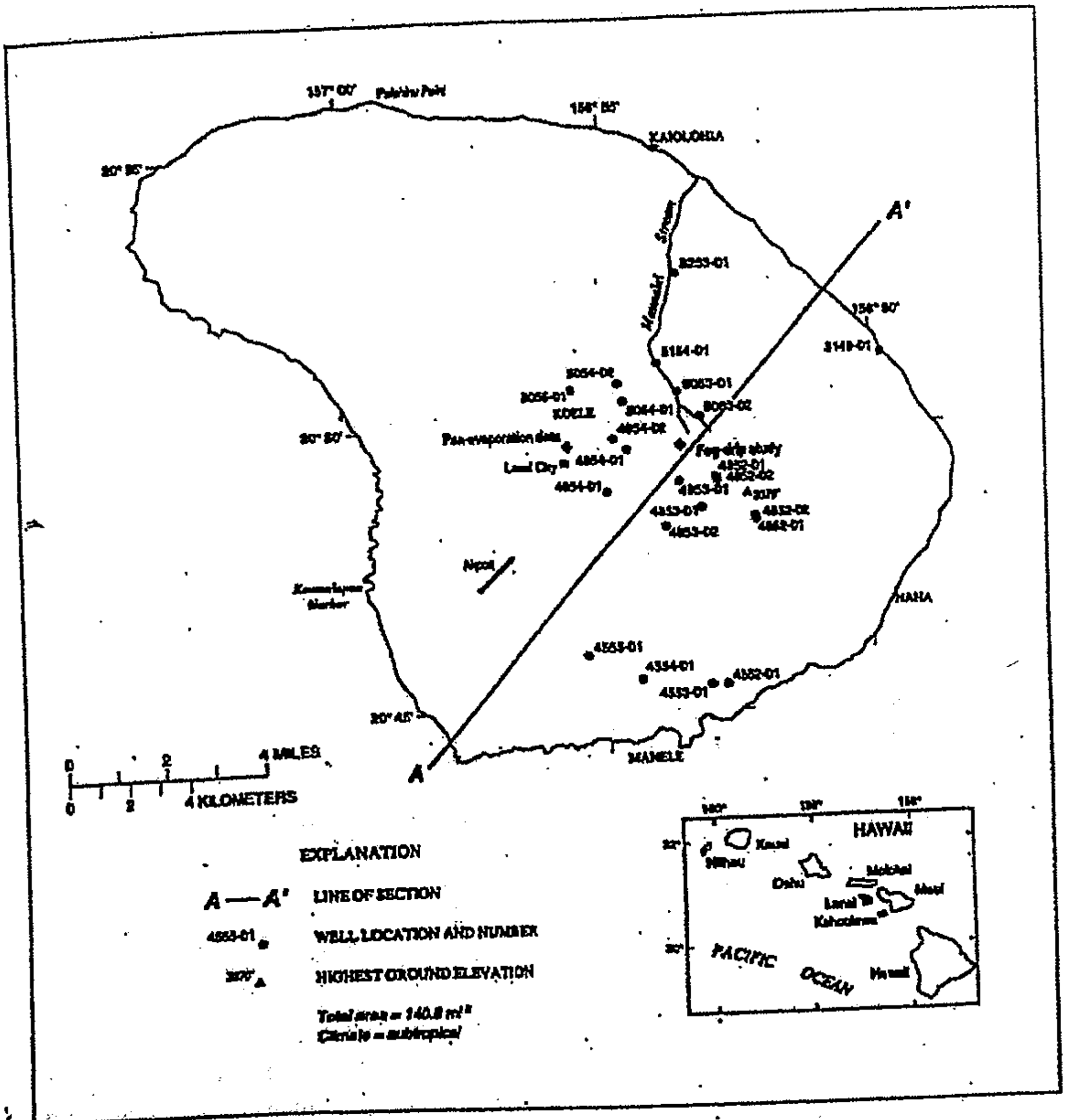

Figure 1. Regional setting for water resources on Lana'i (CWRM, 19 April 96).

Well No.	Well Name	Year Initially Drilled	Initial Water Level Elevation (ft. msl)	Initial Bottom of Well Elevation (ft. msl)
4454-01	Manele	[a]na	2.5	na
4552-01	Well 12	1990	5	-25
4553-01	Well 13	1990	0	-25
4555-01	Well 10	1989	208	208
4852-01	MH Tunnel	1918	Dry	2,700
4852-02	Well 5	1950	1,570	1174
4852-03	USGS T-2	na	na	na
4853-01	Gay Tunnel	1920	Dry	1,920
4853-02	Well 1	1945	initial head → 818	-3
4854-01	Well 9	1990	[f]806	446
4952-01	Walapaa Tun.	1924	Dry	2,220
4952-02	Well 4	1950	1,589	1,149
4953-01	Well 2	1946	1,544	903
4953-02	Shaft 3	1954	1,553	[g]1,510
4954-01	Well 3	1950	[h]1,124	651
4954-02	Well 8	1990	1,014	412
5053-01	Lower Tunnel	1911	1,103	1,103
5053-02	Upper Tunnel	1911	1,500	1,500
5054-01	USGS T-3	1950	[k]1,064	ground-928.6
5054-02	Well 6	1986	1,005	600
5055-01	Well 7	1987	650	450
5149-01	Gay Well A	1900	2	-44
5154-01	Shaft 2	1938	735	479
5253-01	Shaft 1	1936	2.4	1.4
TOTAL Data	24 wells	na	22	20
AVERAGE	na	na	na	na

Table 5. Identification of wells and characteristics by CWRM code and common name (CWRM 19 April 1996).

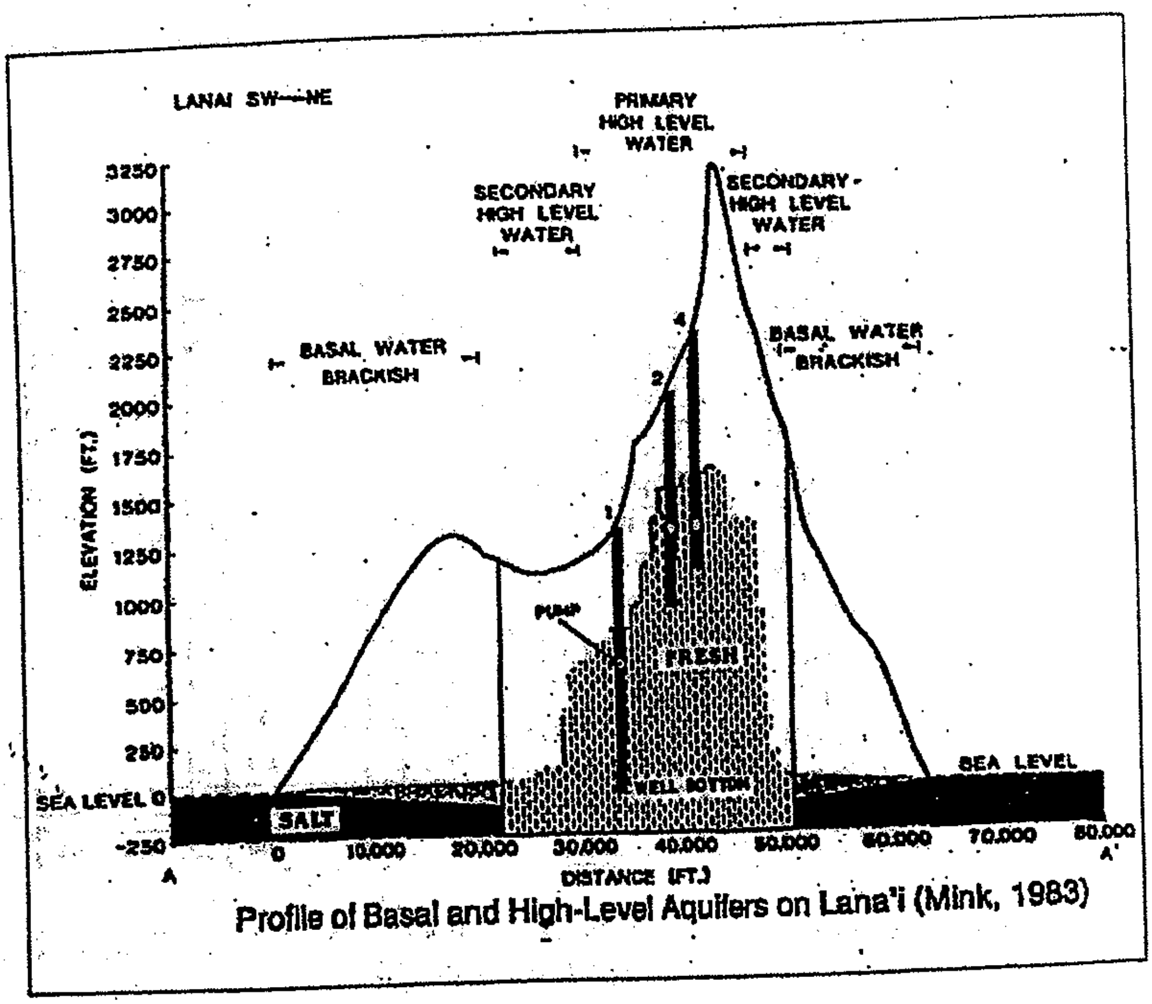

Figure 2. Idealized cross-section of groundwater on Lana'i (CWRM, 19 April 1996).

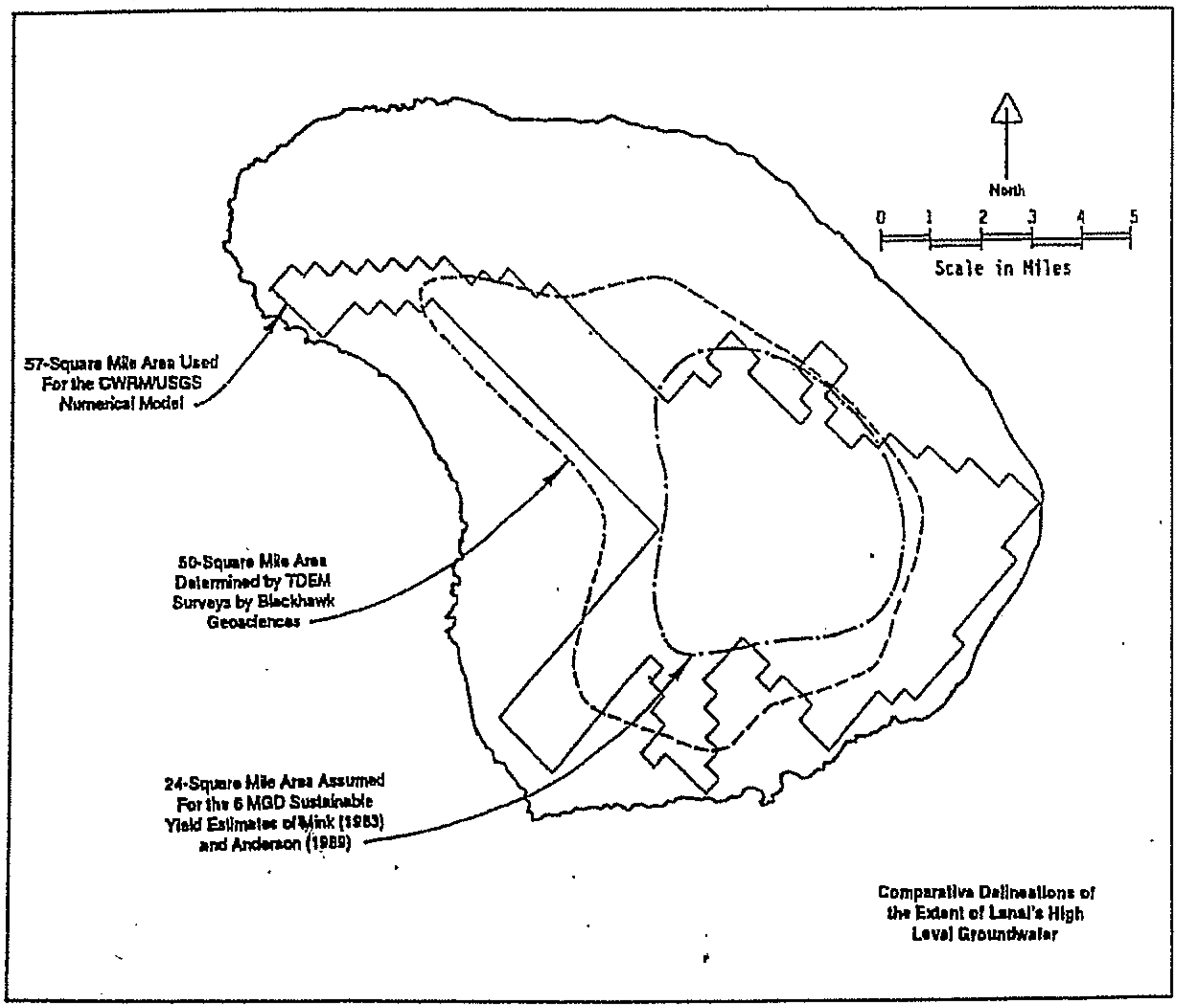

Figure 1. Comparison of different high level areas used in the analysis for recharge and sustainable yield by different investigators (after LCI, Aug 1996). The sustainable yield remains the same at 6.0 mgd for the different recharge scenarios. Water quality is a factor that must be accounted for in each scenario.

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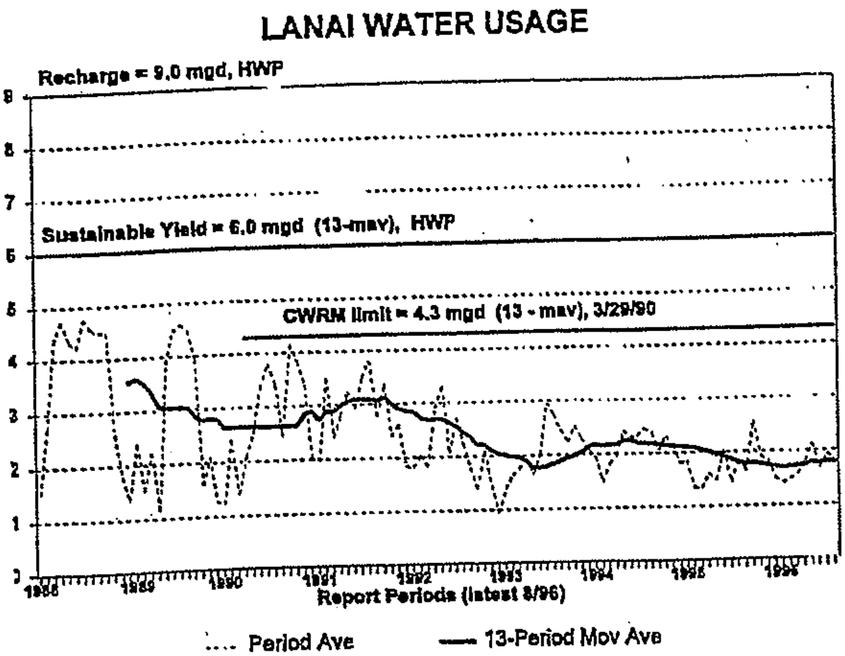

Figure 2. Trend in water usage compared to sustainable yield and CWRM limit (18 Oct 96).

Note the wide swings in water consumption in the different periods prior to 1994. Water consumption steadily declined from 1989 to 1995. Resort construction tapered off and LCI exerted better water supply management. Also, there was a change in water use.

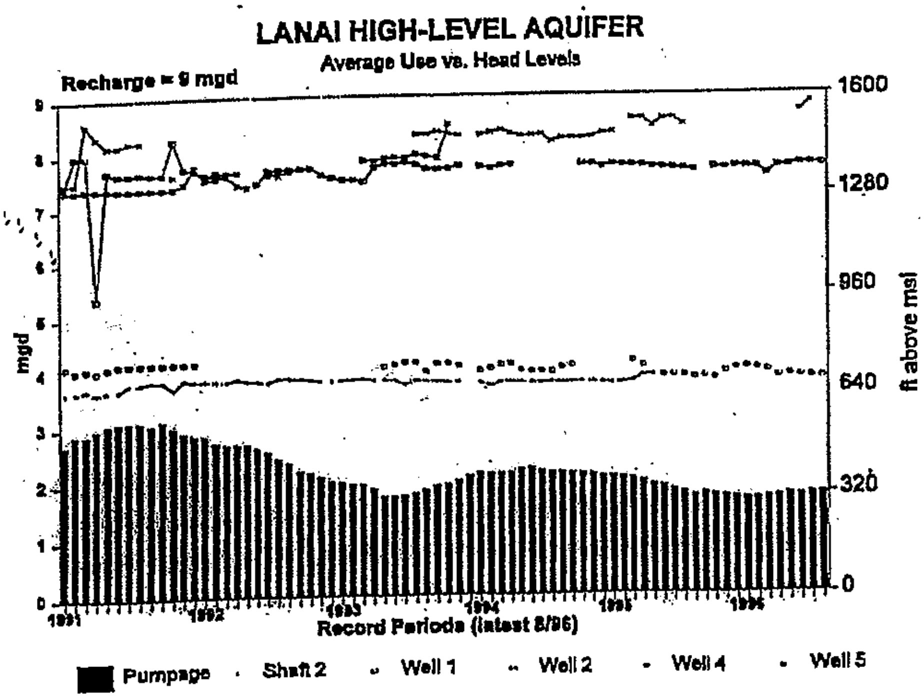

Figure 3. Water levels from 1991 to 1996 (CWRM 18 Oct 96).

Water levels have remained relatively stable since 1991. Well 4 show increase in water level. Pumping has been reduced or stopped in Wells 4 and 5.

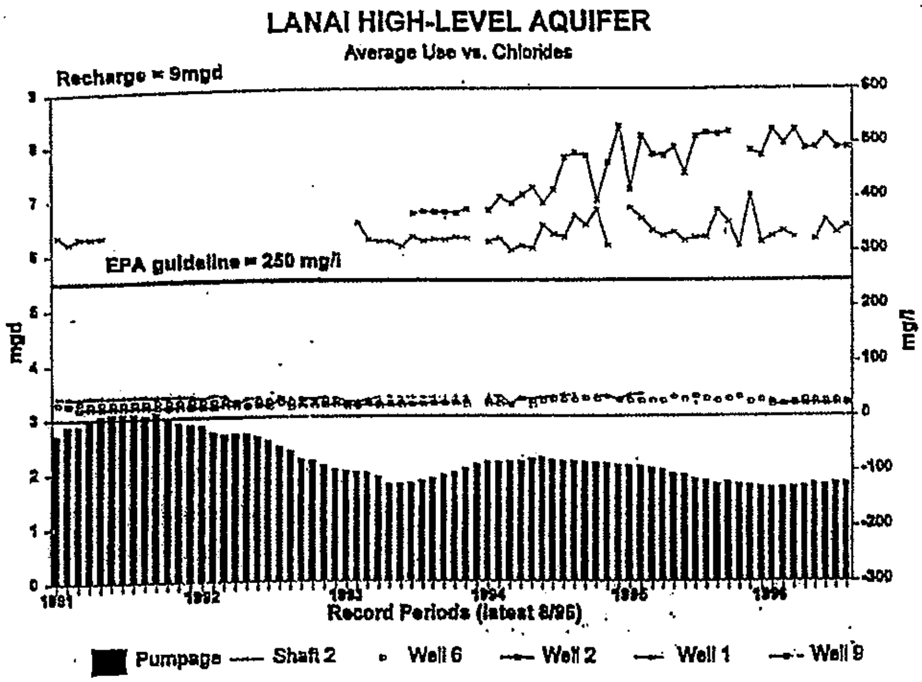

Figure 4. Chloride levels in wells in the Palawai basin compared to other wells (CWRM 18 Oct 96).

Groundwater in the Palawai basin is brackish. Chloride levels appear to be stable in Wells 1 and 9 at their current pumping rates.

The Working Group agrees that a strong watershed management program is essential to its water resources. There are at least three ways that this matter may be approached. The Tri-Isle (Maui County) Resource Conservation and Development District (RC&D) is a channel for federal-state-landowner cooperative cost-sharing and technical support programs sponsored by the federal natural Resources and Conservation Service (NRCS, formerly Soil Conservation Service); its focus is agricultural land, but it can apply to watershed lands that contribute water resources to the agricultural land. The Forest Stewardship Program is a separate federal-state-landowner cooperative cost-sharing and technical program sponsored by the U. S. Forest Service and administered through the State Division of Forestry and Wildlife. Thirdly, private efforts are a time-honored approach in Hawaii evidenced on Lana 'i by years of volunteer reforestation.

The Group feels that it is imperitive that this plan be implemented and its effectiveness be monitored and the plan be revisted as appropriate. To serve this end, the Group recommends that the CWRM appoint a steering committee to set objectives for a fog-drip study and watershed management program.

A forest stewardship plan[6] has been prepared for LCI.

[6] Forest Stewardship Plan for The Lana'i Company, Prepared by: Resource Management, 811 Kaumana Drive, Hilo, Hawaii 96720, November 8, 1996.

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RESOURCE MANAGEMENT

311 Kaumana Drive Hilo, Hawaii 96720
(808) 934-0502 Fax: (808) 935-8291

November 9, 1995

Mr. Michael Buck, Administrator
Division of Forestry and Wildlife
State of Hawaii - DLNR
1151 Punchbowl Street, Room 325
Honolulu, HI. 96813

Dear Mr. Buck,

Attached is a Forest Stewardship Plan for the Lanai Company, Ltd. I feel confident that if we can achieve the goals as outlined for this project, Lanai will be greatly benefited.

This is, of course, only the beginning. Lanai will need more than 10 years to rehabilitate eroded lands, control invasive weeds, and resolve its deer problems. This initial project, however, will start the process.

Thank you for your consideration of the Lanai Company's request to join the State's Stewardship Program. If you have any questions, please do not hesitate to call.

Sincerely,

Michael E. Robinson,
Project Manager

Figure 5. Summary statement of the forest stewardship plan for Lana'i.

This plan is but the start of an on-going process. The goal is to preserve the native ecosystem that fosters groundwater recharge of high water quality.

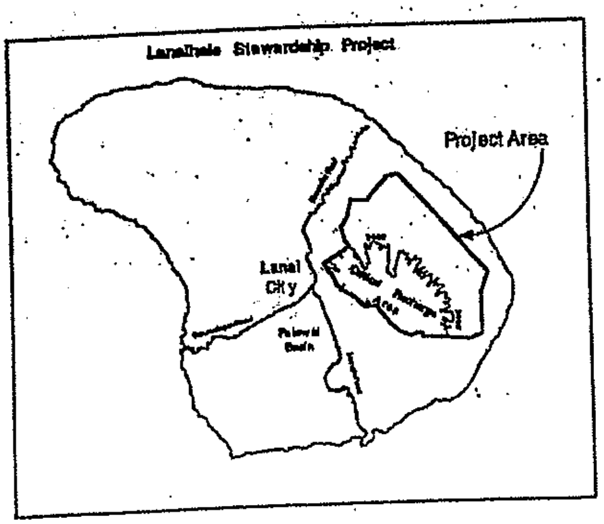

Figure 6. Project area for forest stewardship plan (after Resource Management, 1995).

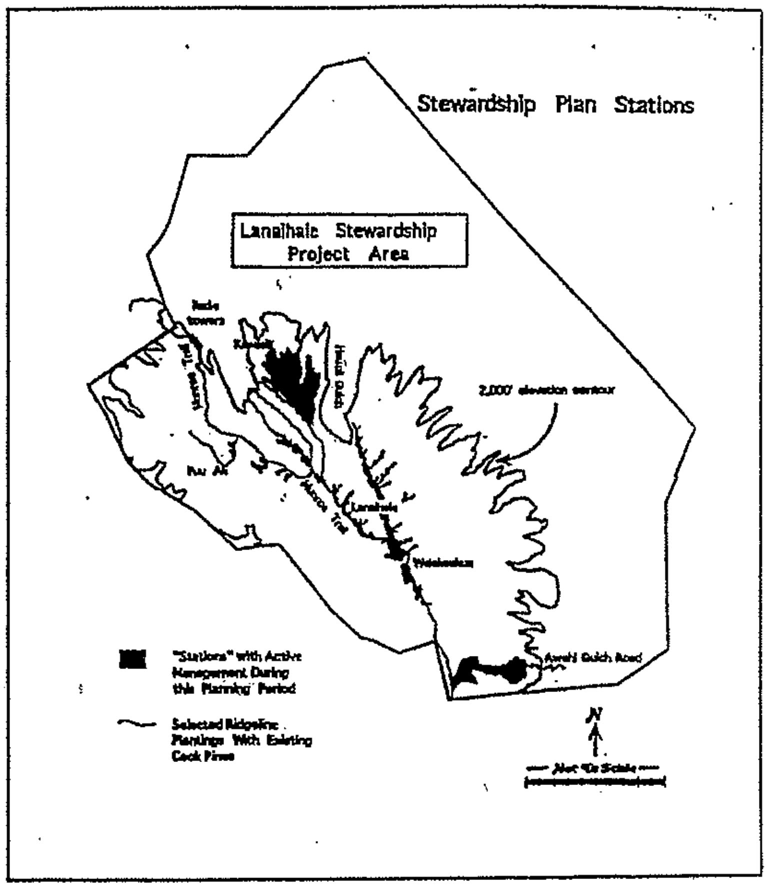

Figure 7. Stations for stewardship plan (after Resource Management, 1995).

Objectives of the plan:

1. Enter into State's Forest Stewardship Program.
2. Improve fog drip, subsurface water quantity, and surface water quality via tree plantings on critical and non-critical planting areas.
3. Protect new and existing plantings from wildlife browsing.
4. Establish vegetative cover which controls erosion.
5. Control undesirable non-native vegetation.

Well Operating Management Guidelines.

LCI developed guidelines for managing groundwater resources and described them as voluntary well operating mangement guidelines (VWOMG).[7] The Working Group recommended revisions and further recommended that the revised guidelines be made mandatory.

1. The moving 12-month average pumpage of high level brackish wells in Palawai Basin which are used to irrigate Manele Golf Course, shall not exceed 650,000 gpd. If other non-potable water becomes available, such as sewage effluent or other brackish

[7] Lana 'i Water Resources Management Plan, Prepared by Lana 'i Company, Inc., August 1996

water, the amount withdrawn from the high level aquifer shall be reduced proportionately.[8]

2. Pumpage shall be distributed among well sources so as to maintain their water levels within the following specified limits:

Table 6. Action levels for groundwater sources.

Potable Well	Initial water level (ft elev)	Current water level (ft elev)	Action Level* (ft elev)	Lowest allowable level (ft elev)
2	1544	1390	1050	750
3	1124	992	750	562
4	1589	1573	1100	750
5	1570	(Not operating)	1100	750
6	1005	998	750	500
8	1014	893	750	500
Brackish Wells				
1	818	748	550	410
9	808	755	550	410
14	?	?	400	292

***Requires public review of all pumpage, water level, and water quality data for possible changes in the resource management procedures, policies, and plans.**

3. In event that it is not possible to stay within the limitations set for potable wells, LCI will develop new wells and/or outfit Well 7, whichever is most hydrologically appropriate.

Desalination and Future Water Development

LCI made a significant commitment to implement desalination for the irrigation of Manele Golf Course in the event the 12-month moving average of total pumpage from the high level aquifer exceeds 70 percent of the sustainable yield for six consecutive months. Desalination incurs a substantial cost in present-day terms, and it will continue to do so in the future despite cost-cutting advances being made in technology. The Working Group understands that the cost for this alternative is to be borne by LCI and not the community. Nevetheless, the Group feels that there are other more cost-effective alternatives to meeting the water demands in the future than desalinating golf course irrigation water. For this reason, the Group does not support the guideline for desalinating irrigation water. This issue will be discussed more fully in the following sections of this report.

[8] Resolution 93-42. Relating to the use of non-potable water for the construction of the Manele Golf Course. County of Maui, 1993.

Demand-side Factors

The consumer-oriented factors are considered here to reduce demand and increase efficiency of water use.

Dual Systems

The 1992 Draft WUDP recommended dual water systems especially for Manele project district for potable and non-potable water. This is a recommendation of this report. It is anticipated that water quality will become a more significant factor in resource management as urbanization progresses in the future.

Conservation measures

There are two basic alternatives to meeting future demand. One is to increase supply. The other is to improve efficiency. Reducing the future demand is often the more cost-effective engineering solution, but it requires changes in habits of people and in traditional uses of water.

The major categories of consumers evaluated here are residential, landscape, and resort. Commercial consumers are specific and require more study to fully evaluate.

Residential (single family units)

The unit consumption averaged 316 gpd/unit in 1995. By comparison, Paia, Maui had 342 gpd/unit in 1991. Both communities started as plantation camps with similar architecture and layout. It is reasonable to expect similar consumption patterns in this case.

However, there are wide differences in average water consumption in Maui County. Climate appears to be a significant factor. The range of values for 1991 in Maui County is shown in Appendix C.

The pattern of residential water use is measurable in terms of indoor and outdoor use. Data developed in the 1992 WUDP[9] show this relationship for the Kihei and Kahului. The result is shown in Table 7. For Kihei, outdoor use is 57 percent. For Kahului, it is 32 percent.

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[9] M&E Pacific, Inc., Draft WUDP, Maui, 1992, Prepared for Department of Water Supply, County of Maui, 1992, Table 1.41, p 1-10.

Table 7. Difference in residential water consumption in Kihei and Kahului. The major use in Kihei is outside the dwelling units.

(Draft WUDP,1992)

District	Number of SFR Units	Consumption ave gpd/unit	Outside use* % of ave
Kihei	2520	841	57
Kahului	3404	519	32

*Outside use = [(Potable water in) - (Sewage flow out)]/(Potable water in)
SFR= single family residential

The sewage flow (1995) averaged 0.27 mgd from Lana'i City and 0.05 mgd from Manele Hotel. Therefore, inside usage was 0.32 mgd. That was the total for the island. By comparison, groundwater pumped for delivery island-wide was 1.70 mgd.

Therefore, inside use is a minor part of the overall water use. Table 8 summarizes this situation. Greater returns would be possible by focusing conservation efforts on outside usage instead.

Table 8. Summary of inside and outside uses of water on Lana'i (1995).

Catergory	mgd	Remarks
Water pumped	1.70	Refer to Table 3. Figure includes losses at 7.89% and Manele Golf course irrigation at 0.51 mgd. Koele Golf course uses reclaimed water exclusively.
Lana'i City and Manele Wastewater flows	0.32	This represents inside use of water. Most can be reclaimed for reuse. Current amount reclaimed is about 0.22 mgd.
Outside use, mainly landscape irrigation	1.38	This is 81% which is the predominant use of groundwater on Lana'i. It should be the main focus of conservation efforts on Lana'i.

Landscape

Landscape irrigation is the major water use on Lana'i. Irrigation requirement is fairly predictable based on type of plant or grass, climate, and irrigation efficiency. Turf grass consumes water equivalent to pan evaporation. In contrast, pineapple consumes substantially less water, about one-tenth of turf grass.[10] Plant type and irrigation efficiency are matters of choice, and they are manageable. Climate is not.

Data on pan evaporation for Lana'i are sparse. Hardy[11] estimated pan evaporation for areas on Lana'i below elevation 2000 feet by extrapolation.[12] Measured pan evaporation data at Lana'ihale was used along with other observations. Pan evaporation for Lana'ihale was 25.63 inches per year. Below elevation 2000 feet, pan evaporation was estimated to be 95.00 inches per year. Details are summarized in Table 9 below.

Table 9. Estimates of pan evaporation (ET) and irrigation application rate for turf grass on Lana'i (after Report CWRM-1).

Characteristic	ET inches	ET gpd/acre	Irrigate* gpd/acre
Areas below Elev 2000 ft (annual)	95	7067	9425
Minimum month (Nov)	3.80	3439	4585
Maximum month (Jul)	9.50	8320	11,093

*Application rate is based on 75% irrigation efficiency and on optimum growth.

Irrigation of turf grass is greater than 9000 gpd/acre for optimum growth at 75 percent efficiency. By comparison, pineapple cultivation on Lana'i used 240 gpd/acre (2.40 mgd, Table 1, for 10,000 acres).

Drought tolerant plants and grasses can reduce water consumption. Xeriscaping is recommended for Manele. The impact can be significant. For example, the projection for single family residential units in Manele is 1600 gpd/unit. Of that amount, 600 gpd/unit is the estimate for domestic use and 1000 gpd/unit is for outside use such as landscape irrigation. These rates can be reduced with conservation measures. A target of 400 gpd/unit for domestic usage is reasonable. Perhaps more can be done with conservation to reduce total consumption even further.

The projection for Manele project district is 1.03 mgd (Table 4). A likely target for Manele project district is to reduce future demand to 0.53 mgd, a savings of 0.5 mgd.

Resort

Water features are part of the amenities common to hotel-resorts. Swimming pools and ornamental ponds require back-wash, water treatment of some sort, and make-up water. They represent a water demand. Water from these features can and should be reused for irrigation. Some work has already been start to retrofit water saving devices and facilities.

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[10] Ekern, Paul C. and Jen-Hu Chang, Pan Evaporation: State of Hawaii, 1894-1983, Prepared in Cooperation with Hawaiian Sugar Planters' Association, Report R74, Department of Land and Natural Resources, Division of Water and Land Development, State of Hawaii, August 1985, p2.

[11] Hardy, Roy, Numerical Ground-Water Model for the Island of Lana'i, Hawaii, Report No. CWRM-1, Commission on Water Resource Management, State of Hawaii

[12] Eckern, Ibid.

At present, backwash water at the hotels from water features are disposed of in the sewer system. Consumptive use would be a fraction of the total water delivered. However, as in the case of Manele, water reuse from these features is unplanned. It is being discharged to the sewer system, pumped to the treatment plant, and then to the reuse system. With prior planning, it could have been diverted to the irrigation system directly for reuse with minimum effort and cost. Therefore, the issue here is mainly on economics of reuse.

It is recommended that that recycling and reuse of water within the resort be added as a retrofit where possible in existing systems and as a designed feature in future systems.

Recommended Conservation Strategy

Outside usage of water (landscape irrigation) is and will continue to be the predominant demand. Water conservation is a significant alternative to meeting future demand. Therefore, the Working Group recommends the following actions:

1. Reuse water from water features for irrigation within the resort complex to save water and avoid treatment costs.
2. Prepare a plan for a conservation program with the following scope of work:
    - Develop an inventory of current irrigated acreage with type of plant and/or ground cover.
    - Develop a system of monitoring water application rates by month.
    - Set up climatological stations in strategic locations for measuring rainfall, temperature, humidity, evapotranspiration (ET), and other parameters to assist in establishing reasonable irrigation rates.
    - Adjust irrigation application rates according to evapotranspiration rate and type of plant.
    - Develop water pricing system as incentive for water conservation, that is, penalize excessive use based on ET and type of plants.
    - Develop library of drought resistant and salt-tolerant plants and ground cover that can be used in landscaping at Manele.
    - Incorporate drought resistent and non-invasive plants in all landscapes.
    - Set annual targets for adjusting irrigation application rates for different areas based on climatological data and type of plants and ground cover.
    - Set water allocation for each future development.
    - Adjust projections of future demand based on monitoring results and performance of this conservation program.
    - Adjust criteria and procedures for the water conservation plan as part of the WUDP update.
    - Pursue action to cover all open reservoirs.

- Provide additional storage capacity in the water systems as part of the conservation program.

Conclusion

The major issue is community involvement and participation in total water management. What is sorely needed is a company-community partnership in the truest sense of the word, based on trust and cooperation. To serve this end, an on-going organization and forum is recommended.

Recommendations

1. Establish the Working Group by ordinance.
2. Establish watershed management program as an on-going basis with special emphasis on preserving native ecosystem and the fog drip component of recharge in the watershed.
3. Adopt the revised well operating management guidelines as mandatory.
4. Implement water conservation measures aimed at reducing outside use as the strategy for meeting future demand, then consider desalination as required specifically to meet future demand for new hotels and resort facilities. The cost of desalination for hotel and resort activities shall not be passed on to the residential and agricultural consumers on the island.
5. Develop inventory of all irrigated acreage and water application rates as part of the program aimed at water conservation.
6. Retrofit and plan for recycling and reusing water from water features within the resort complex, particularly for landscape irrigation.
7. Implement and maintain dual water systems in Manele.
8. Establish a forum for community involvement and participation in planning for total water management, including the updating of the WUDP and monitoring implementation.

Glossary

Sustainable Yield	A management parameter indicating the amount of water that can be withdrawn without impairing the beneficial use of that source.
Brackish Water	Water that is too salty to drink, generally defined by US EPA as having 250 mg/l of chlorides.
Chloride Levels	Concentration of chlorides which is used as the indicator of salts in the water.
Hawaii State Water Plan	Plan required under the State Water Code.
Recharge	The replenishment of a groundwater source. It occurs naturally from rainfall.
Potable	Water that can be drunk without noticeable salty taste or without being bad to public health.
Desal	Desalination, the process of desalting or removing minerals from water.
Project District	A concept in land use zoning in Maui County which identifies the boundaries of a particular tract of land where development occurs according to Council approved standards and criteria.
Lana'i Water Group	A community group representing the company, government, and the citizens of Lana'i who have volunteered to develop a consensus document for resolving conflicts in water resource issues.
Aquifer	The geologic medium which stores and transports water underground ultimately to the sea.
Fog Drip	The condensation of moisture on plants and other objects like dew drops in sufficient quantity to infiltrate into the ground to groundwater.
Pan Evaporation	The amount of water that vaporizes from a standard container exposed to the weather in the same way that plants and vegetation are. There is a correlation between pan evaporation and the amount plants consume in their life cycle.
Forest Stewardship Progam	This is a cooperative program among federal and state agencies with the land-owners to preserve forestry resources and ecosystem. It is a cost-sharing program sponsored by the U. S. Forestry Service and administered by the State Division of Forestry and Wildlife, Department of Land and Natural Resources.

APPENDICES

Calculation of Projected Water Demand

Note: "Future" water demand represents the fully built-out condition according to authorized zoning. The time period for attainment is unspecified. The "2010" demand represents the foreseeable future.

Table A1. This is Table 4 in report.

LAND USE CATEGORY	Present mgd	2010 mgd	Future mgd	Source of Water**
Residential	0.274	0.414	0.494	Primary
Agriculture	0.219	0.50	1.50	Primary
Commercial & Institutional (10 adddditional acres)	0.379	0.439	0.439	Primary
Light Industrial (15 acres)	0	0.09	0.09	Primary
Kaumalapau Harbor	0.009	0.01	0.01	Primary
Lanai Airport	0.004	0.005	0.005	Primary
Manele Project District	0.078	0.68	1.03	Primary & Secondary
Manele Golf Course	0.51	0.65	0.65	Secondary
Manele Effluent	0.05*	0.07*	0.14*	Effluent
Koele Project District	0.096	0.20	0.42	Primary
Koele Golf Course	0.25*	0.25*	0.25*	Effluent
Subtotal Groundwater	1.569	2.99	4.64	Primary & Secondary
System losses 12% future	0.134	0.41	0.63	
Subotal Groundwater	1.703	3.40	5.28	
Total Effluent	0.3	0.32	0.44	
Total Water Demand	1.73	3.72	5.72	
*Reclaimed wastewater effluent				
**Sources of Water:				
Primary= Wells 2,3,4,5,6,8, Maunalei				
Secondary=Palawai (Wells 1,7,9,10) and beyond				
Effluent=reclaimed water				

Table A2. Calculation of projected water demand in Manele Project District

Project	Acres	Reference	Remarks	2010	Future
Manele Hotel Existing		Increased occupancy	250 units, 600 gpd/unit, less exist	0.18	0.18
Manele Hotel II	25	Lanai Co., Feb 1990	150 units, 600 gpd/unit	0.09	0.09
Manele II Landscape	20	Draft WUDP	Ave irrigation 7000 gpd/ac	0.14	0.14
Manele PD SFR	248	Lanai Co. 3/1/90	325 units, 600 gpd/unit	0.08	0.20
			325 units, 1000 gpd/unit	0.12	0.32
Manele PD MFR	27	Lanai Co. 3/1/90	100 units, 300 gpd/unit	0.015	0.03
			100 units, 300 gpd/unit	0.015	0.03
Manele Commercial	5.25	1985 Project District	6000 gpd/ac	0.04	0.04
Manele Golf Course	100	Council Resolution	Included in present usage		
			Total	0.68	1.03

Table A3. Calculation of projected water demand for Koele Project District

Project	Acres	Reference	Remarks	2010 mgd	Future mgd
Koele Hotel Existing		Increased occupancy	102 units, 500 gpd/unit, less e:	0.01	0.01
Koele PD SFR	138.35	Lanai Co. 6/28/96	254 units, 600 gpd/unit	0.05	0.15
Koele PD MFR	18.46	Lanai Co. 6/28/96	90 units, 400 gpd/unit	0.04	0.04
Koele PD Hotel	21.1	Lanai Co. 6/28/96	250 units, 500 gpd/unit		0.13
			Present Demand	0.096	0.096
			Total	0.20	0.42
Koele Golf Course			Reclaimed water use	0.25	0.25

Table A4. Population and demographic data used in analyzing population and residential water demand.

Parameter		Value	Remarks
1980	Census Population	2119	
1990	Census Population	2426	Approximately 1% growth rate from 1980
1990	Housing units	1007	1990 census
	1990 Household size	2.86	1990 census
1988	Total number of Jobs	845	State DLIR
1988	Dole Pineapple	560	
1988	Lanai Company	30	
1988	Koele	8	
1996	Population	2800	LCI
1996	Housing Units	1273	
1996	Household size	2.2	
1996	Total Jobs	1400	State DLIR
1996	Hotel Workers	750	
1996	Other Service	100	
1996	Hotel units	362	Manele=250, Koele=102, Lana'i=10
Population / total job		2.0	Computed values
Service job/hotel job		1.13	Computed
Hotel jobs/hotel unit		2.07	Computed
Population/hotel job		2.27	Computed

Table A5. Projection of residential demand based on different scenarios. New hotel construction is the key driver for population growth.

Scenario (1996 population = 2800)	2010 Population	Population increase	New housing Needed	New Acres needed at 4.5/ac	Increased demand mgd
Community Plan Projection	4968	2168	638	142	0.22
1% Growth Rate (1980 to 1990 growth on Lana'i)	3219	419	190	42	0.07
1% Growth Rate with New Manele Hotel	3672	872	396	88	0.14
2% Growth Rate	3695	895	407	90	0.14
1% Growth Rate with New Manele and Koele Hotels	4805	2005	912	203	0.32

Table A6. Computation of the number of housing units that can be constructed on the land being considered for future housing. DHHL and the County have no plans for development at this time.

Project	Acres**	Remarks	Assumption on maximum density	Units*
In-fill housing		Lanai Co. Feb 96	Net 53 units	53
DHHL Housing	50	LUC Condition. Assuming	4.5 units/ac	225
County Housing	115	LUC Condition	4.5 units/ac	518
			Total	796

*The number of residential housing units possible from the density assumed is more than projected need. A lower density can be considered for future housing developments.
**Refer to Figure A1 for proposed locations of the 115 acres. The County has no definite plans for development. DHHL has no plans for the 50 acres at this time. The site has not been selected.

Table A7. Projection of future commercial demand in Lana'i City.

New Commercial Acres	= 10
Reference	OSP
Standard	= 6000 gpd/acre (County)
2010 additonal demand	= 0.06 mgd
Future demand	=0.06 mgd No further increase anticipated over 2010 demand/

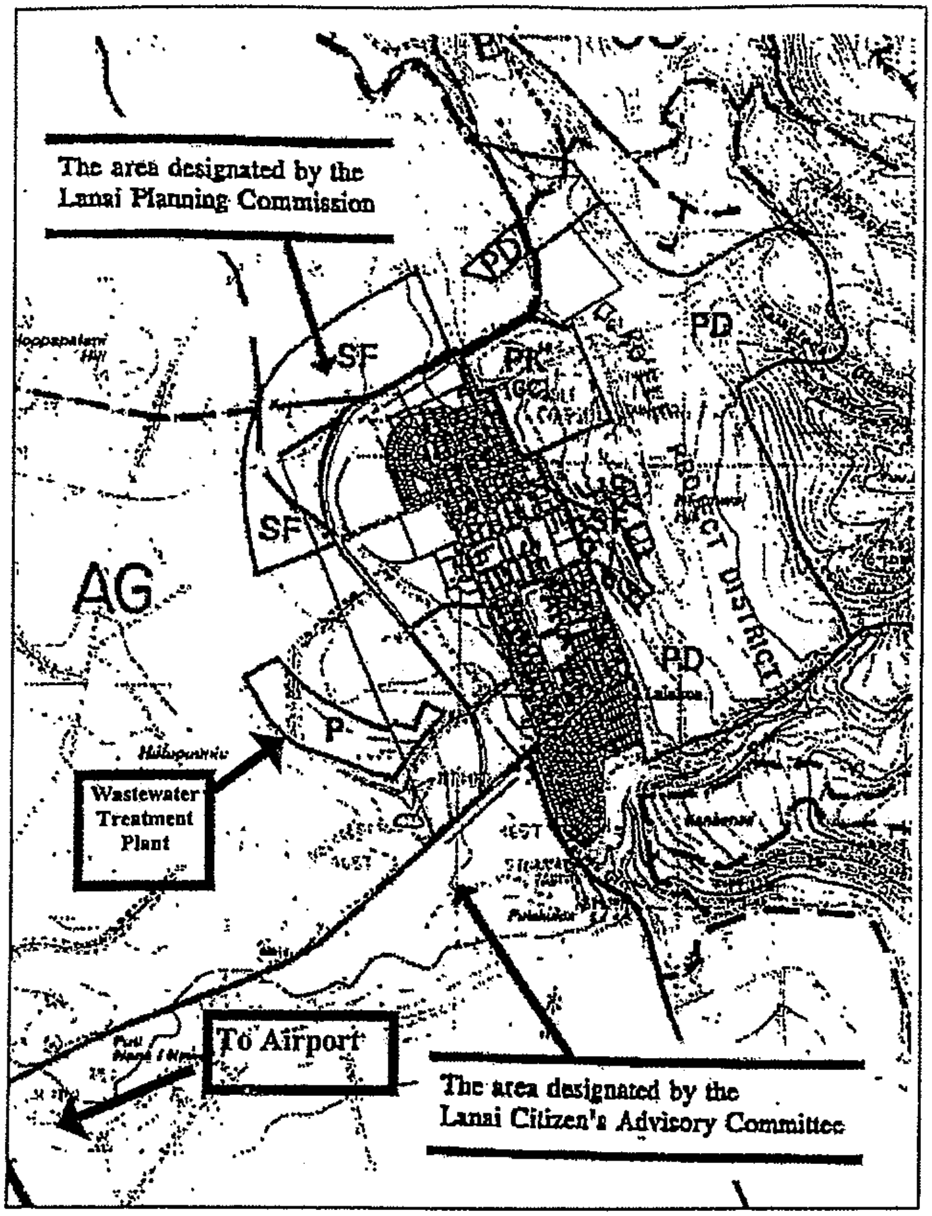

Figure A1. Different sites have been considered for the 115-acre residential development intended for County housing projects. The County has no projects planned. DHHL has no plans at this time for developing the 50 acres. The site has not yet been selected.

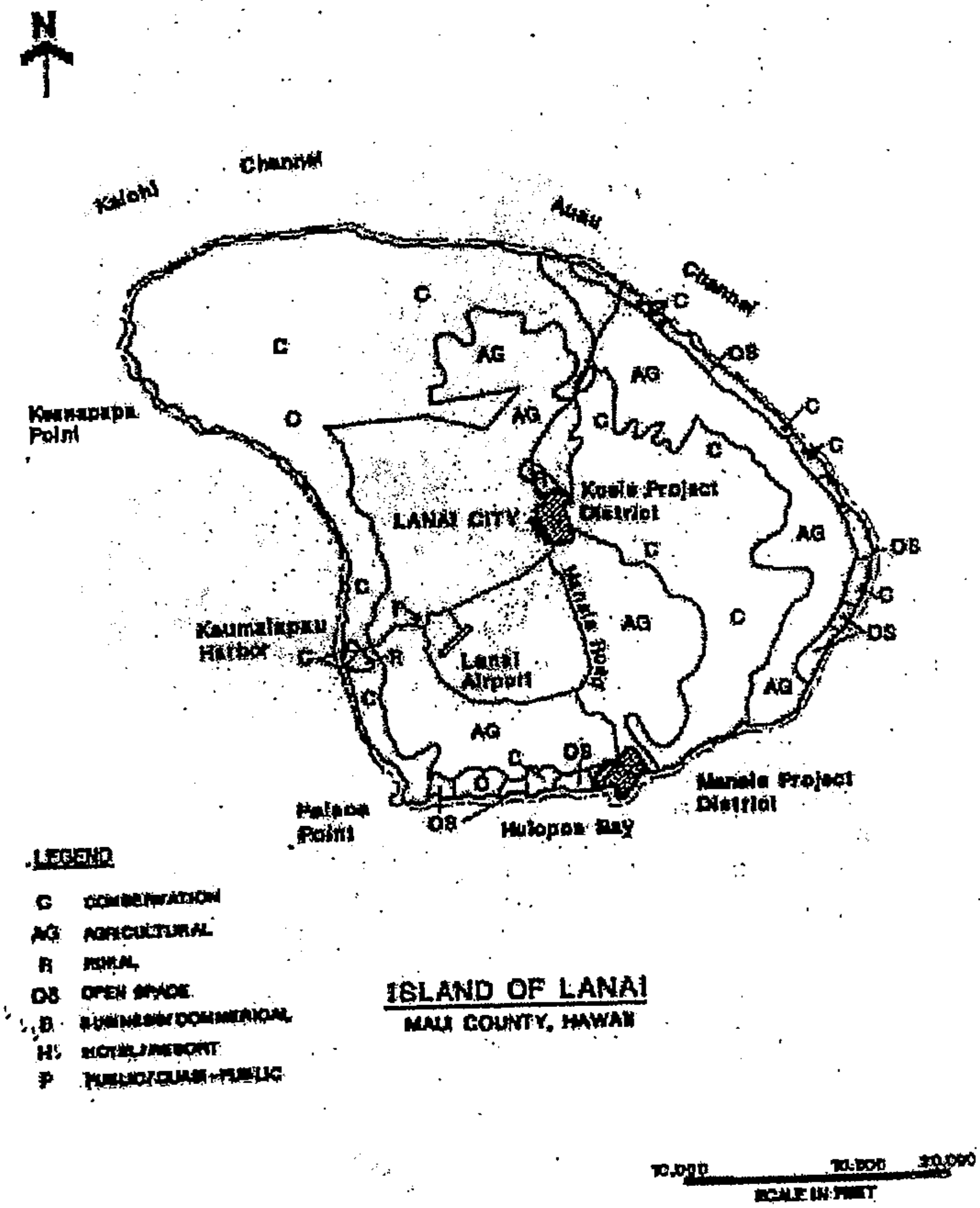

Figure A2. Land use designation for the island of Lana'i. The two major developments planned for the future are the Koele and Manele project districts.

Briefing Memorandum for Chair, State Board of Agriculture

July 22, 1996

MEMORANDUM

To: James Nakatani, Chair
Board of Agriculture
State of Hawaii

From: James Kumagai

RE: Briefing for your meeting on Lanai agriculture

Your meeting with the Lanai Water Working Group (WG) on August 1, 1996, will focus on the potential for diversified agriculture on Lanai. It is a sensitive and controversial issue. You will hear different viewpoints on what agriculture means to Lanai. It is a business. It is a way of life. It is a hope for diversifying a vulnerable economic base. In the end, the WG must pull it all together and decide how much water to recommend as the allocation to diversified agriculture. You can help them decide.

Lanai has a history of change. It has gone from sugar, to ranching, and then to pineapple in this century. Now, Lanai is going out of pineapple altogether and phasing into a resort economy.

Pineapple provided a narrow economic base. It made Lanai citizens feel vulnerable, and they have been calling on government and industry for over two decades to diversify agriculture on the island. The community could do nothing on its own. It had no land and no resources. Lanai Company owned all the land and the infrastructure. Government could help, and the Department of Agriculture tried to create opportunity for the community. It negotiated a 100-acre site with Lanai Company for an agricultural park, but it did not develop it.

Lanai Company tried several ventures, but none proved to be attractive as a business. Data on company projects are given below in this memo.

The Water Use and Development Plan

The WG is dealing with the issue of agricultural water as part of the Water Use and Development Plan (WUDP). The planning process comes under the State Water Code. Ultimately, the County Council and the Commission on Water Resource Management (CWRM) will decide the issue of allocation.

Council must adopt the WUDP by ordinance. CWRM must accept it as part of the state plan.

The process is a bottom-up effort. The WUDP starts at the county level under the principle of home rule. For Lanai, the WG is the planning group. It is made up of county officials, Lanai Company officials, and community members. The WG is an outgrowth of the Water Subcommittee created by the county council.

The WUDP process gives the community a chance to work out its differences in water use and development. In this sense, the community has the means to control its own destiny if it chooses to do so.

The Community Plan is the starting point

The Community Plan is intended as the starting point for the WUDP. It reflects what the community wants for its future. The 1983 Plan is being revised and a draft is now before the council for action.

There is a problem with the process. Revision to the 1983 Plan is overdue. Therefore, all other plans being developed now are either out of sequence or are being delayed. Because of the practical problems of sequencing, more people now are saying that the Community Plan and the WUDP should be developed together. It makes sense when it comes to water. Decisions on land use and water allocation should be made together, not one over the other. Of course, that is only my opinion.

The 1983 Community Plan and the draft of the revised plan both envision agriculture as part of the economy of the island. There are subtle differences in philosophy and expectations of the community.

The 1983 Community Plan for Lanai recommended the following:

1. *Keep pineapple as the primary economic activity and add tourism as the secondary activity.*
2. *Develop diversified agriculture as an economic activity and a source of local food products for the island.*

The 1995 draft currently before the Council for action has these recommendations:

1. *Promote diversified agriculture as a means of establishing job and income stability.*
2. *Establish and reserve a minimum water allocation to meet the needs of diversified agriculture.*

3. *Ensure the long-term availability of low-cost water for agricultural purposes.*

Lanai Company Initiatives

The information presented here came from Steve Snow, the person in charge of diversified agriculture for the company. The date is November 1994. Steve Snow is no longer in charge. More current information should be available from the company when we meet on August 1.

Data on agriculture is summarized below:

Land available for diversified agriculture	14,000 acres
Planned Use (Nov 1994)	
Pasture lands	12,000 acres
Dryland forage crops	2,000 acres
Planned Livestock (Nov 1994)	
Cattle for mainland shipment	800 to 1000 head
Hogs (300 sows)	4,000 hogs/year
Dairy heifers	No estimate
1994 Crops	
Banana	5.5 acres
Papaya	20 acres
Pineapple and herbs	50 acres
Barge Schedule	Once/week
Water consumption (1994 approx)	200,000 gpd
Cost of agricultural water (1994)	$0.96/1000 gal

Lanai is at a disadvantage when competing in the state agricultural market. Barging is only once a week. The shipping schedules and cost are problems to marketing products outside the island.

Cost of agricultural water is higher here than anywhere else. For example, DOA water sells for $0.16/1000 gal. Large users on Maui pay $0.64/1000 gal. I believe farmers using Waiahole water will be paying around $0.35/1000 gal. That was the number being tossed around in discussions among the farmers there. Lanai farmer pays $0.96/1000 gal or greater.

Recent Proposals for Agricultural Water

The community is going through the third iteration of the WUDP. The first was in 1990. It was prepared by the Maui BWS. The second was the 1992 WUDP that remained in draft form. Now, the WG is working on the 1996 WUDP. The agricultural components of the projected water demand are as follows:

Plan	Agricultural Use	Mgd	Remarks
1990 Maui BWS	Pineapple	1.8	1988 usage was 2.4 mgd. Reduction in pineapple.
1992 Draft Maui BWS	Diversified Agriculture (No pineapple)	1.5	Lanai Company disagreed. Company proposed 1.0 mgd.
Present Maui Council	Diversified Agriculture	??	

The decision to phase out pineapple was made public sometime in 1991. The company proposed that diversified agriculture would be somewhere around 1.0 mgd operation. The Department of Agriculture proposed the creation of a 100-acre agricultural park, requiring 0.5 mgd of irrigation water. The water task force recommended adding the 0.5 mgd to 1.0 mgd to get 1.5 mgd as the amount of water to be set aside for diversified agriculture. Lanai Company disagreed, claiming that the 1.0 mgd includes the 0.5 mgd demand for the agricultural park. Besides, the company said, DOA agreed to a lower number of 0.2 mgd for agricultural demand.

There was a problem over the agricultural park water demand. DOA reported to the CWRM in the state projects plan that the demand for the agricultural park of 0.5 mgd. At the same time, it agreed with Lanai Company that it should be lower, at around 0.2 mgd, without telling the WUDP task force or the CWRM about it.

The issue in the 1992 draft boiled down to whether diversified agriculture should be 1.0 mgd or 1.5 mgd operation, a difference of 0.5 mgd. Obviously, there are different philosophies and criteria involved here. That is not surprising. As I mentioned before in this memo, agriculture means different things to different people.

Conclusion

There is no doubt that the issue is complex. I sense that agriculture on Lanai means more than growing crops and getting them to market. You can help the WG and other members of the community sort through the complexities and gain insight into the issue of agriculture on Lanai. In the end, it will be their decision to make.

Call if you have questions.

cc: Members, Lanai Water Working Group

UNIT WATER CONSUMPTION FOR SFR, MAUI COUNTY WATER DISTRICTS. (Ref: Water Use and Development Plan, County of Maui, 1992) AREA	District	Class	Number Served	Max, gpd/serv	10%-tile gpd/serv	Median gpd/serv	Average gpd/serv
Makena	155	SFR	36	12789	5403	903	2090
Wailea	151w	SFR	93	4512	2496	1334	1455
Maalaea	153	SFR	21	7518	2055	921	1289
Maui Meadows	151m	SFR	561	5559	2151	1153	1229
Ulupalakua	335	SFR	31	6104	1458	342	841
Kihei	151	SFR	2520	6814	1312	655	841
Spreckelsville	173	SFR	88	5126	1521	599	809
Honokowai	513	SFR	209	6405	1310	614	641
Lahaina	511	SFR	1805	4499	1044	501	630
Alaeloa	515	SFR	207	3173	1101	434	556
Lower Kula	333	SFR	577	64888	6767	381	537
Kahului	131	SFR	3404	3290	915	458	519
Kawela-Kaunakakai	711	SFR	533	3036	800	405	454
Ualapue	713	SFR	273	6219	904	290	452
Pukalani	316	SFR	1569	8874	762	359	442
Haliimaile	317	SFR	188	1762	797	374	430
Waihee	113	SFR	142	7112	682	322	428
Upper Kula	331	SFR	1138	6784	789	293	413
Wailuku	111	SFR	3121	4693	759	342	407
Kuiaha	312	SFR	187	6893	707	260	392
Waikapu	115	SFR	202	3178	718	296	391
Lanai	Private	SFR	899	1970	654	333	373
Wailuku Heights	117	SFR	380	0.15	1855	833	367
Kokomo-Kaupakalua	311	SFR	611	2874	712	279	365
Hana	911	SFR	252	3129	707	274	351
Paia-Kuau	171	SFR	634	3323	773	344	342
Makawao	315	SFR	1657	3773	619	279	339
Haiku-Pauwela	313	SFR	514	3416	614	255	334
Honokohau	517	SFR	10	1370	285	217	303
Kalae	715	SFR	88	1058	466	227	251
Halawa	717	SFR	5	562	123	71	174
Makena	155	MFR	6	864	NA	NA	629
Wailea	151w	MFR	4	779	535	476	493
Kahului	131	MFR	26	568	431	415	426
Maalaea	153	MFR	12	408	350	308	293
Lahaina	511	MFR	47	2553	813	309	273
Wailuku	111	MFR	70	16899	448	223	266
Kawela-Kaunakakai	711	MFR	18	530	375	274	261
Kihei	151	MFR	4970units	1345	1191	352	259
Makawao	315	MFR	4	311	288	245	253
Pukalani	316	MFR	6	319	259	164	203
Paia-Kuau	171	MFR	3	348		279	203

UNIT WATER CONSUMPTION FOR SFR, MAUI COUNTY WATER DISTRICTS.							
(Ref: Water Use and Development Plan, County of Maui, 1992)							
AREA	District	Class	Number Served	Max, gpd/serv	10%-tile gpd/serv	Median gpd/serv	Average gpd/serv
Pukalani	316	MFR	6		259	164	203
Honokowai	513	MFR	90	4849	770	113	179
Alaeloa	515	MFR	23	570	405	279	172
Puunene	141	COM	9	76825	33433	14701	21262
Wailea	151w	COM	43	134076	24301	3222	8542
Kihei	151	COM	160	78500	15083	1982	7423
Wailuku Heights	117	COM	7	24066	8230	4112	6842
Honokowai	513	COM	70	31279	19956	1807	5711
Waihee	113	COM	7	38411	463	378	5700
Makawao	315	COM	27		8666	2433	4086
Maalaea	153	COM	6	17153	3499	907	3756
Alaeloa	515	COM	35	12877	9170	2964	3691
Spreckelsville	173	COM	16	9337	7077	1759	3133
Kahului	131	COM	354	55395	7364	818	2918
Lahaina	511	COM	170	25055	8756	438	2173
Wailuku	111	COM	400	34008	3915	449	1675
Upper Kula	331	COM	45	13381	1603	334	1214
Pukalani	316	COM	23	9285	2321	471	1076
Paia-Kuau	171	COM	44	15762	1978	254	1053
Kokomo-Kaupakalua	311	COM	12	4373	4132	462	1041
Haiku-Pauwela	313	COM	13	6181	899	249	755
Kawela-Kaunakakai	711	COM	67	12548	1638	233	740
Lower Kula	333	COM	18	3274	1510	331	678
Waikapu	115	COM	15	2323	696	342	505
Ualapue	713	COM	18	893	532	82	188
Lahaina	511	HOTEL	7	14748	4356	638	3260
Makena	155	HOTEL	4	NA	NA	NA	609
Wailea	151w	HOTEL	4	6836	1389	1449	531
Kihei	151	HOTEL	170units	NA	NA	NA	458
Honokowai	513	HOTEL	960	708		456	392
Alaeloa	515	HOTEL	7	340		310	267
Kahului	131	HOTEL	450 units	NA	NA	NA	206
Kawela-Kaunakakai	711	HOTEL	1	0	0	0	0
Kahului	131	IND	58	90058	25348	3134	8527
Kihei	151	IND	26	33337	18071	4137	6905
Lahaina	511	IND	43	41060	17088	3532	6678
Waikapu	115	IND	3	5764		5769	4829
Honokowai	513	IND	2	6775			4819
Wailuku	111	IND	71	23710	5918	100	2307
Kawela-Kaunakakai	711	IND	7	5844	2688	964	1638
Paia-Kuau	171	IND	10	6836	1452	930	1446

APPENDIX B

Water Conditions of Project Approvals

Ordinances Pertaining to Project District I - Manele

Ordinance #1578(1986) – A Bill for an Ordinance Relating to the Standards for the Project District At Manele, Lanai, and the Procedures for Project Districts

Slopes

12 to <15% slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands –

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. The use of recycled water is to be considered for irrigation purposes.

Ordinance #2066(1991) – A Bill for an Ordinance Pertaining to the Use of Potable Water for Golf Courses - Restrictions on the Use of Potable Water for Golf Courses

Restrictions:

Permit application shall be transmitted to Department of Water Supply for its review and recommendations. The department shall consider whether potable water will be used for irrigation and other non-domestic purposes.

No permits shall be approved for any new golf course if potable water is to be used for irrigation and other non-domestic purposes.

If the State Commission on Water Resources Management designates as water management are pursuant to Chapter 174C, Hawaii Revised Statutes, withdrawals or diversions shall be pursuant to that chapter.

Ordinance #2132 – A Bill for an Ordinance Amending Title 19 of the Maui County Code, Pertaining to the PD –L-/1 Project District for the Property Situated at Manele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non potable water sources.

Slopes

12 to < 15% slope – No more than 40% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

15 to < 30% slope – No more than 30% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

30% slope or more – No more than 40% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40% shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. The use of recycled water is to be considered for irrigation purposes.

Ordinance #2133(1992) – A Bill for an Ordinance to Establish Zoning in PD-L/1 (Manele) Project District (Conditional Zoning) for Property Situated at Manele, Lanai, Hawaii

Conditions: (Declarant)

Establish a loan fund of $1M to be administered and managed by the Bank of Hawaii, in consultation with Lanai Resort Partners for the purpose of assisting current Lanai City merchants with improvements of their commercial facilities.

On a fee simple basis, donate at no cost and free and clear of all mortgage and lien encumbrances, 115 acres of land adjacent to the Lower Waialua SF site to the County.

On a fee simple basis, donate at no cost and free and clear of all mortgage and lien cumbrances, a minimum of an acre of land on Lanai to the County for use as a veterans' cemetery.

Consummate a land exchange with the County for new police station upon terms and conditions acceptable to the declarant and the County.

Use only non-potable water as defined in Ordinance #2066 enacted by the county on 12/17/91, for the irrigation of the golf course in the Manele PD.

Make the Manele Golf course available for play to Lanai residents at a Kamaaina rate of 50% of the standard rate and for Hawaii residents at 60% of the standard rate.

Take appropriate preventive measures so that is development, construction, operation, and maintenance activities in the Manele PD do not cause any deterioration in the Class AA water quality standards currently in existence at Hulopoe Bay and the coastal waters adjacent to the Manele Bay Hotel and the Manele Golf Course.

Provide additional non-potable sources of water as may be needed for Manele Golf Course irrigation after consultation with the State CWRM and DOH.

Comply with the environmental health concerns addressed, entitled “Twelve (12) Conditions Applicable to All New Golf Course Development dtd 1/92 issued by the State DOH. (copy attached)

Ordinance #2408(1995) – A Bill for an Ordinance Amending Chapter 19.70 of the Maui County Code, Pertaining to Irrigation in Lanai Project District I Manele

Effective 1/1/95, no potable water drawn from the high level aquifer may be used for irrigation of the golf course, driving range, and other associated landscaping. The total amount of non-potable water drawn from the high level aquifer that may be used for irrigation of the golf course, driving range, and other associated landscaping shall not exceed an average 650,000 gallons per day expressed as a moving annualized average using 13-28 day period rather an 12 calendar months or such other reasonable withdrawal as may be determined by the Maui County Council upon advice from its standing committee on water use.

Ordinance #2411(1995) – A Bill for an Ordinance to Establish the Project District Zoning (Conditional Zoning) in PD-L/1 (Manele) – Project District for Property Situated at Manele, Lanai

Conditions:

Water Resource Management Program be developed for the island and the Manele/Koele resorts and be submitted to the Planning Dept. and CWRM. Essential elements of the program shall include:

Study of the water resource which may include monitor wells, electromagnetic resistivity testing, complete and accurate records of the water budgets, rainfall, pan evaporation, consumptive use and pumping from each well source, in order to increase baseline data in regards to the island’s geomorphology and the sustainable yield and delineation of high level (potable) and alternative (brackish) sources.

Plan for the use of effluent and desalinized water within the resort.

Greater metering and monitoring of specific water uses in order to establish an island-wide pattern of consumption and to control incidents of unreasonable uses and leakage fro m the storage and distribution system.

A detailed study of the projected water consumption patterns in the Manele Resort along with a detailed management scheme to reduce consumption within the resort, including the use of low-flow devices and offering guidelines for landscaping with salinity and drought tolerant plants and grasses.

Covenants for limits on water consumption and irrigated areas for dwelling units and restrictions on other uses to be included as legally binding instruments on the property owners; and a management program established to administer and enforce the covenants.

The applicant shall request a cooperative monitoring agreement with the USGS, through either DWS of CWRM to enhance data gathering and analysis for the islands water resources.

The commercial use area designated in the project district shall be deleted from the Hulopoe Bay Park shoreline area.

A conceptual archeological preservation interpretation plan, including buffer zones and setbacks shall be reviewed by the Maui County Cultural Resources Commission and the Lanai Archeology Committee, before the Phase 2 Project District approval.

All SF dwelling units shall be used only for long-term residential use. At such time additional hotel units are constructed or provided within the project district, the use of MF units for short-term vacation use shall be discontinued.

The applicant shall provide to the State CWRM its 28 day water usage report of potable and non-potable water for the Manele Project District and shall immediately inform said commission of any withdrawal of potable and non-potable water from the high level aquifer in excess of 70% of the sustainable yield as determined by said commission for the island of Lanai.

The applicant shall defer all applications for any approvals for the development of residential units (SF/MF) in the Puupehe Peninsula and the area east of Manele Road in the Manele Project District until the appropriate use of the peninsula and the area east of Manele Road is determined by the enactment of the pending Lanai Community Plan by the Maui County Council.

The applicant may subdivide the agricultural classified lands in the additional area of the Manele PD pursuant to Section 18.16.270 (large lots) and shall defer all applications for any approvals for the development of the Ag classified area in the Manele PD that have not yet been reclassified to urban by the state Land Use Commission in its decision and order dtd Oct. 24, 1994, except that infrastructural improvements necessary to the residential subdivision in the urbanized area, such as but not limited to, drainage and erosion control, sewer force main, water main and roadways, are permitted until said areas are reclassified to urbanized area by the state Land Use Commission pursuant to the said decision and order and any amendment thereof. In the event of an amendment wherein a portion of the Ag area is reclassified to rural, the applicant shall be permitted to develop the newly reclassified urban area and shall defer all applications for any approvals for the development of the newly reclassified rural area established by said amendment until said rural area is reclassified as heretofore stated in this condition.

Ordinance #2743(1998) – A Bill for an Ordinance Pertaining to the PD-L/1 Project District Situated at Manele, Lanai, Hawaii

Conditions: numbers 1 though 8 – same as in Ordinance #2411

No dwellings (residential units) on any kind shall be permitted within the open space designation in the Puupehe Peninsula. However, structures to promote cultural resources and preserve archaeological resources, based upon resource management plan for the area developed by the Cultural Resources Commission and the Hui Malama Pono O Lanai, shall be permitted.

Work with the Cultural Resources Commission and the Hui Malama Pono O Lanai organization to limit impacts of the MF project east of Manele Road to achieve the following:

Cultural protection of archeological sites at the Manele area proper.

Creation of a buffer zone at least 200 feet between the closest building the nearest heiau.

Completion of a drainage plan prior to construction, which would include addressing the adequacy of the siltation basin currently used to protect the small boat harbor

Hiring of Kupuna form Lanai to monitor the project's development during construction consistent with the current agreement with the Lanai Archeological Committee.

The designation of the6.6 acre site from SF to hotel use shall not increase the total number of hotel units within the PD in accordance with the density standards provided in the PD ordinance.

Current Manele PD

Land Use Type	Acres	Max Density (units/ac)	= Max Units	Water or Density Conditions in Ordinance
SF - Residential	328.8	0.8576 net units /acre 6,000 sq. ft. lot minimum min width 60'	282	setbacks front 15, side 8, rear 10 for single story <7,500 sq. ft. ; front 20 for lots greater than 7,500 sq. ft.; side and rear 15' for second story of structure.
Multi-family	55	3.34 net units / acre min lot area 1 acre min lot width 120'	184	front 25', side and rear 15' for one story, side and rear 20' for 2 story.
Commercial	5.25	0.5 acres 75' wide min. max 60% coverage structures min 6' setback +		+ setbacks per requirement of adjacent land-use, but not less than 6'
Hotel	56.6	10 units per acre 5 acres 250' wide min. max 50% coverage	500*	front 50', side 30', rear 30' *Ordinance 2743 (1998) stipulated that additional 6.6 acres added to the hotel site should not be construed to mean that more hotel units were allowed.
Park	66.33	10 acres 350' wide min max lot coverage 2% structures min 50' setback		dedication of park required
Open Space	152.02			
Golf Course	172	50 ac. 9 hole, 110 ac. 18 hole structures min 50' setback		No potable water drawn from the high level aquifer to be used for irrigation of golf course, driving range and other associated landscaping. Non-potable water from the high level aquifer not to exceed 0.65 MGD, annualized avg. basis (13, 28-day periods)..except as allowed by Maui County Council upon advice of standing committee on water use.
Roads	32			
OTHER				no more than 60% of existing woodland area in project area shall be cleared. Rest shall remain as permanent undisturbed open space. Also 95% dunes OS, 95% ravines, all wetlands, all bluffs - permanent open space
				xeriscaping “encouraged”, use of recycled water “considered” for irrigation purposes.

Ordinances Pertaining to Manele Land Use - Density and Acreage

	ORDINANCE 1578 1986 DENSITY*			ORDINANCE 2132 1992 DENSITY*			ORDINANCE 2410 1995 DENSITY*			ORDINANCE 2743 1998 DENSITY*		
	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS
SF RESIDENTIAL	137.00	2.50	342.50	121.00	2.84	343.64	379.00	0.86	325.03	328.80	0.86	281.98
MF RESIDENTIAL	18.60	4.00	74.40	18.60	4.00	74.40	30.00	3.34	100.20	55.00	3.34	183.70
COMMERCIAL	5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%	
HOTEL	50.00	10.00	500.00	50.00	10.00	500.00	50.00	10.00	500.00	56.60	10.00	500*
PARK	66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide	
GOLF COURSE	0.00			201.00	min 110 ac 18-hole		172.00	min 110 ac 18-hole		172.00	min 50 ac 9-hole min 110 ac 18-hole	
PUBLIC	4.25	min 2 acs. 50' setbacks		4.25	min 2 acs. 50' setbacks		4.25				min 2 acs. 50' setbacks	
OPEN SPACE	113.91			89.91			133.42			152.02		
ROADS							32.00			32.00		
TOTALS:												
Acreage	**395.34**			**556.34**			**872.25**			**868.00**		
Units:												
SFR			**342.50**			**343.64**			**325.03**			**281.98**
MFR			**74.40**			**74.40**			**100.20**			**183.70**
HOTEL			**500.00**			**500.00**			**500.00**			**500***
Increases:				**161.00**			**315.91**			**-4.25**		
Notes:				although total acreage change reflected is 161, ord. #2133 added only 138.577 acres. zoning map 2607 reason for discrepancy not clear.			although acreage change reflected is 315.91, ord # 2411 established zoning for 319.447 acres. zoning map L26-10 reason for discrepancy not clear.			* ordinance states that addition of 6.6 acres to hotel site shall not increase total # of units land zoning map L-2613. Ord also lists total ac as 868, though sum seems to be 836.		

* for all conditions, see ordinance, units per acre only given here except where noted otherwise

Ordinances Pertaining to Project District 2 - Koele

Ordinance #1580(1986) – A Bill for an Ordinance Relating to Standards for the Project District at Koele, Lanai

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control.

Required Agreements:

A Bilateral agreement requiring the applicant to develop and coordinate a training program for all phases of hotel operations; provided that development other than hotel development within the PD may proceed before the agreement has been executed and

A bilateral agreement requiring the applicant to develop and coordinate an affordable housing program for residents of Lanai; provided that development other than hotel development within the PD may proceed before the agreement has been executed

Ordinance #2066(1991) – A Bill for an Ordinance Pertaining to the Use of Potable Water for Golf Courses

Restrictions:

Permit application shall be transmitted to Department of Water Supply for its review and recommendations. The department shall consider whether potable water will be used for irrigation and other non-domestic purposes.

No permits shall be approved for any new golf course if potable water is to be used for irrigation and other non-domestic purposes.

If the State Commission on Water Resources Management designates as water management are pursuant to Chapter 174C, Hawaii Revised Statutes, withdrawals or diversions shall be pursuant to that chapter.

This ordinance shall not be construed to prevent the use of reclaimed water for irrigation and other non-domestic purposes.

Ordinance #2139(1992) – A Bill for an Ordinance Amending Title 19 of the Maui County Code Pertaining to the PD-L/2 Project District for Property Situated at Koele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non-potable water sources.

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control.

Ordinance #2407(1995) – A Bill for an Ordinance Amending Section 19.71.090 Koele Project District Standards Ordinance, Maui County Code

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Plans

A tract master plan shall be provided showing the building envelope, required setbacks and preliminary drainage plan for each lot within the given tract and shall be reviewed and approved by the Planning Department during Phase III PD review. The Planning Dept. may impose mitigative measures to ensure minimum subsidence and erosion on slopes exceeding 30% and on portions of the tract that are immediately adjacent to ravines. The tract master plan may include all or any part of the given tract, however, Phase III approval shall only apply to that part. Prior to the issuance of a building permit for a dwelling on a lot, the grading and erosion control plan for that lot shall be submitted to and approved by the Department of Public Works and Waste Management, which shall review the final grading plan in accordance with the following criteria:

Drainage

Individual lot drainage shall conform with the approved Phase III preliminary drainage plan

Erosion Control

Erosion control measures to prevent erosion and sedimentation into the adjoining natural drainage way during construction of the home and exterior improvements shall be specified

A plan shall be submitted for re vegetation of all disturbed and exposed slopes. This plan shall show how exposed surfaces will be planted and covered after construction to prevent erosion and sedimentation into the adjoining drainage way; and

The Planning Dept. may require additional information if deemed necessary to support any request for Phase III approval.

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. Furthermore, the use of recycled water is to be considered for irrigation purposes.

Ordinance #2514(1996) – A Bill for an Ordinance Amending Ordinance #2140 Pertaining to a Condition of the Establishment of Zoning (Conditional Zoning) in PD-L/2 (Koele) Project District for Property Situated at Koele, Lanai, Hawaii

The Declarant shall irrigate the Koele golf course with non-potable water, as defined in Ordinance #2066 enacted by the County on 12/7/91 (after the golf course has been operating for 5 years as provided by the Planning Commission on 11/28/89), except as may otherwise be provided by the provisions of the Maui County Code. Within 2 years of the effective date of this ordinance Lanai Company shall present to the Maui County council a report detailing:

A comprehensive plan to develop additional storage of water for Koele golf course irrigation.

The time frame within which the plan will be implemented.

Steps taken to implement the plan at the time the plan is submitted.

Ordinance #2515(1996) – A Bill for an Ordinance Amending Section 19.71.055 of the Maui County Code, Relating to Irrigation of the Koele Golf course (Lanai Project District PD-L/2) Located at Koele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non-potable water sources, except as may be allowed from time to time as follows:

The director of the Dept. of Public Works and Waste Management, after notification of the chairperson and the deputy director of the CWRM, the chair of the Maui County Council, any appropriate subcommittee established under one of the Maui County Council's standing committees to review water related issues on Lanai, the chair of the Lanai Planning Commission, and other state and/or county officials as appropriate, may authorize the use of potable ground water from the high level aquifer if the director finds, in writing, there is an occurrence of an unanticipated even, including but not limited to:

- Chemical contamination of a non-potable source by chemicals not approved for application to golf courses in accordance with the Golf Course Superintendents Association of America standards; or
- Chemical contamination of a non-potable source resulting in chemical concentrations not approved for golf course application by the Golf Course Superintendents Association of America, excluding however, naturally occurring concentrations of chemicals or minerals; or
- A water transmission line break resulting in the interruption in the delivery of non-potable water for golf course irrigation; or
- Failure of the pumping system used to pump non-potable water; or
- A failure in the sewage reclamation systems which provide irrigation water for the golf course; or
- Draw-down of various lakes or reservoirs due to use of that water to fight fires or other similar emergencies; or
- Due to the failure of the main electrical power feed to facilities used to irrigate the golf course with non-potable water; and

Under no circumstances shall drought be deemed in an unanticipated event, such tat a permit may be issued.

Prior to the director approving the use of potable high level aquifer ground water for golf course irrigation, the golf course owner shall have provided to the director:

- Materials, reports and other supporting document setting forth the facts and/or circumstances which gave rise to the immediate need for golf course irrigation with potable high level aquifer ground water;

- A plan showing that no continuous physical connection will be made between potable and non-potable water systems;
- The remedial plan to restore the use of non-potable water in as short a time as possible, and shall include manufacturing and/or shipping times of various items needed for the restoration, as appropriate, and shall further indicate those items will be obtained and/or shipped by the most expeditious means available; and
- A plan detailing how the following uses will be accommodated, including all sources from which water will be obtained (specifically addressing the use of existing reservoirs and lake water) and a watering/distribution plan, with the priority of uses as follows, such as being bases on a daily average of the historical record use over the prior 12 month period immediately preceding the unanticipated event:
    - Residential/domestic consumption (excluding irrigation uses);
    - Commercial, business, and resort consumption where potable water is necessarily used;
    - Agricultural consumption; and
    - Irrigation (including residential and large scale uses such as golf course). This part of the plan shall address the order in which the portions of the golf course shall cease to be watered as the situation continues.

The permit issued by the director shall:

Be issued only one time for any single unanticipated event and shall be valid for a period not to exceed 30 calendar days. The director may propose a longer period to the council and the council, by resolution, may indicate its concurrence with the director's determination that the permit should be issued for a period greater than 30 days. If the council does not concur, the permit shall be valid for a period not to exceed 30 days. The golf course owner is prohibited from applying for a new permit for the same unanticipated event where the original permit has expired and the remedial action has not been completed, and the director is prohibited from issuing any further permits for the same unanticipated event where the original permit has expired and the remedial action has not been completed;

Require the golf course owner to submit weekly reports to the director and the council regarding the status of the situation, efforts made to address the situation, and the amount of potable ground water used for the high level aquifer for that week. Meter readings shall be physically verified by the Dept of Public Works and Waste Management;

Include any condition or restrictions appropriate and reasonably related to the circumstances surrounding the use of high level aquifer potable ground water and the remedial work to be done, and also including the authority to impose a cap on the use of such water based on the historical monthly average of use on non-potable water, in an amount not to exceed 250,000 gpd.

A copy of the permit shall be transmitted to all persons notified pursuant to subsection D.1, above the same day it is issued.

Ordinance #2516(1996) – A Bill for an Ordinance Amending Title 19 of the Maui County Code, Pertaining to the Re-seeding or Re-grassing of the Golf Course Located in the PD-L/2 Project District for Property Situated at Koele, Lanai, Hawaii

Re-seeding or Re-grassing

Notwithstanding Ordinance #2066, at such time as the fairways at the golf course are to be re-seeded for re-grassed so as to provide the golf course with more efficient or better quality grass, the golf course owner may make a request of the County Council for the use of potable ground water from the high level aquifer in an amount up to 27,000 gpd to supplement irrigation water from alternative non-potable water sources, Such approval, shall be by resolution of the Council. Such additional water may be used for a period not to exceed 28 days per fairway. Only 1 fairway shall be irrigated with the additional water at any given time. No more than 4 fairways shall be re-seeded or re-grassed during any calendar year. Fairways shall only be re-seeded one time only under the provisions of this section. No continuous physical connection will be made between the potable and non-potable water systems. In determining whether or not to approve the golf course owner's request, the Council shall ensure that an adequate supply of water shall be available for golf course irrigation in accordance with the priority of uses as follows:

- Residential/domestic consumption (excluding irrigation uses);
- Commercial, business and resort consumption where potable water is necessarily used;
- Agricultural consumption; and
- Irrigation (including residential and large scale uses such as the golf course).

If during the re-seeding or re-grassing of a fairway, an unanticipated event occurs for which a permit is issued pursuant to Section D above, the golf course owner may continue to use potable water for re-seeding or re-grassing, but only to the extent that such cumulative total of potable water permitted to be used pursuant to Section D and this section does not exceed 250,000 gpd.

Resolution #01-146(9/7/2001) – Approving the Use of Potable Water from the High Level Aquifer for Re-seeding and Re-grassing Koele Golf Course during September and October 2001, Pursuant to Subsection 19.71.55(E), Maui County Code

Conditions: Castle & Cooke Resorts, LLC shall:

- promptly file with the County Clerk a completion bond for the repair of the sewage-treatment plant that serves the Koele golf course;
- repair the sewage-treatment plant that serves the Koele golf course within one year of this resolution's adoption;
- submit a water-storage master plan to the Council by March 1, 2002;
- install a separate water meter, as approved by the Department of Water Supply, prior to the use of potable water approved by this resolution to gauge such use; and
- allow for meter readings to be conducted and verified by two designated members of the Lanai Water Advisory Committee who are not employees of the Castle & Cooke Resorts, LLC or affiliated entities.

Ordinances Pertaining to Project District 2 - Koele

Koele PD History		
Year	**Ordinance/ Approval #**	**Comment**
1985	CIZ for Koele PD	Interim Urban to PD Requirements Included ♦ Resource Study ♦ Maintenance of accurate records ♦ Plans for effluent use & desalinized water ♦ Conservation Plan ♦ Legally binding covenants to limit water consumption ♦ Cooperative aquiifer monitoring with USGS ♦ 28 day periodic water reports ♦ Detailed demand study
1986	1580	Established Koele PD - 468.3 Acres
1991	2066	Prohibits the Use of Potable Water on All Golf Courses
1992	2139	Increased Koele PD from 468.3 to 618 acres Added 332.4 acre golf course Deleted 201.5 acres of open space
1992	Phase II PD	Requirements Prior to Phase III Approval ♦ Detailed monitoring plan for metering - common areas to be metered seperately ♦ Dual system for the GC to be submitted to DWS ♦ Approved xeriscape plan ♦ Use of low flow devices
1995	2407	Amends ordinance for tract master plan requirements Limits density of development on slopes of various grades Use of recycled water for irrigation to be considered No more than 60% of woodland to be cleared Cleared area shld be open space Retain minimum of 35% of tree canopy
1996	2514	Sets conditions in which potable water may be utilized on golf course Requires a comprehensive plan to develop additional storage for the GC Storage plan to include time frame and implementation steps
1996	2515	High level water not to be used for irrigation except as defined Sets triggers & requirements to allow 30 day permits for potable water use Un--anticipated events can be part of a trigger, but it is specified that Drought does NOT meet the criteria for un-anticipated event, Nor does it warrant use of the high level aquifer for GC irrigation
1996	2516	Enables GC owner to aply for up to 27,000 GPD per fairway to supplement non potable irrigation to establish new plantings Stipulates that only one fairway may be watered in this manner No more than four fairways per year to be watered this way Combined use of new fairway establishment and emergencies defined in 2515 should not exceed a total of 250,000 GPD
2001	Res 01-146	Issues temporary permit for use of high level water for re-grassing. Requirements: ♦ Bond repairs to wastewater treatment facility ♦ Implement repairs to WWTF within one year ♦ Submit water storage master plan by March of 2002 ♦ Install separate meter to monitor use of high level water and coordinate with LWAC so that LWAC members can monitor/read it

APPENDIX B

Water Conditions of Project Approvals

Ordinances Pertaining to Project District I - Manele

Ordinance #1578(1986) – A Bill for an Ordinance Relating to the Standards for the Project District At Manele, Lanai, and the Procedures for Project Districts

Slopes

12 to <15% slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands –

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. The use of recycled water is to be considered for irrigation purposes.

Ordinance #2066(1991) – A Bill for an Ordinance Pertaining to the Use of Potable Water for Golf Courses - Restrictions on the Use of Potable Water for Golf Courses

Restrictions:

Permit application shall be transmitted to Department of Water Supply for its review and recommendations. The department shall consider whether potable water will be used for irrigation and other non-domestic purposes.

No permits shall be approved for any new golf course if potable water is to be used for irrigation and other non-domestic purposes.

If the State Commission on Water Resources Management designates as water management are pursuant to Chapter 174C, Hawaii Revised Statutes, withdrawals or diversions shall be pursuant to that chapter.

Ordinance #2132 – A Bill for an Ordinance Amending Title 19 of the Maui County Code, Pertaining to the PD –L-/1 Project District for the Property Situated at Manele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non potable water sources.

Slopes

12 to < 15% slope – No more than 40% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

15 to < 30% slope – No more than 30% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

30% slope or more – No more than 40% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40% shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. The use of recycled water is to be considered for irrigation purposes.

Ordinance #2133(1992) – A Bill for an Ordinance to Establish Zoning in PD-L/1 (Manele) Project District (Conditional Zoning) for Property Situated at Manele, Lanai, Hawaii

Conditions: (Declarant)

Establish a loan fund of $1M to be administered and managed by the Bank of Hawaii, in consultation with Lanai Resort Partners for the purpose of assisting current Lanai City merchants with improvements of their commercial facilities.

On a fee simple basis, donate at no cost and free and clear of all mortgage and lien encumbrances, 115 acres of land adjacent to the Lower Waialua SF site to the County.

On a fee simple basis, donate at no cost and free and clear of all mortgage and lien cumbrances, a minimum of an acre of land on Lanai to the County for use as a veterans' cemetery.

Consummate a land exchange with the County for new police station upon terms and conditions acceptable to the declarant and the County.

Use only non-potable water as defined in Ordinance #2066 enacted by the county on 12/17/91, for the irrigation of the golf course in the Manele PD.

Make the Manele Golf course available for play to Lanai residents at a Kamaaina rate of 50% of the standard rate and for Hawaii residents at 60% of the standard rate.

Take appropriate preventive measures so that is development, construction, operation, and maintenance activities in the Manele PD do not cause any deterioration in the Class AA water quality standards currently in existence at Hulopoe Bay and the coastal waters adjacent to the Manele Bay Hotel and the Manele Golf Course.

Provide additional non-potable sources of water as may be needed for Manele Golf Course irrigation after consultation with the State CWRM and DOH.

Comply with the environmental health concerns addressed, entitled “Twelve (12) Conditions Applicable to All New Golf Course Development dtd 1/92 issued by the State DOH. (copy attached)

Ordinance #2408(1995) – A Bill for an Ordinance Amending Chapter 19.70 of the Maui County Code, Pertaining to Irrigation in Lanai Project District I Manele

Effective 1/1/95, no potable water drawn from the high level aquifer may be used for irrigation of the golf course, driving range, and other associated landscaping. The total amount of non-potable water drawn from the high level aquifer that may be used for irrigation of the golf course, driving range, and other associated landscaping shall not exceed an average 650,000 gallons per day expressed as a moving annualized average using 13-28 day period rather an 12 calendar months or such other reasonable withdrawal as may be determined by the Maui County Council upon advice from its standing committee on water use.

Ordinance #2411(1995) – A Bill for an Ordinance to Establish the Project District Zoning (Conditional Zoning) in PD-L/1 (Manele) – Project District for Property Situated at Manele, Lanai

Conditions:

Water Resource Management Program be developed for the island and the Manele/Koele resorts and be submitted to the Planning Dept. and CWRM. Essential elements of the program shall include:

Study of the water resource which may include monitor wells, electromagnetic resistivity testing, complete and accurate records of the water budgets, rainfall, pan evaporation, consumptive use and pumping from each well source, in order to increase baseline data in regards to the island’s geomorphology and the sustainable yield and delineation of high level (potable) and alternative (brackish) sources.

Plan for the use of effluent and desalinized water within the resort.

Greater metering and monitoring of specific water uses in order to establish an island-wide pattern of consumption and to control incidents of unreasonable uses and leakage fro m the storage and distribution system.

A detailed study of the projected water consumption patterns in the Manele Resort along with a detailed management scheme to reduce consumption within the resort, including the use of low-flow devices and offering guidelines for landscaping with salinity and drought tolerant plants and grasses.

Covenants for limits on water consumption and irrigated areas for dwelling units and restrictions on other uses to be included as legally binding instruments on the property owners; and a management program established to administer and enforce the covenants.

The applicant shall request a cooperative monitoring agreement with the USGS, through either DWS of CWRM to enhance data gathering and analysis for the islands water resources.

The commercial use area designated in the project district shall be deleted from the Hulopoe Bay Park shoreline area.

A conceptual archeological preservation interpretation plan, including buffer zones and setbacks shall be reviewed by the Maui County Cultural Resources Commission and the Lanai Archeology Committee, before the Phase 2 Project District approval.

All SF dwelling units shall be used only for long-term residential use. At such time additional hotel units are constructed or provided within the project district, the use of MF units for short-term vacation use shall be discontinued.

The applicant shall provide to the State CWRM its 28 day water usage report of potable and non-potable water for the Manele Project District and shall immediately inform said commission of any withdrawal of potable and non-potable water from the high level aquifer in excess of 70% of the sustainable yield as determined by said commission for the island of Lanai.

The applicant shall defer all applications for any approvals for the development of residential units (SF/MF) in the Puupehe Peninsula and the area east of Manele Road in the Manele Project District until the appropriate use of the peninsula and the area east of Manele Road is determined by the enactment of the pending Lanai Community Plan by the Maui County Council.

The applicant may subdivide the agricultural classified lands in the additional area of the Manele PD pursuant to Section 18.16.270 (large lots) and shall defer all applications for any approvals for the development of the Ag classified area in the Manele PD that have not yet been reclassified to urban by the state Land Use Commission in its decision and order dtd Oct. 24, 1994, except that infrastructural improvements necessary to the residential subdivision in the urbanized area, such as but not limited to, drainage and erosion control, sewer force main, water main and roadways, are permitted until said areas are reclassified to urbanized area by the state Land Use Commission pursuant to the said decision and order and any amendment thereof. In the event of an amendment wherein a portion of the Ag area is reclassified to rural, the applicant shall be permitted to develop the newly reclassified urban area and shall defer all applications for any approvals for the development of the newly reclassified rural area established by said amendment until said rural area is reclassified as heretofore stated in this condition.

Ordinance #2743(1998) – A Bill for an Ordinance Pertaining to the PD-L/1 Project District Situated at Manele, Lanai, Hawaii

Conditions: numbers 1 though 8 – same as in Ordinance #2411

No dwellings (residential units) on any kind shall be permitted within the open space designation in the Puupehe Peninsula. However, structures to promote cultural resources and preserve archaeological resources, based upon resource management plan for the area developed by the Cultural Resources Commission and the Hui Malama Pono O Lanai, shall be permitted.

Work with the Cultural Resources Commission and the Hui Malama Pono O Lanai organization to limit impacts of the MF project east of Manele Road to achieve the following:

Cultural protection of archeological sites at the Manele area proper.

Creation of a buffer zone at least 200 feet between the closest building the nearest heiau.

Completion of a drainage plan prior to construction, which would include addressing the adequacy of the siltation basin currently used to protect the small boat harbor

Hiring of Kupuna form Lanai to monitor the project's development during construction consistent with the current agreement with the Lanai Archeological Committee.

The designation of the6.6 acre site from SF to hotel use shall not increase the total number of hotel units within the PD in accordance with the density standards provided in the PD ordinance.

Current Manele PD

Land Use Type	Acres	Max Density (units/ac)	= Max Units	Water or Density Conditions in Ordinance
SF - Residential	328.8	0.8576 net units /acre 6,000 sq. ft. lot minimum min width 60'	282	setbacks front 15, side 8, rear 10 for single story <7,500 sq. ft. ; front 20 for lots greater than 7,500 sq. ft.; side and rear 15' for second story of structure.
Multi-family	55	3.34 net units / acre min lot area 1 acre min lot width 120'	184	front 25', side and rear 15' for one story, side and rear 20' for 2 story.
Commercial	5.25	0.5 acres 75' wide min. max 60% coverage structures min 6' setback +		+ setbacks per requirement of adjacent land-use, but not less than 6'
Hotel	56.6	10 units per acre 5 acres 250' wide min. max 50% coverage	500*	front 50', side 30', rear 30' *Ordinance 2743 (1998) stipulated that additional 6.6 acres added to the hotel site should not be construed to mean that more hotel units were allowed.
Park	66.33	10 acres 350' wide min max lot coverage 2% structures min 50' setback		dedication of park required
Open Space	152.02			
Golf Course	172	50 ac. 9 hole, 110 ac. 18 hole structures min 50' setback		No potable water drawn from the high level aquifer to be used for irrigation of golf course, driving range and other associated landscaping. Non-potable water from the high level aquifer not to exceed 0.65 MGD, annualized avg. basis (13, 28-day periods)..except as allowed by Maui County Council upon advice of standing committee on water use.
Roads	32			
OTHER				no more than 60% of existing woodland area in project area shall be cleared. Rest shall remain as permanent undisturbed open space. Also 95% dunes OS, 95% ravines, all wetlands, all bluffs - permanent open space
				xeriscaping “encouraged”, use of recycled water “considered” for irrigation purposes.

Ordinances Pertaining to Manele Land Use - Density and Acreage

	ORDINANCE 1578 1986 DENSITY*			ORDINANCE 2132 1992 DENSITY*			ORDINANCE 2410 1995 DENSITY*			ORDINANCE 2743 1998 DENSITY*		
	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS
SF RESIDENTIAL	137.00	2.50	342.50	121.00	2.84	343.64	379.00	0.86	325.03	328.80	0.86	281.98
MF RESIDENTIAL	18.60	4.00	74.40	18.60	4.00	74.40	30.00	3.34	100.20	55.00	3.34	183.70
COMMERCIAL	5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%	
HOTEL	50.00	10.00	500.00	50.00	10.00	500.00	50.00	10.00	500.00	56.60	10.00	500*
PARK	66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide	
GOLF COURSE	0.00			201.00	min 110 ac 18-hole		172.00	min 110 ac 18-hole		172.00	min 50 ac 9-hole min 110 ac 18-hole	
PUBLIC	4.25	min 2 acs. 50' setbacks		4.25	min 2 acs. 50' setbacks		4.25				min 2 acs. 50' setbacks	
OPEN SPACE	113.91			89.91			133.42			152.02		
ROADS							32.00			32.00		
TOTALS:												
Acreage	**395.34**			**556.34**			**872.25**			**868.00**		
Units:												
SFR			**342.50**			**343.64**			**325.03**			**281.98**
MFR			**74.40**			**74.40**			**100.20**			**183.70**
HOTEL			**500.00**			**500.00**			**500.00**			**500***
Increases:				**161.00**			**315.91**			**-4.25**		
Notes:				although total acreage change reflected is 161, ord. #2133 added only 138.577 acres. zoning map 2607 reason for discrepancy not clear.			although acreage change reflected is 315.91, ord # 2411 established zoning for 319.447 acres. zoning map L26-10 reason for discrepancy not clear.			* ordinance states that addition of 6.6 acres to hotel site shall not increase total # of units land zoning map L-2613. Ord also lists total ac as 868, though sum seems to be 836.		

* for all conditions, see ordinance, units per acre only given here except where noted otherwise

Ordinances Pertaining to Project District 2 - Koele

Ordinance #1580(1986) – A Bill for an Ordinance Relating to Standards for the Project District at Koele, Lanai

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control.

Required Agreements:

A Bilateral agreement requiring the applicant to develop and coordinate a training program for all phases of hotel operations; provided that development other than hotel development within the PD may proceed before the agreement has been executed and

A bilateral agreement requiring the applicant to develop and coordinate an affordable housing program for residents of Lanai; provided that development other than hotel development within the PD may proceed before the agreement has been executed

Ordinance #2066(1991) – A Bill for an Ordinance Pertaining to the Use of Potable Water for Golf Courses

Restrictions:

Permit application shall be transmitted to Department of Water Supply for its review and recommendations. The department shall consider whether potable water will be used for irrigation and other non-domestic purposes.

No permits shall be approved for any new golf course if potable water is to be used for irrigation and other non-domestic purposes.

If the State Commission on Water Resources Management designates as water management are pursuant to Chapter 174C, Hawaii Revised Statutes, withdrawals or diversions shall be pursuant to that chapter.

This ordinance shall not be construed to prevent the use of reclaimed water for irrigation and other non-domestic purposes.

Ordinance #2139(1992) – A Bill for an Ordinance Amending Title 19 of the Maui County Code Pertaining to the PD-L/2 Project District for Property Situated at Koele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non-potable water sources.

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control.

Ordinance #2407(1995) – A Bill for an Ordinance Amending Section 19.71.090 Koele Project District Standards Ordinance, Maui County Code

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Plans

A tract master plan shall be provided showing the building envelope, required setbacks and preliminary drainage plan for each lot within the given tract and shall be reviewed and approved by the Planning Department during Phase III PD review. The Planning Dept. may impose mitigative measures to ensure minimum subsidence and erosion on slopes exceeding 30% and on portions of the tract that are immediately adjacent to ravines. The tract master plan may include all or any part of the given tract, however, Phase III approval shall only apply to that part. Prior to the issuance of a building permit for a dwelling on a lot, the grading and erosion control plan for that lot shall be submitted to and approved by the Department of Public Works and Waste Management, which shall review the final grading plan in accordance with the following criteria:

Drainage

Individual lot drainage shall conform with the approved Phase III preliminary drainage plan

Erosion Control

Erosion control measures to prevent erosion and sedimentation into the adjoining natural drainage way during construction of the home and exterior improvements shall be specified

A plan shall be submitted for re vegetation of all disturbed and exposed slopes. This plan shall show how exposed surfaces will be planted and covered after construction to prevent erosion and sedimentation into the adjoining drainage way; and

The Planning Dept. may require additional information if deemed necessary to support any request for Phase III approval.

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. Furthermore, the use of recycled water is to be considered for irrigation purposes.

Ordinance #2514(1996) – A Bill for an Ordinance Amending Ordinance #2140 Pertaining to a Condition of the Establishment of Zoning (Conditional Zoning) in PD-L/2 (Koele) Project District for Property Situated at Koele, Lanai, Hawaii

The Declarant shall irrigate the Koele golf course with non-potable water, as defined in Ordinance #2066 enacted by the County on 12/7/91 (after the golf course has been operating for 5 years as provided by the Planning Commission on 11/28/89), except as may otherwise be provided by the provisions of the Maui County Code. Within 2 years of the effective date of this ordinance Lanai Company shall present to the Maui County council a report detailing:

A comprehensive plan to develop additional storage of water for Koele golf course irrigation.

The time frame within which the plan will be implemented.

Steps taken to implement the plan at the time the plan is submitted.

Ordinance #2515(1996) – A Bill for an Ordinance Amending Section 19.71.055 of the Maui County Code, Relating to Irrigation of the Koele Golf course (Lanai Project District PD-L/2) Located at Koele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non-potable water sources, except as may be allowed from time to time as follows:

The director of the Dept. of Public Works and Waste Management, after notification of the chairperson and the deputy director of the CWRM, the chair of the Maui County Council, any appropriate subcommittee established under one of the Maui County Council's standing committees to review water related issues on Lanai, the chair of the Lanai Planning Commission, and other state and/or county officials as appropriate, may authorize the use of potable ground water from the high level aquifer if the director finds, in writing, there is an occurrence of an unanticipated even, including but not limited to:

- Chemical contamination of a non-potable source by chemicals not approved for application to golf courses in accordance with the Golf Course Superintendents Association of America standards; or
- Chemical contamination of a non-potable source resulting in chemical concentrations not approved for golf course application by the Golf Course Superintendents Association of America, excluding however, naturally occurring concentrations of chemicals or minerals; or
- A water transmission line break resulting in the interruption in the delivery of non-potable water for golf course irrigation; or
- Failure of the pumping system used to pump non-potable water; or
- A failure in the sewage reclamation systems which provide irrigation water for the golf course; or
- Draw-down of various lakes or reservoirs due to use of that water to fight fires or other similar emergencies; or
- Due to the failure of the main electrical power feed to facilities used to irrigate the golf course with non-potable water; and

Under no circumstances shall drought be deemed in an unanticipated event, such tat a permit may be issued.

Prior to the director approving the use of potable high level aquifer ground water for golf course irrigation, the golf course owner shall have provided to the director:

- Materials, reports and other supporting document setting forth the facts and/or circumstances which gave rise to the immediate need for golf course irrigation with potable high level aquifer ground water;

- A plan showing that no continuous physical connection will be made between potable and non-potable water systems;
- The remedial plan to restore the use of non-potable water in as short a time as possible, and shall include manufacturing and/or shipping times of various items needed for the restoration, as appropriate, and shall further indicate those items will be obtained and/or shipped by the most expeditious means available; and
- A plan detailing how the following uses will be accommodated, including all sources from which water will be obtained (specifically addressing the use of existing reservoirs and lake water) and a watering/distribution plan, with the priority of uses as follows, such as being bases on a daily average of the historical record use over the prior 12 month period immediately preceding the unanticipated event:
  - Residential/domestic consumption (excluding irrigation uses);
  - Commercial, business, and resort consumption where potable water is necessarily used;
  - Agricultural consumption; and
  - Irrigation (including residential and large scale uses such as golf course). This part of the plan shall address the order in which the portions of the golf course shall cease to be watered as the situation continues.

The permit issued by the director shall:

Be issued only one time for any single unanticipated event and shall be valid for a period not to exceed 30 calendar days. The director may propose a longer period to the council and the council, by resolution, may indicate its concurrence with the director's determination that the permit should be issued for a period greater than 30 days. If the council does not concur, the permit shall be valid for a period not to exceed 30 days. The golf course owner is prohibited from applying for a new permit for the same unanticipated event where the original permit has expired and the remedial action has not been completed, and the director is prohibited from issuing any further permits for the same unanticipated event where the original permit has expired and the remedial action has not been completed;

Require the golf course owner to submit weekly reports to the director and the council regarding the status of the situation, efforts made to address the situation, and the amount of potable ground water used for the high level aquifer for that week. Meter readings shall be physically verified by the Dept of Public Works and Waste Management;

Include any condition or restrictions appropriate and reasonably related to the circumstances surrounding the use of high level aquifer potable ground water and the remedial work to be done, and also including the authority to impose a cap on the use of such water based on the historical monthly average of use on non-potable water, in an amount not to exceed 250,000 gpd.

A copy of the permit shall be transmitted to all persons notified pursuant to subsection D.1, above the same day it is issued.

Ordinance #2516(1996) – A Bill for an Ordinance Amending Title 19 of the Maui County Code, Pertaining to the Re-seeding or Re-grassing of the Golf Course Located in the PD-L/2 Project District for Property Situated at Koele, Lanai, Hawaii

Re-seeding or Re-grassing

Notwithstanding Ordinance #2066, at such time as the fairways at the golf course are to be re-seeded for re-grassed so as to provide the golf course with more efficient or better quality grass, the golf course owner may make a request of the County Council for the use of potable ground water from the high level aquifer in an amount up to 27,000 gpd to supplement irrigation water from alternative non-potable water sources, Such approval, shall be by resolution of the Council. Such additional water may be used for a period not to exceed 28 days per fairway. Only 1 fairway shall be irrigated with the additional water at any given time. No more than 4 fairways shall be re-seeded or re-grassed during any calendar year. Fairways shall only be re-seeded one time only under the provisions of this section. No continuous physical connection will be made between the potable and non-potable water systems. In determining whether or not to approve the golf course owner's request, the Council shall ensure that an adequate supply of water shall be available for golf course irrigation in accordance with the priority of uses as follows:

- Residential/domestic consumption (excluding irrigation uses);
- Commercial, business and resort consumption where potable water is necessarily used;
- Agricultural consumption; and
- Irrigation (including residential and large scale uses such as the golf course).

If during the re-seeding or re-grassing of a fairway, an unanticipated event occurs for which a permit is issued pursuant to Section D above, the golf course owner may continue to use potable water for re-seeding or re-grassing, but only to the extent that such cumulative total of potable water permitted to be used pursuant to Section D and this section does not exceed 250,000 gpd.

Resolution #01-146(9/7/2001) – Approving the Use of Potable Water from the High Level Aquifer for Re-seeding and Re-grassing Koele Golf Course during September and October 2001, Pursuant to Subsection 19.71.55(E), Maui County Code

Conditions: Castle & Cooke Resorts, LLC shall:

- promptly file with the County Clerk a completion bond for the repair of the sewage-treatment plant that serves the Koele golf course;
- repair the sewage-treatment plant that serves the Koele golf course within one year of this resolution's adoption;
- submit a water-storage master plan to the Council by March 1, 2002;
- install a separate water meter, as approved by the Department of Water Supply, prior to the use of potable water approved by this resolution to gauge such use; and
- allow for meter readings to be conducted and verified by two designated members of the Lanai Water Advisory Committee who are not employees of the Castle & Cooke Resorts, LLC or affiliated entities.

Ordinances Pertaining to Project District 2 - Koele

Koele PD History		
Year	**Ordinance/ Approval #**	**Comment**
1985	CIZ for Koele PD	Interim Urban to PD Requirements Included • Resource Study • Maintenance of accurate records • Plans for effluent use & desalinized water • Conservation Plan • Legally binding covenants to limit water consumption • Cooperative aquiifer monitoring with USGS • 28 day periodic water reports • Detailed demand study
1986	1580	Established Koele PD - 468.3 Acres
1991	2066	Prohibits the Use of Potable Water on All Golf Courses
1992	2139	Increased Koele PD from 468.3 to 618 acres Added 332.4 acre golf course Deleted 201.5 acres of open space
1992	Phase II PD	Requirements Prior to Phase III Approval • Detailed monitoring plan for metering - common areas to be metered seperately • Dual system for the GC to be submitted to DWS • Approved xeriscape plan • Use of low flow devices
1995	2407	Amends ordinance for tract master plan requirements Limits density of development on slopes of various grades Use of recycled water for irrigation to be considered No more than 60% of woodland to be cleared Cleared area shld be open space Retain minimum of 35% of tree canopy
1996	2514	Sets conditions in which potable water may be utilized on golf course Requires a comprehensive plan to develop additional storage for the GC Storage plan to include time frame and implementation steps
1996	2515	High level water not to be used for irrigation except as defined Sets triggers & requirements to allow 30 day permits for potable water use Un--anticipated events can be part of a trigger, but it is specified that Drought does NOT meet the criteria for un-anticipated event, Nor does it warrant use of the high level aquifer for GC irrigation
1996	2516	Enables GC owner to aply for up to 27,000 GPD per fairway to supplement non potable irrigation to establish new plantings Stipulates that only one fairway may be watered in this manner No more than four fairways per year to be watered this way Combined use of new fairway establishment and emergencies defined in 2515 should not exceed a total of 250,000 GPD
2001	Res 01-146	Issues temporary permit for use of high level water for re-grassing. Requirements: • Bond repairs to wastewater treatment facility • Implement repairs to WWTF within one year • Submit water storage master plan by March of 2002 • Install separate meter to monitor use of high level water and coordinate with LWAC so that LWAC members can monitor/read it

APPENDIX C

Public Process

Documentation of Public Participation and Partial History of Community Water Committees on Lanai

03/03/89 Petition from concerned citizens on Lana`i to the State Commission on Water Resource Management (CWRM) to designate the aquifer as a groundwater management area.

08/29/89 Public hearing held on Lana`i. CWRM staff recommended not to designate.

03/29/90 CWRM decided not to designate any of the aquifer systems on Lana`i as groundwater management areas. However, in lieu of designation, the Commission required data monitoring, submittal of a water shortage plan, and annual October information status hearings. CWRM also retained the authority to re-institute designation proceedings if specified conditions were met.

10/23/90 First annual public informational meeting held on Lana`i.

01/17/91 Lana`i Company Water Shortage Plan approved. *(by whom? staff has not seen it.)*

02/17/93 Council Chair requests stop-work at Manele golf course pursuant to violation of condition of county code §19.70.085 prohibiting the use of water from the high level aquifer for Manele golf course.

05/7/93 Council Resolution 93-42 defers enforcement of county code §19.70.085 given certain conditions. Allows use of 750,000 gpd for the interim, with restrictions. Establishes Lana`I Water Subcommittee until 12/31/93 "to monitor the use of water from Lana`I's high level aquifer. Subcommittee has 9 members:

1 from CWRM
1 from Lanai Planning Commission
1 Lanai Council Member
3 Lanai Company
3 Lana`ians for Sensible Growth

06/17/94 Proposed bill amending §19.70.085 to allow withdrawal of 650,000 gpd considered by Planning Commission.

09/22/94 Planning Director recommends a total allowance of 650,000 gpd MAN of 13-28 day monitoring periods, to be monitored by council standing committee. Recommends that subcommittee be impaneled as subcommittee of Human Service, Water & AG committee. Proposed subcommittee composition:

3 Lanai Company
3 Lana`ians for Sensible Growth
1 Lanai Council Member
1 Lanai Planning Commission Director
Pubic Works Director
BWS Director
CWRM Representative

09/28/94 Referred to council. Hearing deferred until 4/17/95

10/07/94 State Commission on Water Resource Management (CWRM) receives request from Lanaians for Sensible Growth to "reconsider its initial refusal to designate Lanai as a water management area in view of the serious disputes that have arisen over the future use of the islands's very limited water resource."

01/25/95 CWRM defers action on the petition to designate Lana`i until it can meet on Lana`i in October. Requests quarterly status updates on community plan and Water Use & Development Plan.

05/15/95 Council Subcommittee Established (Bill #13, 1995, Committee Rpt 95-79) Membership:

2 LSG
2 Lanai Co

1 Lanai Council Member
1 Lanai Planning Commission Chair
Planning Director
Public Works Director
1 LEGS - Non Voting
BWS Director - Non Voting

9/13/95 *A Numerical Groundwater Model for the Island of Lana`i, Hawaii* approved by CWRM.

10/24/95
01/10/96 On both these dates, CWRM defers action on petition to designate to allow more time for public and peer review of the document *A Numerical Groundwater Model for the Island of Lana`i Hawaii*.

04/96 CWRM Establishes Lanai Water Working Group as successor of Subcommittee. CWRM adopts final draft of *A Numerical Groundwater Model for the Island of Lana`i, Hawaii* CWRM defers action on the petition to designate until October 1996.

06/27/96 Water Subcommittee Meeting. Concluded that the housing projection of 1,019 additional units by 2010 was unrealistic. Discussion of per-unit allocations at Manele and Koele. Recommended 1,600 gpd per unit - with 600 potable and 1,000 non-potable. 600 gpd for hotel. Higher than generally used per-unit standards and should be reviewed further. For Koele, 1000 gpd / unit was questioned. As per 1992 Draft WUDP, dual system under construction for Manele. Committee elected to add "Agricultural Reserve" as a line item and to discuss further with Dept. of Ag. Discussion of Working Group Report / Draft WUDP policy document - using 1995 data as base year. Mechanism for home rule and to forge consensus on resource issues.

08/01/96 Water Subcommittee Meeting. Discussion of diversified agriculture on Lanai. Introduction of James Nakatani, Chair of the Board of Agriculture. Background: Workiing Group Report in progress based on last approved community plan from 1983. With community plan overdue, other plans are out of sequence. 1983 Community Plan recommended that pineabple continue to be primary economic activity and tourism secondary. Not consistent with what's happening now. Draft 1995 Community Plan recomends promotion of diversified agriculture, establishing a reserve for agriculture, and ensuring the long-term availability of low cost water for agriculture. 14,000 acres available for diversified agriculture per document form Steve Snow, who was in charge of diversified agriculture for the company in November 1994. At that time planned acreages were: 12,000 ac pasture, 2,000 ac dryland forage, 5.5 acres banana, 20 acres papaya, 50 acres pineapple and herbs, with an estimate of 200,000 gpd at 96 cents per 1000 gallons. 1990 WUDP proposed 1.8 MGD for ag. The end of pineapple was announced in 1991. The 1992 Draft WUDP proposed 1.5 MGD for diversified ag. At that time, the Dept of Ag had proposed the creationof a 100 acre agricultural park to use 500,000 gpd. The water task force at the time recommended increasing that set-aside to 1.5 MGD, although the company was initially in disagreement, recommending an Ag reserve of 1.0 MGD. Issue still under discussion for Working Group Report. DOA has as yet received no proposals for Ag park. Will develop only if there is community interest. Suggests focus on high-value niche crops. Waiahole consumptive use about 3,500 gp acre. More discussion on development proposals, criteria, projections and analysis, 1995 demand data and plans for Working Group Report. Lanaʻi Co. suggested 2% per year growth projection as more realistic than Community Plan. Committee to consider. Roy Hardy summary: 9 MGD recharge, 6 MGD sustainable yield, 4.3 MGD 13-MAV limit for designation proceedings, 3.6 13-MAV trigger for deepening wells, declining water levels to 50% also trigger for CWRM action. Company reports working on watershed plan as recommended previously. Conservation - largest potential savings in Manele PD area. Hotel water features, landscaping, leak detection, improved monitoring, promotion of conservation. Committee to discuss timelines for demand.

08/29/06 Water Subcommittee Meeting. Discussed alternate projections of water demand for residential, agricultural and other sectors. Discussion on alternative startegies, supply and demand side management, public participation, etc.

9/26/96 Water Subcommittee Meeting. Reviewed allocations proposal for Working Group Report. More discussion on alternative strategies, demand-side and supply-side management, conservation, watershed protection, governance and public participation.

10/18/96 CWRM Public Informational Meeting on Lanaʻi. Commission votes to proceed with designation process based upon the prospect of serious disputes. Instructs Lanaʻi Water Company and Workiing Group to prepare a Working Group Final Report, prepare a schedule nd procedure or adoption, and identify any differences between teh consensus report and the company's findings in their Water Resources Management Plan, and to attend the public hearing in February.

10/31/96 Letter from Lanai Subcommittee Chair, requesting to extend subcommittee to 02/97

11/29/96 First Draft Subcommittee / Working Group Report - Working Draft and Policy Core of WUDP Update.

12/17/96 Water Subcommittee / Working Group Meeting. Discussion - Nov 96 Draft Report was submitted to CWRM in lieu of a final report. Discussion centered on comments and review of draft. Also discussed Ordinance 2408, Bill 13 1995 - the ordinance allowing withdrawal of 650,000 gpd from high levvel aquifer and Council Resolution 93-42 clarification of high level water and conditions for withdraawal of high level water for Manele Golf Course, dated May 7, 1993.

12/31/96 Council Subcommittee dissolved - continued under CWRM as Lanai Working Group until 02/97

01/21/97 BWS moves that Lanai Water Use & Development Plan is part of County Water Use & Development Plan, and properly handled by Board. At the request of the Water Working Group, BWS moves to continue working with the Lanai Committee/Working Group until completion of the Water Use and Development Plan.

01/28/97 Board communicates its decision to the Lanai Working Group in a letter from the Director, that the Lanai Working Group shall continue as an advisory committee to the Board for the Development of the Lanai Water Use and Development Plan, that the working group will not sunset until the entire Water Use and Development Plan is finalized and approved, (even though that would be substantially later than completion of the Lanai chapter), that the Board may also be willing to continue to staff an on-going group, but wanted further clarification from the committee as to the purpose, function and role of this group.

02/10/97 Lanai Water Working Group Meeting - Final Report of the Lana`i Water Working Group, also known as the 1997 Draft Water Use & Development Plan, is completed and adopted by the Lana'i Water Working Group. Although this was the last meeting of the LWG under the auspices of the State Commission on Water Resources Management, the Department of Water Supply continued to work with this group until the Lana`i Water Advisory Committee could be established. At this point, LWG begins being referred to as LWG/LWAC. Discusson at the meeting also focused on distribution, implementation and next steps. Notes that at this point the update to the Community Plan is still awaiting review and adoption by the County Council.

02/18/97 CWRM hearing on designation of Lana'i. Elects not to designate subject primarily to continuing efforts to systematize community involvement, continuing efforts to protect the watershed, remaining within the previously established triggers : pumpage less then 4.3 MGD, water level declines not exceeding 50% and wells within approved operational guidelines, continued efforts to conserve.

04/15/97 Board approves Director's report 97-21, resolves again to continue to work with community advisory committees for the completion of the Water Use and Development Plan, and adds to this a resolution to develop and propose to Council an ordinance to County Code §2.88A pertaining to the Water Use and Development Plan, to be submitted upon completion of the WUDP update, and including provision for ongoing community participation in water use and development planning. Board also approves contract with M&E for update of Water Use & Development Plan. Committee now referred to as LWG/LWAC.

04/30/97 LWG/LWAC Meeting. Discussion of Board decision, and proposed Lana`i Company Stewardship Plan. Decides to hold skybridge conference to obtain expert advice on management and protection of the watershed. Committee also agrees that additional capital proposals are needed prior to finalization of the WUDP.

05/20/97 Board received an ordinance proposal, after some discussion, it seemed that Board was more inclined to establish committee by rule than by ordinance. Instructed staff to discuss this idea with committee, and to draft rule, but deferred further discussion and action to August Tech&Planning Committee meeting. Director's Report 97-36.

06/03/97 Pursuant to committee request, Deputy Director of DOFAW Mike Buck assigns Bob Hobdy to represent the DOFAW as resource person for the Lana`i Water Advisory Committee.

06/09/97 LWG/LWAC continues discussion of establishment of Lana`i Water Advisory Committee. Also discusses company's proposed operational guidelines. Agrees to approve them, and recommends that these be placed in the WUDP and function as mandatory limits. Additional items desired by the committee in the WUDP update as discussed include a capital plan for source development, updated implementation matrix, updated community plan analysis and better system schematics and information.

08/26/97&
09/16/97 Rule drafted but not placed on Board agenda.

10/21/97 Board discussed proposal for a rule and determined that a resolution was a more appropriate vehicle for establishing on-going committee. Instructed staff to discuss resolution with committee and draft resolution.

11/18/97 &
12/9/97 Resolution drafted but not placed on Board agenda. However, testimony received from members of Lanai Water Advisory Committee that establishment of on-going committee is very important to community members and that before deciding on whether to use a rule or a resolution, committee members would appreciate written guidance from corporation council as to what the legal implications would be for such a group were it established by resolution vs. rule.

12/15/97 Letter from Corporation Counsel regarding differences in establishing Lanai Water Advisory Committee by rule vs. by resolution. Paraphrasing: " A Board resolution may be adopted or changed by the Board at any time with proper notice, is non-binding and does not have the force & effect of law......A Board rule, on the other hand, can only be adopted and changed by going through the rule making process as set forth in HRS Chapter 91. When adopted it is legally binding and has the force and effect of law......"

12/17/97	LWG/LWAC Meeting. Committee reviews letter from Corporation Counsel. Staff reports Board instructions to sound committee out on whether a resolution would be acceptable rather than a rule, and relayed information from Board that if necessary a skybridge meeting would be considered. Committee voted for skybridge and more discussion with Board. Resolution wording also discussed. Status of Lana`i Co. stewardship plan proposal - not funded.
02/17/98	Staff requests permission to schedule skybridge meeting for Board to discuss issues with Lanai Committee re: rule vs. resolution. Board moves that "Lanai Committee to submit a letter to the Board stating exactly what they want to discuss with them. Matter will be placed back on the agenda once the letter is received."
02/25/98	LWG/LWAC Meeting. Decision of Board discussed with Lanai Working Group/Future Lana`i Water Advisory Committee. Group votes that preference is still to be established by rule over resolution. Rather than press for skybridge meeting, decides to reiterate preference for rule and send request to be established by rule.
03/10/98	Letter from Lanai Water Working Group confirming request to have a rule established by BWS pertaining to the establishment of A Lanai Water Advisory Committee. Committee's preference is to be established by rule, because (paraphrasing): resolution can be changed at any time and does not have force and effect of law, whereas rule has force and effect of law and can only be undone through the rule making process.
05/09/98	Skybridge meeting held to discuss protection of Lanaihale watershed. Most important item according to all experts was to construct fence and eliminate feral ungulates in key recharge areas. Hunting to be maintained outside the fence.
06/29/98	LWG/LWAC Meeting. Committee reviews minutes of skybridge and suggestions for watershed. Begins discussion of possible fence alignment proposals. Determines that broader community involvement is needed in fencing decisions.

08/07/98 LWG/LWAC meeting. Attendance list but no minutes. Given date, discussion topics were probably establishment of water advisory committee and fence options.

10/29/98 LWG/LWAC Meeting. Discussed Planning Department projections and other community plan items as they related to the WUDP update. Planning Dept. estimated that 1,019 new housing units would be needed to accommodate a projected population of 4,968 over the next 20 years. Committee members agreed that this seemed a bit high, and did not recommend growing at this pace. (Although per-unit analysis is about 600,000 gallon increase - total build-out would reflect more), and recommended lower values. Also discussed objectives noted in the plan.

Objective: Ensure long term availability of low cost water for agricultural purposes

Objective: Establish and reserve a minimum water allocaiton for diversified agriculture consistent with the WUDP

LWG/LWAC elected to combine set-asides for DHHL and Ag to one large reserve of 1.5 MGD

LWG/LWAC noted the need to re-visit needs for Ag Park, Community Gardens, HHL, Horse Paddock and other potential agricultural efforts.

Objective: Protect, preserve, restore and enhance Lana`i's existing potential recharge areas.

Objective: Forest Management

LWG/LWAC re-confirmed its decision to include a watershed protection chapter in the WUDP update.

Objective: Prohibit the use of the high level aquifer water for golf course irrigation, consistent with the WUDP

Objective: Use recycled and brackish water for irrigation

LWG/LWAC deterimined that there was a need for improved inventory of irrigated acreage and that sources and destinations of irrigation water should be better delineated for the WUDP. Company to provide improved information.

LWG/LWAC made the caveat that the CP should be clarified on prohibiting the use of brackish water and limiting the use of reclaimed water over fresh potable aquifers. Brackish and reclaimed water best considered for Manele Harbor, Kamalapau, other down-gradient areas where possible.

Objective: Comprehensive planning and management of water resoruces consistent with the WUDP.

LWG/LWAC elected to re-visit allocations for agricultural park, HHL, lands designated for affordable housing, community gardens & Lana`i Horse Owner Associations Paddock to insure that these needs are met.

Objective: Develop alternate sources, xeriscape landscaping, and strict conservation enforcement, especially for Manele Project District area.

LWG/LWAC suggested that alternate sources be considered in the WUDP update, and that the company include these in its capital proposals.

Objective: Develop and utilize a hydrologic model

LWG/LWAC suggested that data for this model might need updating, especially relating to fog drip.

12/04/98 LWG/LWAC discussed LWAC membership and preparations for presentation of fence discussion to community.

12/21/98 Lana`i Community Plan update adopted.

01/21/99 First public presentation and informational meeting regarding fence proposal held at Public Library.

03/16/99 Lana`i Water Advisory Committee Established - from here on committee is referred to as LWAC.

11/19/99 LWAC meets - discusses committee objectives and priorities for WUDP, voting, rules of conduct, agendas, handling of disagreements, rotating chair, etc. Also discussed biodiversity committee and possible formation of partnership to work together for watershed protection, lobbying for fence and other protective funding etc.

01/28/00 LWAC meeting. No minutes. "Rehearsal" / review by LWAC of draft presentation for "fence summit", large, jointly-sponsored public meeting to be held on fence options.

02/00 State Commission on Water Resource Management approves *Framework for Updating the Hawaii Water Plan* - guidelines on WUDP update.

03/??/00 LWAC discussed watershed management, pumpage report and monitoring & reporting. Certain areas in the reports need clarification. Committee members also discussed regularity of reports.

04/11/00 LWAC Meeting / “Fence Summit” - jointly sponsored meeting (LWAC, biodiversity committee, & company) and company-catered event / meeting to discuss options for fencing the Hale. Afternoon and evening meetings. In afternoon, Manele Spa permit was main topic of discussion. Also discussed Miki Basin, watershed status and periodic water reports. Evening meeting included dinner and presentation on fence proposals to more than 50 community members.

05/26/00 LWAC Meeting. Company presentation on Terraces at Manele project. Maximum allocation for Manele Project overall remains 1.03, regardless of changes to sub-components of that project. . Difficult to separate actual PD use in water reports. Company proposes planning and allocation deduction estimates of 400 GPD potable and 400 GPD non-potable for irrigation, based on irrigation calculations of company consultant. Committee concerns whether estimated estimates are consistent with empirical data for the area. Asked DWS staff to obtain empirical data for similar elevation and climate regions on Maui. Committee also wanted requirement that brackish or reclaimed water be used for irrigation and other non-potable uses, and asked that company provide better documentation of reasons for potable and non-potable estimates. Committee also noted that prohibition on pools should have been included in CC&Rs for the luxury homes. More discussion on pumpage reports, watershed status, possible funding sources. More in-depth introduction of biodiversity committee and LWAC - discussions of jointly sponsored “fence summit meeting” , common goals and of possible formation of “Forest and Watershed Partnership”. Draft of watershed chapter handed out to committee members. Also handed out State adopted - Framework for Updating the Hawaii Water Plan, which was approved by the State Commission on Water Resource Management in February, 2000.

09/22/2000 LWAC Meeting. Review of draft response on Manele Terraces based on previous meeting. Presentation on overall Manele Project District status by company. Company consultants explained water use and irrigation calculations. Proposal was still 400 GPD potable and 400 GPD non-potable for MF units. Nothing in CC&Rs of units sold to date indicates any restrictions on water use. Each unit will have two potable hose bibbs. Committee recommended that approval re-iterate 1.03 total limit on Manele PD, set allocation of 400 GPD potable and 400 GPD non-potable water, include these quantities in the CC&Rs for the project - specifically wording the covenant to indicate that potable water use not exceed 400 gpd, the applicant shold be requied to utilize reclaimed and or brackish water for irrigation to the fullest extent possible, and the applicant should implement conservation measures including limits to turf and use of appropriate plants, rain-shutoff devices, regular maintenance, low flow fixtures, etc. DWS staff handed out table on PD densities, units and other conditions of the PD, as well as the empirical data on similar areas in Maui requested at prior meeting. Discussion of re-grassing/re-seeding of Koele GC - result was to recommend filing of the application since rainfall had increased and the question could always be re-opened when necessary. Discussion on grant funding applications for watershed. Pumpage report discussed. Committee member Hokama requested that bulkhead pressure readings at Shaft 3 be included in the reports again. Committee member McOmber requestee an independent non-company entity monitor water levels, chlorides and pumpage. Discussion on status of aquifers and on impacts if water levels should fall. Consultant Dr. Kumagai noted that existing infrastructure not appropriate to deliver 6 MGD and that it should not exceed 3.52 MGD with the current configuration of withdrawals. Also that hydrologists in the past had estimated practical yields more conservatively in past (3.5 Anderson; 4.3 Takasaki).

01/18/2001 Joint CWRM Public Informational Meeting with LWAC meeting. Aquifer status report from CWRM & discussion served as annual Public Informational meeting. Also discussed WUDP - Committee wants to include conditions of approvals section. Staff asked for more data on system infrastructure and conservation measures from company. Committee discussed additional monitoring and reporting requested:

Monitoring
• drive exposed pipelines monthly
• leak detection on old pipes at least once per year
• meter testing sizing and replacement
Reporting
• tank and reservoir levels and pumpage from large storage
• source to use reporting of water - especially better break down of irrigation water use
• status of system - liners, leaks, broken/repaired pumps, etc.
Committee discussed difficulty of including financial plan without company data - but that need to consider realistic factors in capital or other proposals. Need to consider do-ability. DWS staff requested PUC submittal from company. Later received two pages from company staff. Had someone copy additional info at PUC.
Discussion of brackish wells in high level aquifer that could freshen, and company's inability to use those if that occurred.
Discussion of new source development vs. demand. Committee set policy that additional distribution of withdrawals be required by 3.2 MGD total pumpage.
Discussion of possible conservation measures -
• Cover large storage such as 10 MG Koele and 15 MG Manele holding ponds?
• Landscape retrofit at projects to save more water.
• Upgrade irrigation systems to include rain-shutoffs, soil-moisture sensors, etc.
• Need for systematic, reportable maintenance program discussed.
Implementation matrix needs rework w/ tracking items for each measure.
Future Mtg.

05/31/01 LWAC Meeting. Company gave powerpoint presentation on re-seeding and re-grassing of fairways at Koele GC. Requested LWAC support for requets to use high level aquifer for this project and amendment to ordinance to allow it. Customers dissatisfied with status of GC. Committee did not vote. Staff distributed data, referred to in minutes of subsequent meeting. Update that Stewardship plan as revised had been approved for funding.

07/26/01	LWAC Meeting. Discussed proposed ordinance amendment regarding irrigation of Koele and re-seeding re-grassing efforts. Flouridation also discussed. Questions on periodic water report. Committee still not happy with monitoring and reporting.
09/25/01	LWAC Meeting. Presentations by Lana`i Company hydrologists on use of water from the high level aquifer for Koele Golf Course. Reviewed updated implementation matrix. More discussion on pumpage report.
10/10/01	Meeting of LWAC, Biodiversity committee, and other future Lana`i Forest & Watershed Partnership members to prepare for MOU signing.
10/11/01	Formal signing of the Lana`i Forest and Watershed Partnership Memorandum of Understanding. Celebration.
10/26/01	LWAC Meeting / CWRM Annual Public Informational update. Handouts were provided but chair did not call on CWRM staff to speak. DWS staff passed out to committee members for review, ahupuaa map, community plan map, wellhead protection area maps, draft map of Lana`i systems - needs further input and information from company, graph of 50 years pumpage on Lana`i, minutes of 01/18/01 meeting, proposed implementation matrix edits, draft community plan consistency section, chronology of water, biodiversity and land use on Lana`i, reclaimed water production graphs and tables, draft section on conditions of approvals, minutes of May meeting. Committee discussed findings of TDEM studies by Blackhawk GeoSciences. No additional water identified. Committee discussed “borrowing” from potable allocation until additional reclaimed water is available. Opted against it on the theory that it would be hard to actually replace the water once used - that once allowed, it would probably continue until there were other new potable uses proposed for the same water...thereby hastening the pace of the use. Corp counsel indicated that e-mail is acceptable method of notification for LWAC meetings. However, committee wished to continue to have agendas posted. Committee noted that meeting needs to be scheduled to discuss systematic changes to periodic reporting. Discussed WUDP status and data needs. Some of the items passed out for discussion today had been passed out previously (in May), and still needed committee review,

discussion & input. Also needed is better data on company systems and consumption by class and area, GIS layer from Planning for community plan still not finalized, and capital proposals/costs of operations still not provided by company.

12/07/01 Presentations by Dr. Aly El Kadi and Robert Whittier on research for wellhead protection section. Modeling, model parameters and purpose discussed. Discussion of request to utilize high level aquifer for Koele Golf Course irrigation. Committee not yet ready to vote. Discussion again re-iterating need for group review of certain draft elements as well as for additional data under the guidelines. Demand and capital planning data not adequate.

02/20/02 Discussion on proposal to use high level water to irrigate the Koele golf course and proposed amendment to Koele PD to enable that. DWS staff passed out Allocation references, implementation matrix and community plan consistency section passed out for discussion, list of all wells, tunnels and shafts on Lana`i, and conservation materials prepared in Tagalog language. Company passed out proposed revisions to allocation table and SMART plan for Koele GC management. Issues raised included condition of aquifer, effects of drought, relation of forest condition, existing ordinance, agreements and past representations, maintenance issues and island economics. Conditions of approval if the request were granted were discussed. LWAC was unable to reach consensus. A summary of the discussion and both sides to be presented to the Planning Commission. Committee reviewed implementation matrix section of WUDP.

08/01/02 Scheduled workshop between LWAC and Lana`i Planning Commission on Koele PD, status of aquifers, WUDP, etc. - cancelled?

09/27/02 LWAC Meeting. DWS staff passed out updated project-based demand anaylsis tables, and updated population projections based on SMS data for review. Also updated demand regressions, well pumpage,chlorides and water levels and reclaimed water use graphs. Committee agreed not to make any further changes to allocations other than those agreed upon in previous meetings. Suggested 5 year incremental demand projections required under Framework for Updating the Hawaii Water Plan be done proportionally. Did not review project build-out analysis passed out. Also did not comment on draft pump facilities inventory provided by company. Discussed problems with periodic water reports. Agreed to put 3.5 as the trigger for distribution of withdrawal projects. Not clear whether group realized they had previously set 3.2. at 01/18/01 meeting. In any case - discussed that design for distribution of withdrawal projects to commence at 3 MGD, to be sure it is accomplished in timely fashion.

10/??/02 Rescheduled Workshop between LWAC and Lana`i Planning Commission on Koele PD, status of aquifers, WUDP, etc (need to verify which date this actually occurred).

02/27/03 Passed out draft wellhead protection ordinance for committee review. Discussion on pumpage report design and on wells 1, 9 and 14.

08/01/03 Ground rules reviewed. Committee to meet independently. Agreed to rotating facilitation with Chair to handle agendas. Minutes to rotate as well. DWS staff not present. C&CR presented system status handout and indicated that three new master meters would be installed at Manele, one for residential and two for golf course use. Indicated that once well 14 was up, they planned to pull and repair well 1. Noted that new plans were in progress for storage upgrade at Koele, and that bids had been obtained for floating covers for the 10 & 15 MG reservoirs. Discussed using two rather than four holding ponds at the auxilliary wastewater treatment plant, and converting the other two to storage.

09/05/03 ?

12/ /03 ? Minutes of Jan meeting include review of Dec minutes, but missing.

01/09/04 LWAC Meeting. Low attendance. Discussed primarily system issues and periodic water report. Reservoirs full, Wells 9 & 14 awaiting repairs. RM Towill consultants to work on periodic water report. Fence material for hale fences beginning to arrrive.

02/13/04 LWAC Meeting. RM Towill working on supply and demand data. not yet finalized. Collins Lam recently assigned to run water company. Anticiapates well 14 pump to be re-installed the following week.

Determined that tying together the lakes at the Experience at Koele would not be cost effective. Discussion 20 MG storage pond for overflow and drainage. SCADA budget allocation increased. Will work on standardizing and calibrating to improve data. In the development arena, Manele spa and keiki center to be set aside in favor of a “well being” center.

03/05/04 Reviewed procedures of committee. Committee wants work to date submitted to CWRM as working document to be continually under updated. Staff points out missing elements, including certain requested demand data from company, better capital plan enunciation, certain policy questions. Discussion on revised long term build-out demand proposal from company, still in draft. Discussed system status and ongoing projects. DWS staff repeated request for assistance with completion of meter map that DWS had started for company. Discussed how this map was put together, and gaps in data.

4/2/2004

05/07/04 No minutes

07/14/04 LWAC Meeting. Discussed revised demand criteria and project analysis proposals from Castle & Cooke Resorts. DWS staff reviewed changes in assumptions reflected in these proposals. 1997 WGR allocation tables as amended by subsequent minutes to be included in WUDP as well as regressions and other projections, including revised demand proposals. Framework for Updating the Hawaii Water Plan, as well as earlier contracts stipulate that multiple demand forecasts be considered. LWAC will ultimately need to select allocations as policy matter, and may consider any or all of the demand forecasts.

08/04 LWAC Meeting. First Draft handed out to committee

09/20/04 LWAC Meeting. Review first draft. Various suggestions for content, format and clarification.

02/25/05 LWAC Meeting. Discussedpublic notification and minutes. Need protocol. Lanai Water Company working on verifying and calibrating its meters. All accuratre so far except for the one on Well 4. Plan to change meter. Also working on some safety improvements for Well 2 / Shaft 3. Well 14 having some startup problems. Residential meter beteween the 15 MG reservoir and Manele Project District installed and operational. Golf Course meter installation pending. Periodic water report discussed. new meters and SCADA should improve some previous inaccuracies. Collins Lam to leave Lanai Water Co. after April 05. Committee disappointed as he seemed to work well with them. Phase I of fence complete. Phase II pending, will be more expensive and slower due to steeper terrain. LWAC made request to Corporation Counsel after January Meeting to clarify ordinance 2408. Awaiting word.

07/28/05 LWAC Meeting. Discussed system status leaks and water loss. Breaker tanks project to start soon. Request for proposal for 2 MG tank has been issued. Initial SCADA field work complete. Constructin 11 buildings with 48 units on 10th and Lanai Ave. Contract issued for water hyacinth removal.

10/25/05 LWAC Meetiing. Low attendance. Discussed need for Fog Drip study, establishing ordinance, and how to use the WUDP. Should be reference for applicatons, determine if application conforms to the plan, if not discuss revisions either to plan or project prior to approvals. Amendments to WUDP to be reviewed by LWAC.

11/22/05 LWAC Meeting. More discussion on how to use WUDP, revisited goals of plan, discussion on various tables within draft.

1/26/06 LWAC Meeting. Discussed the use of R-1 water on the Golf Course at Koele, Draft ordinance to establish LWAC by ordinance, periodic water resport, letter from C&CR attorney on WUDP and allocations. C&CR proposed to use potable water on the golf course. DWS staff agreed that potable water over a wellhead protection area would be a nice idea, and suggested trade-off of equivalent amount of potable water to non-potable water elsewhere in same system area but outside wellhead protection area. C&CR proposes trading off for more reclaimed water use in Manele. Committee members do not agree. DWS staff would agree if trade-off were in area with same mix of potable sources, such as irrigated area immediately makai of Lanai City and surrounds. LSG points out that company has made agreement not to use potable water on Koele GC. Committee concludes that this should not be proposed to council without further discussion within committee. Company opposes ordinance to establish LWAC. Other committee members recall that C&CR initially expressed support for the idea and voted for it. C&CR does not want to be held to that, nor does it want this incuded in the WUDP. Discussion on periodic report. Committee members have questions on the discrepancies between pumpage at wells 1, 9 and 14 vs. use from the potable reservoir. C&CR says this is natural evaporative loss. Committee expresses concern that it is too much. Discussion on C&CR letter opposing plan. C&CR wrote long letter with many items, including opposition to elements of plan, various policies and statements within plan, and some corrections. Committee points out that C&CR representatives were present for and voted in concurrence on all elements of plan, including ordinance proposal. C&CR wants to know if entire plan becomes ordinance, or what becomes ordinance. Committee points to implementation matrix and policy section. Segways into primary concern of C&CR which all agree is allocation table. Committee agrees unanimously to work together to re-visit allocation table. Discussion on allocation - need agreement on unit factors, C&CR updated proposal not based on system standards, but has some empirical basis. Needs further review. Need better breakdown of existing and proposed uses. Need to spacify allocation to project and to system area. Need explicit allocation for ag park. Need individual information per project distrct.

02/06/06 LWAC Meeting. Discussed agricultural allocation. Brackish wter for residential landscape irrigation at MPD, Project analysis tables in Chapter 4, per unit consumption, consucmption classes. Also posting for new at-large member.

4/06/06 LWAC Meeting. Discussed pubic notice, project build out proposal from C&CR and analysis, allocation table and C&CR attorney correspondence. Also discussed data still missing to enable assignment of location and subdistrict for each meter. Value of disaggregated data in system analysis, conservation planning, etc. Corp Counsel memo indicates tthat sunshine law notification not requried, but does recommend good public notification. DWS points out that since it is no longer creating agendas or schedule it would be better to have someone else do the posting. However, agrees that public notice is important. Chair will post notice at post office and committee member volunteers to inform Lana‘i councilmember’s office. DWS to prepare ad for Lana‘i Times to recruit new at-large member. Allocation table - proposals should be broken down to indicate 5, 10, 15, 20, 25, 30 year anticipated build-out levels. Committee wants triggers defined for when “alternate water source” is requried - so that it can be clear with glance at final allocation table. Discussion of “alternative” water sources, increased wastewater use, desalinaization, run-off, conservation. DWS points out that table 6-2 weighs the cost benefits of some demand and supply side options, while desalt is found in 6-1. Increased wastewater use option not costed as “source” -

existing plants large enough to accommodate additional flow , but it may still be good to add. Discussion of C&CR attorney letter - Committee members express that it goes against the spirit of working with the group to vote one way in a meeting, and then have subsequent representation for the same entity raise these concerns outside the group to a higher body. Lack of continuity in C&CR representation and views is a problem. CWRM reports that fog drip study should begin in late summer of 06.

5/05/06 LWAC Meeting. Reviewed updated demand chapter and policy chapter allocation table. C&CR requests provision to be able to maneuver within a project district allocation, provided that the total remains same. Committee concurs in principple with hte caveat that such allocations be discussed at an LWAC meeting before being finalized. Vote will come when table and associated text are finalized. Discussed 650,000 gallon limit on the use of wells 1, 9 and 14. LSG still interprets this as applying to all use of high level water for Manele. C&CR interprets it as applying only to the Golf Course. Discussed results on the Well 6 oil sheen. C&CR reports that water is safe. Regarding ag reserve, given low sustainable yield, should some additional reserve be set aside to protect aquifer in event of uncertainty ? Committee members note that chlorides in well 1 seem to be decreasing. If this goes fresh, will impact irrigation source for Manele PD. Water levels dropping. Trees on Hale dying. C&CR doesn’t think additional reserve is needed. Gradual development, slow development, ag reserve & gradually increasing conservation are adequate. In future de-salt may prove cost effective.

7/ /06 LWAC Meeting. Discussed ordinance establishing LWAC, demand analysis tables and company plans. Company now opposing ordinance. Other committee members want review vis a vis WUDP prior to Planning Commission decisions. Want to be sure Planning Commission receives their comments on water issues. C&CR does not want another layer of bureaucracy or added review time. C&CR confirmed that it had not yet given DWS staff its final table 4-21 (company’s proposal), so staff therefore could not complete analysis and comparison. C&CR is revisiting its MF and SF plans for Manele. Considering Increasing MF and decreasing SF.

8/11/06

9/08/06

10/20/06

11/16/06 LWAC Meeting. DWS staff has C&CR final proposal. To make “straw man” revised allocation table using 10, 15, 20, 15, 30 year and build-out.

1/18/07 LWAC Meeting. Two “straw man” allocation tables presented. One based on project build-outs proposed by C&CR with some adjustments based on committee discussions, the other based on econometric forecast numbers - for comparison. Discussed. Some areas in table need clarification.

2/15/07 LWAC Meeting. DWS staff out. Discussed tables, Chair presented alternate format. No votes taken.

4/19/07 LWAC Meeting. Discussed C&CR objection to moving WUDP meetings forward pending results of LUC proceding. Committee members reiterated that it went against spirit of collaboration to present legal challenges rather than raising and discussing concerns in the group. Given disparate positions, difficult to progress. Nevertheless, discussed allocation table. DWS staff wanted some changes to revised allocation table format, to facilitate internal data review - consistent breakdowns by system and region. More work needed to resolve discrepancies between the three tables. DWS noted that assumption for straw-man tables was that build-out would be beyond 2030, but C&CR stated that it intended to build-out by 2027, although this would not be consistent with forecasts.

5/17/07 LWAC Meeting. Discussed membership. Voted to appoint a fourth “alternate” at-large member, to be invited to all meetings and to vote in the even that one of the other at-large members are absent. Discussed Challenge at Manele. Discussed fog-drip study. Dr. Juvick collecting data at eight stations on the Hale. At 6 months of a 2 years study. Progress report scheduled at 12 months. Committee requested C&CR to bring map of Hale showing fog drip stations. Discussed Groundwater study. Tom Nance will formulate parameters for updated model, scope to be reviewed by CWRM and implemented by Howard Endo. Time table of fog drip study may be such that updated data won’t get into model update. Model itself won’t change sustainable yield estimates, but may provide info on when additional measures might be needed to accommodate various pumping scenarios. Discussed Periodic Water Report. Committee members would like effluent / influent to auxilliary plant included in report. Committee would like monthly vs. 28 day reporting. Need to check with corp counsel re: reporting period under 19.70.085. Discussed period of inconsistent measurement in PWR. Discussed Water

Use & Development Plan. CWRM staff noted that capital plan should be further fleshed out for WUDP. Committee suggested consideration of lining reservoirs. County staff discussed exchange in which reclaimed water would be used for irrigation rather than potable water somewhere outside high level aquifer, enough to enable use of potable water on Koele GC where potable water underlies. Discussed table 5-1. Went from 9 to 13 categories on table and discussed adding subtotals by system area, type of water and pumped vs. other. Discussed controversy over ordinance 2408. CWRM staff asked for Unit Quantity Analysis of assumptions used to determine allocations in C&CR proposal, others. Discussed buildout analysis of C&CR proposal. Discrepancy between proposal and existing project entitlement in that proposal lists fewer units. Either PD should be amended to allow fewer units, or analysis should include all units. First Cut Pace of Resource Use policy proposed by committee member. 2010 3.5, 2015 4.0, 2020 4.5, 2025 5.0 , 2030 5.25 Buildout 5.5. Trigger for new source development 3 and 3.52 reiterated. System status discussed. Committee supports replacement of well #3.

07/12/2007 LWAC Meeting. Discussed Corp Counsel response re: reporting period. Reporting methodology could probably be changed without ordinance, but by a resolution of council. Resolution drafted and presented, as per previous meeting discussion. However, company said it does not support shift from 28-day to monthly cycle. Regarding other changes, company willing but wants clearly delineated list of all changes desired, vs. piecemeal. Discussed Unaccounted-for water. Some committee members concerned re: system losses, particularly from 15 MG reservoir. Some committee members also want more accounting of where water comes from and goes to. Company indicated that systematic leak detection program may be more efficient than revisions to PWR for identifying problems. DWS staff agreed. Started discussion of Unit Quantity Analysis requested at May meeting. C&CR proposal differs from Statewide Standards and existing entitlements in several areas: some items are requested that are not in existing PDs or proposals currently under review, build-out for some items represents less than all entitled units, in some cases consumption estimates are not explained but merely listed as lump sum. These tend to be small, but since there are 13 out of 40 line items in this category, they add up. Finally, some items are adjusted from standards based on empirical data for the area. In some cases these changes are reasonable or allow for more flexibility or even more realistic assessment of demands, but in others they allow for the potential of padding - room for additional approvals not listed. Also, if entitled projects are not traded or un-entitled in exchange for new proposals, then build-out is likely to be higher than proposal indicates. Minutes include more details of discussion of first page of 5 page unit quantity analysis table.

1/25/2008 (have notes, still have to type up) LWAC Meeting. Presentation from Gordon Tribble of USGS pertaining to the uncertainties of high level dike confined water. (more, need to find).

2/28/2008 LWAC Meeting. Discussed lack of data for forecast. Staff handed out letter from consultant stating that data provided was inadequate to prepare good forecast. Discussed well construction and pump installation permits for New Lana‘i Well 3 - 4954-03, and for Lana‘i Well 11 - 4753-01. No vote was taken but committee expressed support for the replacement of well 3 in particular. and slightly more guarded support for distribution of withdrawals with well 11. The concern was expressed that well 11 not be used to further increase pumping of brackish water from the high level aquifer. Discused the need for resource reserve.

4/25/2008 LWAC Meeting. Discussed 8 different scenarios for buildout and pace of resource use policy. Discussed line-item allocations for conservation and “alternate source”. Discussed pros and cons of resource reserve. Discussed triggers for additional distrubution of withdrawal. 3.0 to start 3.52 to be completed. Discussed status of water levels in wells 1,9 & 14 as well as in wells 6 & 8. All declining. Also status of pumps 2 and 3 - both down. Permits for well 3 replacement and for distribution of non-potable withdrawals well 11 have been submitted to CWRM and are being reviewed. were passed out to group at 2/28/08 meeting.

5/30/08 LWAC Meeting. Presantations by Bob Hobdy and Jay Penniman regarding history and status of watershed, concerns re: Increment III alignment, and description of work to preserve Hawaiian petrels. Had been t hought extinct or nearly extinct until about 2001. Now it is believed that several thousand birds remain. The biggest threats to the birds right now are invasive plants that over-run natural habitat and form impenetrable thickets where the birds can not nest. Examples of such problem plants are waiowi (strawberry guava), manuka and tibouchina. Other threats include predation, and flying into the deer fence and meteorological towers. Suggested that white fiberglass eelctric fence tape be woven into the top of the fence wire to enable the birds to see and go over the fence. Also described was a three acre habitat restoration project around the fog drip station. This restoration will make a corridor to Maunalei breeding grounds. . CCR is providing funding as part of its Habitat Conservation Plan for its potential wind farm. There was strong support for watershed protection by some of the LWAC members. CCR staff agreed to consider the fence line proposed by Hobdy. Discussion of the Implementation Matrix.

06/27/08 Discussion of fence increments. All phases surveyed. However as it may be a while before Increment III is actually constructed, additional survey may be done. CCR outlined the expected timeline for completion of the fencing project; they are currently 2-3 years behind schedule. The costs of materials have almost doubled over the last 4 years. CCR emphasized that it will get completed. Initial results from the 2-year study by Jim Juvik are showing that fog drip is significant on Lanaihale. The new alignment will incorporate suggestions made by Robert Hobdy at the last meeting and in discussions with Conservation personnel. Discucssed capital projects of CCR. Lana‘i City 2 MG tank done. Improvements made to Well 2/Shaft 3 main from Hi‘i to the bottom of the slope. Other plans include replacement of Well 3 and drilling of Well 15. Anticipated yield on Well 7 was small. Discussion of allocation table.

07/25/08 LWAC Meeting. The pace-of-resource proposal was reviewed. Some billing data is still missing. Also discussed were problems / inconsistencies in the Periodic Water Report. A tiered pricing proposal has been filed with the PUC. Some LWAC members requested that the justification prepared by DWS for the proposed Allocation be included in the WUDP, possibly as part of the Policy chapter as an explanation. The LWAC discussed the status of wells. CCR explained its plans for industrial use development at Miki Basin. Concerns were expressed that the line is very leaky and suggestions to condition approval for the project on fixing the line. CCR said it would be too expensive to put in new line. LWAC members requested continued updates on plans. The group continued discussion on the Implementation Matrix, including tiered rate structure, low flow devices, use of water audits, and importance of education. LWAC members requested that someone from the Fire Department attend the next meeting to address the threat fire poses to the Watershed.

08/22/08 Discussion of whether or not to shut down water source on the west end. Fire Department representative came to discuss concerns. Concerns and possible solutions discussed. Miles of old 10” pipe sitting. Pipe is old, with frequent breaks. Area is fire prone, and water source is needed to be able to fight brush fire. Helicopters alone not enough. Lana‘i has two fire engines, one tanker and 6 firefighters. It takes about an hour to get additional manpower. Water is also needed for the Kanepuu project. Discussed cost of Lanaihale fence. No funding yet Discussed breaks in Palawai Grid. Discussed allocation table. Some thought too generous. Raised precautionary principle. One suggested alternate, more stringent proposal. Others thought not generous enough, that LWAC had been close to agreement on CCR proposal. Still others said that regardless of final numbers, setting allocation amounts would not be enough in itself, triggers and actions needed to ensure adequate distribution of withdrawals. Discussed triggers in proposal. Also some discussion of per unit consumption. The group discussed the issues of identifying alternate sources, including a resource reserve, including triggers for future action, applying the precautionary principle.

10/24/08 LWAC Meeting. The group discussed whether the meetings could or should be recorded (video-taped). CCR said it was a public meeting. Others expressed concern about that recording the meeting might limit participants' willingness to speak freely. The group agreed to allow video-taping by CCR, but only if two free copies were made available for the group. CCR has a proposal for an additional swimming pool at Manele. The group agreed to inform the Planning Commission that there was not an opportunity to have a presentation from the Company on the proposal, so request Commission defer action on it. LWAC reviewed what conditions trigger review by the LWAC of major development projects. Also the Planning Commission can request LWAC input on a proposal. The group continued discussion on Table 5-1 (Pace of Resource Use) and the overall timeline for WUDP.

1/30/2009 LWAC meeting. Discussed status of wells, fire protection issues, periodic water report. Discussed allocation table. Discussion included need for a precautionary approach and the need to avoid “paper water”. Additional monitors put in wells 3, 5 and 7. Discussed breaks in Palawai Grid.

2/27/09 LWAC Meeting. Those present discussed possible approaches for when there is no CCR representative at the meeting and suggested sending a letter requesting their regular participation. Agreed to move forward with or without CCR, given need to make progress. The group discussed whether LWAC should take a position on CCR Miki Basin heavy industrial permit application. This involves infrastructure only, not an increase in use; concerns relate to maintenance and fire protection (when draining the lines). LWAC agreed that it wants issues relevant Table 5-1 to come before it. The group discussed CCR's PUC rate case and whether LWAC should take a position. It was agreed that given the timing and the inability to discuss with CCR, that no formal letter would be written; individuals could testify on their own about concerns discussed (e.g. lack of conformity with existing covenants). The group discussed the issue of whether the existing water system and rates is fiscally viable. Current rates are estimated to be ¼ of the actual cost. The group also discussed inconsistency of water use with existing covenants and the possibility of a "conservation rate." CCR informed the group that reporting of water use is up to date now and will be current in the future. CCR reported on the status of repairs to the Palawai Basin system

3/27/09	LWAC Meeting. The group reviewed Chapter 2 (Regulatory Framework) and Chapter 3 (Resources) and made some general organizational suggestions. It was noted that Lanai is not currently meeting System Standards in terms of needed resources, but this should reflect more of a Call to Action vs. a panic. CCR said it has plans to move toward meeting those standards. Some wells are closer than others to action levels. LWAC agreed it should watch trends and if approaching action level, do a test. One request was for clear criteria for action level and CWRM designation. Regarding Water Reports and use, CCR presented revised format for reporting. On the PUC rate case for brackish water, there were concerns about how it was costed and whether there was adequate consideration of operating and maintenance costs.
7/31/09	LWAC Meeting. The group was informed that the WUDP needs to be approved by the Board of Water Supply before it is sent to County Council, which then has only 45 days to approve it or reject it. However, Council was looking at amendments to the County Code to change that schedule. DWS reviewed the status of the chapters, with an in-depth review of Chapter 4. The previous calculations were updated with information from 2008. It was suggested that information about Miki Basin should be included in Table 4-23 (4-21), but that it did not equal an "imprimatur" for planning approval. The group also reviewed and discussed the allocation table. A number of LWAC members stated a desire to take a more conservative approach, given the current economy and actual building activity. LWAC also discussed the issue of reporting water use on a 13-period basis and that it would be preferable to have it on a monthly basis.
12/11/09 & 12/21/09	LWAC Meetings. Reviewed 10/19/2009 Review Draft of WUDP for Lana‘i. Presentation and discussion of review draft.

APPENDIX D **Lana'i Species**

HAWAIIAN ISLANDS ANIMALS: Updated September 10, 2009

LISTED SPECIES, AS DESIGNATED UNDER THE U.S. ENDANGERED SPECIES ACT

Species status by island: E=endangered; T=threatened; (CH)=critical habitat designated; P=proposed.
N.W. Hawaiian Islands: Frigate; Kure; Laysan; Midway; Necker; Nihoa; PH = Pearl & Hermes

VERTEBRATES (39 Endangered + 4 Threatened = 43 taxa)

LISTED MAMMALS (4 Endangered taxa)

		STATUS	DISTRIBUTION: Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands, Kaho'olawe, Ni'ihau, or Oceanic
Lasiurus cinereus semotus	Bat, Hawaiian hoary; 'Ōpe'ape'a	E	x	x			x	x	
Megaptera novaeangliae	Whale, humpback; Koholā	E	x	x	x	x	x	x	O
Monachus schauinslandi (CH)	Hawaiian monk seal; 'Ilio-holo-i-ka-uaua	E	x	x	x	x	x	x	N.W. islands
Physeter macrocephalus	Whale, sperm; Palaoa (uncommon)	E							O

LISTED BIRDS (33 Endangered + 1 Threatened = 34 taxa; 2 Proposed Endangered)

		STATUS	Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands, Kaho'olawe, Ni'ihau, or Oceanic
Acrocephalus familiaris kingi	Millerbird, Nihoa	E							Nihoa
Anas laysanensis	Duck, Laysan	E							M, L
Anas wyvilliana	Duck, Hawaiian; Koloa maoli	E	x	x			x	x	
Branta sandvicensis	Goose, Hawaiian; Nēnē	E	x	x		x		x	
Buteo solitarius	Hawk, Hawaiian; 'Io	E	x						
Chasiempis sandwichensis ibidis (CH)	'Elepaio, O'ahu	E					x		
Corvus hawaiiensis	Crow, Hawaiian; 'Alalā	E	x						
Fulica alai	Coot, Hawaiian; 'Alae ke'oke'o	E	x	x	x	x	x	x	
Gallinula chloropus sandvicensis	Moorhen, Common; Hawiian gallinule; 'Alae 'ula	E	x	x		x	x	x	
Hemignathus lucidus affinus	Nuku pu'u, Maui	E		x					
Hemignathus lucidus hanapepe	Nuku pu'u, Kaua'i	E						x	
Hemignathus munroi	Akia pōlā'au	E	x						
Hemignathus procerus	'Akia loa, Kaua'i	E						x	
Himantopus mexicanus knudseni	Stilt, Black-necked; Hawaiian stilt; Ae'o	E	x	x	x	x	x	x	Ni'ihau
Loxioides bailleui (CH)	Palila	E	x						
Loxops caeruleirostris (pCH)	'Ākepa, Kauai; Akekee	PE						x	
Loxops coccineus coccineus	'Ākepa, Hawai'i	E	x						
Loxops coccineus ochraceus	'Ākepa, Maui	E		x					

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N.W. Hawaiian Islands: Frigate; Kure; Laysan; Midway; Necker; Nihoa; PH = Pearl & Hermes

		STATUS	DISTRIBUTION Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands, Kaho'olawe, Ni'ihau, or Oceanic
Melamprosops phaeosoma	Po'ouli	E		x					
Moho braccatus	Ō'ō, Kaua'i; 'Ō'ō 'ā'ā	E						x	
Myadesxes lanaiensis ruxha	Thrush, Moloka'i; Oloma'o	E				x			
Myadestes myadestinus	Thrush, Large Kaua'i; Kāma'o	E						x	
Myadestes palmeri	Thrush, Small Kaua'i; Puaiohi	E						x	
Oeromystis bairdi (pCH)	Creeper, Kauai; Akikiki	PE						x	
Oreomystis mana	Creeper, Hawai'i	E	x						
Palmeria dolei	Honeycreeper, Crested; 'Ākohekohe	E		x					
Paroreomyza flammea	Creeper, Moloka'i; Kākāwahie	E				x			
Phoebastria albatrus	Albatross, Short-tailed	E							M
Paroreomyza maculata	Creeper, O'ahu; O'ahu 'Alauahio	E					x		
Pseudonestor xanthophrys	Parrotbill, Maui	E		x					
Psittirostra psittacea	Ō'ū	E	x					x	
Pterodroma phaeopygia sandwichensis	Petrel, Dark-rumped; Hawaiian Petrel; 'Ua'u	E	x	x	x			x	
Puffinus auricularis	Shearwater, Newell's	T	x				x	x	
Telespyza cantans	Finch, Laysan	E							L
Telespyza ultima	Finch, Nihoa	E							Nihoa

LISTED REPTILES (2 Endangered + 3 Threatened = 5 taxa)

		STATUS	Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands, Kaho'olawe, Ni'ihau, or Oceanic
Caretta caretta	Turtle, Loggerhead sea; (incidental in Hawai'i)	T	x	x	x	x	x	x	O+all islands
Chelonia mydas	Turtle, Green sea; Honu	T	x	x	x	x	x	x	O+all islands
Dermochelys coriaceae	Turtle, Leatherback sea; (incidental in Hawai'i)	E	x	x	x	x	x	x	O+all islands
Eretmochelys imbricata	Turtle, Hawksbill; 'Ea	E	x	x	x	x	x	x	O+all islands
Lepidochelys olivacea	Turtle, Olive ridley sea; (incidental in Hawai'i)	T	x	x	x	x	x	x	O+all islands

INVERTEBRATES (55 Endangered +2 Threatened = 57 taxa)

LISTED SNAILS (41 Endangered + 1 Threatened = 42 taxa)

		STATUS	Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands, Kaho'olawe, Ni'ihau, or Oceanic
Achatinella abbreviata	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella apexfulva	Snail, O'ahu tree; Pupu kani oe	E					x		

HAWAIIAN ISLANDS ANIMALS: Updated September 10, 2009

LISTED SPECIES, AS DESIGNATED UNDER THE U.S. ENDANGERED SPECIES ACT

Species status by island: E=endangered; T=threatened; (CH)=critical habitat designated; P=proposed.
N.W. Hawaiian Islands: Frigate; Kure; Laysan; Midway; Necker; Nihoa; PH = Pearl & Hermes

			DISTRIBUTION						
		STATUS	Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands, Kaho'olawe, Ni'ihau, or Oceanic
Achatinella bellula	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella buddii	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella bulimoides	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella byronii	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella caesia	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella casta	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella cestus	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella concavospira	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella curta	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella decipiens	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella decora	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella dimorpha	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella elegans	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella fulgens	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella fuscobasis	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella juddii	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella juncea	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella lehuiensis	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella leucorrhaphe	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella lila	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella livida	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella lorata	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella mustelina	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella papyracea	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella phaeozona	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella pulcherrima	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella pupukanioe	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella rosea	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella sowerbyana	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella spaldingi	Snail, O'ahu tree; Pupu kani oe	E					x		

HAWAIIAN ISLANDS ANIMALS: Updated September 10, 2009

LISTED SPECIES, AS DESIGNATED UNDER THE U.S. ENDANGERED SPECIES ACT

Species status by island: E=endangered; T=threatened; **(CH)**=critical habitat designated; P=proposed.
N.W. Hawaiian Islands: Frigate; Kure; Laysan; Midway; Necker; Nihoa; PH = Pearl & Hermes

		STATUS	DISTRIBUTION						
			Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands, Kaho'olawe, Ni'ihau, or Oceanic
Achatinella stewartii	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella swiftii	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella taeniolata	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella thaanumi	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella turgida	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella valida	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella viridans	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella vittata	Snail, O'ahu tree; Pupu kani oe	E					x		
Achatinella vulpina	Snail, O'ahu tree; Pupu kani oe	E					x		
Erinna newcombi **(CH)**	Snail, Newcomb's; Pupu wai lani	T						x	

LISTED ARTHROPODS (14 Endangerd + 1 Threatened = 15 taxa; 3 proposed Endangered)

Adelocosa anops **(CH)**	Wolf spider, Kaua'i cave	E						x	
Manduca blackburni **(CH)**	Moth, Blackburn's sphinx	E	x	x					Ka
Drosophila aglaia (CH)	Picture-wing fly, Oahu	E					x		
Drosophila attigua (pCH) (syn.w/D. sharpi)	Picture-wing fly, Kauai	PE						x	
Drosophila differens (CH)	Picture-wing fly, Molokai	E				x			
Drosophila hemipeza (CH)	Picture-wing fly, Oahu	E					x		
Drosophila heteroneura (CH)	Picture-wing fly, Hawaii	E	x						
Drosophila montgomeryi (CH)	Picture-wing fly, Oahu	E					x		
Drosophila mulli (CH)	Picture-wing fly, Hawaii	T	x						
Drosophila musaphila (CH)	Picture-wing fly, Kauai	E						x	
Drosophila neoclavisetae (CH)	Picture-wing fly, Maui	E		x					
Drosophila obatai (CH)	Picture-wing fly, Oahu	E					x		
Drosophila ochrobasis (CH)	Picture-wing fly, Hawaii	E	x						
Drosophila substenoptera (CH)	Picture-wing fly, Oahu	E					x		
Drosophila tarphytrichia (CH)	Picture-wing fly, Oahu	E					x		
Megalagrion nesiotes	Flying earwig Hawaiian damselfly	PE	x	x					
Megalagrion pacificum	Pacific Hawaiian damselfly	PE	x	x	x	x	x	x	
Spelaeorchestia [illegible]*na (CH)*	Amphipod, Kaua'i cave	E						x	

HAWAIIAN ISLANDS PLANTS: Updated April 9, 2009
LISTED SPECIES, AS DESIGNATED UNDER THE U.S. ENDANGERED SPECIES ACT

Species status by island: E= endangered; T= threatened; P= formally proposed as E or T;
(CH)=critical habitat designated; pCH=critical habitat proposed ;*=possibly extirpated in the wild.
‡=N.W. Hawaiian Islands: Frigate; Kure; Laysan; Midway; Necker; Nihoa; PH = Pearl & Hermes.

LISTED PLANTS (285 Endangered, 10 Threatened; 45 proposed Endangered)

Species	Common name	STATUS	DISTRIBUTION: Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands‡, Kaho'olawe, and Ni'ihau
Abutilon eremitopetalum	No common name	E			✓				
Abutilon menziesii	Ko'oloa'ula	E	✓	✓	✓		✓		
Abutilon sandwicense (CH)	No common name	E					✓ CH		
Acaena exigua	Liliwai	E		✓*				✓*	
Achyranthes mutica (CH)	No common name	E	✓ CH					✓*	
Achyranthes splendens var. *rotundata*	Hinahina ewa	E			✓*	✓*	✓		
Adenophorus periens (CH)	No common name	E	✓CH		✓*	✓CH	✓*CH	✓CH	
Alectryon macrococcus var. *auwahiensis* (CH)	Mahoe	E		✓CH					
Alectryon macrococcus var. *macrococcus* (CH)	Mahoe	E		✓CH		✓CH	✓CH	✓CH	
Amaranthus brownii (CH)	No common name	E							Nihoa CH
Argyroxiphium kauense (CH)	'Ahinahina, Ka'u silversword	E	✓CH						
Argyroxiphium sandwicense ssp. *macrocephalum* (CH)	'Ahinahina, Haleakala silversword	T		✓CH					
Argyroxiphium sandwicense ssp. *sandwicense*	'Ahinahina, Mauna Kea	E	✓						
Asplenium peruvianum var. *insulare* (CH) (listed as Asplenium fragile var. insulare)	No common name	E	✓CH	✓CH					
Astelia waialealae	painiu	PE						pCH	
Bidens micrantha ssp. *kalealaha* (CH)	Ko'oko'olau	E		✓CH	✓CH				
Bidens wiebkei (CH)	Ko'oko'olau	E				✓CH			
Bonamia menziesii (CH)	No common name	E	✓CH	✓CH	✓	✓*	✓CH	✓CH	
Brighamia insignis (CH)	'Olulu	E						✓CH	Niihau*CH
Brighamia rockii (CH)	Pua 'ala	E		✓*CH	✓*	✓CH			
Caesalpinia kavaiensis	Uhiuhi	E	✓	✓*	✓*		✓	✓*	
Canavalia molokaiensis (CH)	'Awikiwiki	E				✓CH			
Canavalia napaliensis	Awikiwiki	PE						pCH	
Cenchrus agrimonioides var. *agrimonioides* (CH)	Kamanomano	E	✓*	✓CH	✓*		✓CH		
Cenchrus agrimonioides var. *laysanensis*	Kamanomano	E							L*, K*, M*
Centaurium sebaeoides (CH)	'Awiwi	E		✓CH	✓	✓CH	✓CH	✓CH	
Chamaesyce celastroides var. *kaenana* (CH)	'Akoko	E					✓CH		
Chamaesyce deppeana (CH)	'Akoko	E					✓CH		
Chamaesyce eleanoriae	'Akoko	PE						pCH	
Chamaesyce halemanui (CH)	'Akoko	E						✓CH	
Chamaesyce herbstii (CH)	'Akoko	E					✓CH		

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			Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands‡, Kaho'olawe, and Ni'ihau
Chamaesyce kuwaleana (CH)	'Akoko	E					✓CH		
Chamaesyce remyi var. kauaiensis	'Akoko	PE						pCH	
Chamaesyce remyi var. remyi	'Akoko	PE						pCH	
Chamaesyce rockii (CH)	'Akoko	E					✓CH		
Chamaesyce skottsbergii var. *kalaeloana* (listed as *Euphorbia skottsbergii* var. *kalaeloana*)	'Akoko	E					✓		
Charpentiera densiflora	Papala	PE						pCH	
Clermontia drepanomorpha (CH)	'Oha wai	E	✓CH						
Clermontia lindseyana (CH)	'Oha wai	E	✓CH	✓CH					
Clermontia oblongifolia ssp. *brevipes* (CH)	'Oha wai	E				✓CH			
Clermontia oblongifolia ssp. mauiensis (CH)	'Oha wai	E		✓CH	✓*				
Clermontia peleana ssp. *peleana* (CH)	'Oha wai	E	✓CH						
Clermontia peleana ssp. *singuliflora* (CH)	'Oha wai	E	✓*CH	✓*					
Clermontia pyrularia (CH)	'Oha wai	E	✓CH						
Clermontia samuelii ssp. *hanaensis* (CH)	'Oha wai	E		✓CH					
Clermontia samuellii ssp. *samuelii* (CH)	'Oha wai	E		✓CH					
Colubrina oppositifolia (CH)	Kauila	E	✓CH	✓CH			✓CH		
Ctenitis squamigera (CH)	Pauoa	E		✓CH	✓	✓CH	✓CH	✓*CH	
Cyanea acuminata (CH)	Haha	E					✓CH		
Cyanea asarifolia (CH)	Haha	E						✓CH	
Cyanea copelandii ssp. *copelandii*	Haha	E	✓*						
Cyanea copelandii ssp. *haleakalaensis* (CH)	Haha	E		✓CH					
Cyanea crispa (CH)	Haha	E					✓CH		
Cyanea dolichopoda	Haha	PE						pCH	
Cyanea dunbariae (CH)	Haha	E				✓CH			
Cyanea eleeleensis	Haha	PE						pCH*	
Cyanea glabra (CH)	Haha	E		✓CH					
Cyanea grimesiana ssp. *grimesiana* (CH)	Haha	E				✓*CH	✓*CH		
Cyanea grimesiana ssp. *obatae* (CH)	Haha	E					✓CH		
Cyanea hamatiflora ssp. *carlsonii* (CH)	Haha	E	✓CH						
Cyanea hamatiflora ssp. *hamatiflora* (CH)	Haha	E		✓CH					
Cyanea humboldtiana (CH)	Haha	E					✓CH		
Cyanea kolekoleensis	Haha	PE						pCH*	
Cyanea koolauensis (CH)	Haha	E					✓CH		
Cyanea kuhihewa	Haha	PE						pCH*	
Cyanea lobata ssp. [illegible]ii (listed as *Cyanea lobata*)	Haha	E			✓				

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			Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands‡, Kaho'olawe, and Ni'ihau
Cyanea lobata ssp. *lobata* (listed as *Cyanea lobata*) (CH)	Haha	E		✓ CH					
Cyanea longiflora (CH)	Haha	E					✓CH		
Cyanea macrostegia ssp. gibsonii	Haha	E			✓				
Cyanea magnicalyx (listed as *Cyanea grimesiana* ssp. *grimesiana*) (CH)	Haha	E		✓CH					
Cyanea mannii (CH)	Haha	E				✓CH			
Cyanea mauiensis (listed as *Cyanea grimesiana* ssp. *grimesiana*)	Haha	E		✓*					
Cyanea mceldowneyi (CH)	Haha	E		✓CH					
Cyanea munroi (listed as *Cyanea grimesiana* ssp. *grimesiana*) (CH)	Haha	E			✓	✓CH			
Cyanea pinnatifida (CH)	Haha	E					✓CH		
Cyanea platyphylla (CH)	'Aku'aku	E	✓CH						
Cyanea procera (CH)	Haha	E				✓CH			
Cyanea recta (CH)	Haha	T						✓CH	
Cyanea remyi (CH)	Haha	E						✓CH	
Cyanea rivularis (listed as *Delissea rivularis*) (CH)	No common name?	E						✓CH	
Cyanea salicina (listed as *Cyanea recta*) (CH)	Haha	T						✓CH	
Cyanea shipmanii (CH)	Haha	E	✓CH						
Cyanea st.-johnii (CH)	Haha	E					✓CH		
Cyanea stictophylla (CH)	Haha	E	✓CH						
Cyanea superba ssp. *regina* (CH)	Haha	E					✓*CH		
Cyanea superba ssp. *superba* (CH)	Haha	E					✓CH		
Cyanea truncata (CH)	Haha	E					✓CH		
Cyanea undulata (CH)	Haha	E						✓CH	
Cyperus fauriei (CH)	No common name	E	✓CH		✓*	✓CH			
Cyperus pennatiformis ssp. *bryanii* (CH) (listed as Mariscus pennatiformis)	No common name	E							L CH
Cyperus pennatiformis ssp. *pennatiformis* (CH) (listed as Mariscus pennatiformis)	No common name	E		✓CH			✓*CH	✓*CH	
Cyperus trachysanthos (CH)	Pu'uka'a	E			✓*	✓*	✓CH	✓CH	Niihau *
Cyrtandra crenata	Ha'iwale	E					✓*		
Cyrtandra cyaneoides (CH)	Mapele	E						✓CH	
Cyrtandra dentata (CH)	Ha'iwale	E					✓CH		
Cyrtandra giffardii (CH)	Ha'iwale	E	✓CH						
Cyrtandra kealiae ssp. *kealiae* (listed as *Cyrtandra limahuliensis*)(CH)	Ha'iwale	T						✓CH	
Cyrtandra munroi (CH)	Ha'iwale	E		✓CH	✓				
Cyrtandra oenobarba	Ha'iwale	PE						pCH	
Cyrtandra paliku	Ha'iwale	PE						pCH	
Cyrtandra polyantha (CH)	Ha'iwale	E					✓CH		

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			Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands‡, Kaho'olawe, and Niihau
Cyrtandra subumbellata (CH)	Ha'iwale	E					✓CH		
Cyrtandra tintinnabula (CH)	Ha'iwale	E	✓CH						
Cyrtandra viridiflora (CH)	Ha'iwale	E					✓CH		
Delissea argutidentata (listed as *Delissea undulata*) (CH)	No common name	E	✓*CH						
Delissea kauaiensis (listed as *Delissea undulata*) (CH)	No common name	E						✓CH	
Delissea niihauensis (listed as *Delissea undulata*)	No common name	E							Niihau*
Delissea rhytidosperma (CH)	No common name	E						✓CH	
Delissea subcordata (CH)	No common name	E					✓*CH		
Delissea takeuchii (listed as *Delissea subcordata*) (CH)	No common name	E					✓*CH		
Delissea undulata	No common name	E		✓*					
Delissea waianaeensis (listed as *Delissea subcordata*) (CH)	No common name	E					✓CH		
Diellia erecta (CH)	No common name	E	✓CH	✓CH	✓*	✓CH	✓CH	✓*CH	
Diellia falcata (CH)	No common name	E					✓CH		
Diellia mannii	No common name	PE						pCH	
Diellia pallida (CH)	No common name	E						✓CH	
Diellia unisora (CH)	No common name	E					✓CH		
Diplazium molokaiense (CH)	No common name	E		✓CH	✓*	✓*CH	✓*CH	✓*CH	
Doryopteris angelica	No common name	PE						pCH	
Dryopteris crinalis var. *podosorus*	Palapalai aumakua	PE						pCH	
Dubautia herbstobatae (CH)	Na'ena'e	E					✓CH		
Dubautia imbricata ssp. imbricata	Na'ena'e	PE						pCH	
Dubautia kalalauensis	Na'ena'e	PE						pCH	
Dubautia kenwoodii	Na'ena'e	PE						pCH	
Dubautia latifolia (CH)	Kaholapehu	E						✓CH	
Dubautia pauciflorula (CH)	Na'ena'e	E						✓CH	
Dubautia plantaginea ssp. *humilis* (CH)	Na'ena'e	E		✓CH					
Dubautia plantaginea ssp. magnifolia	Na'ena'e	PE						pCH	
Dubautia waialealae	Na'ena'e	PE						pCH	
Eragrostis fosbergii (CH)	No common name	E					✓*CH		
Eugenia koolauensis (CH)	Nioi	E				✓*CH	✓CH		
Euphorbia haeleeleana (CH)	No common name	E					✓CH	✓CH	
Exocarpos luteolus (CH)	Heau	E						✓CH	
Flueggea neowawraea (CH)	Mehamehame	E	✓CH	✓CH		✓*CH	✓CH	✓CH	
Gahnia lanaiensis	No common name	E			✓				
Gardenia brighamii	Nanu	E	✓*	✓*	✓	✓*	✓		

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			Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands‡, Kaho'olawe, and Ni'ihau
Gardenia mannii (CH)	Nanu	E					✓CH		
Geranium arboreum (CH)	Nohoanu	E		✓CH					
Geranium kauaiense	Nohoanu	PE						pCH	
Geranium multiflorum (CH)	Nohoanu	E		✓CH					
Gouania hillebrandii (CH)	No common name	E		✓CH	✓*	✓			K*
Gouania meyenii (CH)	No common name	E					✓CH	✓CH	
Gouania vitifolia (CH)	No common name	E	✓CH	✓*CH			✓CH		
Haplostachys haplostachya	No common name	E	✓	✓*				✓*	
Hedyotis cookiana (CH)	'Awiwi	E	✓*					✓CH	
Hedyotis coriacea (CH)	Kio'ele	E	✓CH	✓CH			✓*CH		
Hedyotis degeneri var. *coprosmifolia* (CH)	No common name	E					✓*CH		
Hedyotis degeneri var. *degeneri* (CH)	No common name	E					✓CH		
Hedyotis mannii (CH)	Pilo	E		✓CH	✓	✓			
Hedyotis parvula (CH)	No common name	E					✓CH		
Hedyotis schlechtendahliana var. *remyi*	Kopa	E			✓*				
Hedyotis st.-johnii (CH)	No common name	E						✓CH	
Hesperomannia arborescens (CH)	No common name	E		✓	✓*	✓CH	✓CH		
Hesperomannia arbuscula (CH)	No common name	E		✓CH			✓CH		
Hesperomannia lydgatei (CH)	No common name	E						✓CH	
Hibiscadelphus distans	Hau kuahiwi	E						✓	
Hibiscadelphus giffardianus (CH)	Hau kuahiwi	E	✓CH						
Hibiscadelphus hualalaiensis (CH)	Hau kuahiwi	E	✓CH						
Hibiscadelphus woodii (CH)	Hau kuahiwi	E						✓CH	
Hibiscus arnottianus ssp. *immaculatus* (CH)	Koki'o ke'oke'o	E				✓			
Hibiscus brackenridgei ssp. *brackenridgei* (CH)	Ma'o hau hele	E	✓CH	✓CH	✓				
Hibiscus brackenridgei ssp. *mokuleianus* (CH)	Ma'o hau hele	E				✓CH	✓*CH		
Hibiscus brackenridgei ssp. *molokaiana* (CH)	Ma'o hau hele	E				✓*CH	✓CH		
Hibiscus clayi (CH)	Koki'o 'ula'ula	E						✓CH	
Hibiscus waimeae ssp. *hannerae* (CH)	Koki'o ke'oke'o	E						✓CH	
Huperzia mannii (CH)	Wawae'iole	E	✓*	✓				✓*	
Huperzia nutans (CH)	Wawae'iole	E					✓	✓*	
Ischaemum byrone (CH)	Hilo ischaemum	E	✓CH	✓CH		✓CH	✓	✓CH	
Isodendrion hosakae (CH)	Aupaka	E	✓CH						
Isodendrion laurifolium (CH)	Aupaka	E					✓CH	✓CH	
Isodendrion longifolium (CH)	Aupaka	T					✓CH	✓CH	

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			Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands‡, Kaho'olawe, and Ni'ihau
Isodendron pyrifolium (CH)	Wahine noho kula	E	✓	✓*CH	✓*	✓*CH	✓*CH		Niihau*
Kanaloa kahoolawensis (CH)	Kohe malama malama o Kanaloa	E							K CH
Keysseria erici	No common name	PE						pCH	
Keysseria helenae	No common name	PE						pCH	
Kokia cookei	Koki'o	E				✓*			
Kokia drynarioides (CH)	Hau hele 'ula; koki'o	E	✓CH						
Kokia kauaiensis (CH)	Koki'o	E						✓CH	
Labordia cyrtandrae (CH)	Kamakahala	E					✓CH		
Labordia helleri	Kamakahala	PE						pCH	
Labordia lydgatei (CH)	Kamakahala	E						✓CH	
Labordia pumila	Kamakahala	PE						pCH	
Labordia tinifolia var. *lanaiensis*	Kamakahala	E			✓				
Labordia tinifolia var. *wahiawaensis* (CH)	Kamakahala	E						✓CH	
Labordia triflora (CH)	Kamakahala	E				✓CH			
Lepidium arbuscula (CH)	'Anaunau	E					✓CH		
Lipochaeta lobata var. *leptophylla* (CH)	Nehe	E					✓CH		
Lobelia gaudichaudii ssp. *koolauensis* (CH)	No common name	E					✓CH		
Lobelia monostachya (CH)	No common name	E					✓CH		
Lobelia niihauensis (CH)	No common name	E					✓CH	✓CH	Niihau*
Lobelia oahuensis (CH)	No common name	E					✓CH		
Lysimachia daphnoides	Lehua makanoe	PE						pCH	
Lysimachia filifolia (CH)	No common name	E					✓CH	✓CH	
Lysimachia iniki	No common name	PE						pCH	
Lysimachia lydgatei (CH)	No common name	E		✓CH					
Lysimachia maxima (CH)	No common name	E				✓CH			
Lysimachia pendens	No common name	PE						pCH	
Lysimachia scopulensis	No common name	PE						pCH	
Lysimachia venosa	No common name	PE						pCH	
Marsilea villosa (CH)	'Ihi'ihi	E				✓	✓CH		Niihau
Melanthera fauriei (CH) (listed as *Lipochaeta fauriei*)	Nehe	E						✓CH	
Melanthera kamolensis (CH) (listed as *Lipochaeta kamolensis*)	Nehe	E		✓CH					
Melanthera micrantha ssp. *exigua* (CH) (listed as *Lipochaeta micrantha*)	Nehe	E						✓CH	
Melanthera micrantha ssp. *micrantha* (CH) (listed as *Lipochaeta micrantha*)	Nehe	E						✓CH	
Melanthera tenuifolia (CH) (listed as *Lipochaeta tenuifolia*)	Nehe	E					✓CH		
Melanthera venosa [illegible] as *Lipochaeta venosa*)	Nehe	E	✓						

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			Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands‡, Kaho'olawe, and Ni'ihau
Melanthera waimeaensis (CH) (listed as *Lipochaeta waimeaensis*)	Nehe	E					✓CH		
Melicope adscendens (CH)	Alani	E		✓CH					
Melicope balloui (CH)	Alani	E		✓CH					
Melicope degeneri	Alani	PE						pCH	
Melicope haupuensis (CH)	Alani	E						✓CH	
Melicope knudsenii (CH)	Alani	E		✓CH				✓CH	
Melicope lydgatei (CH)	Alani	E					✓CH		
Melicope mucronulata (CH)	Alani	E		✓*CH		✓CH			
Melicope munroi	Alani	E			✓	✓			
Melicope ovalis (CH)	Alani	E		✓CH					
Melicope pallida (CH)	Alani	E					✓*CH	✓CH	
Melicope paniculata	Alani	PE						pCH	
Melicope puberula	Alani	PE						pCH	
Melicope quadrangularis	Alani	E						✓*	
Melicope reflexa (CH)	Alani	E				✓CH			
Melicope saint-johnii (CH)	Alani	E					✓CH		
Melicope zahlbruckneri (CH)	Alani	E	✓CH						
Munroidendron racemosum (CH)	No common name	E						✓CH	
Myrsine juddii (CH)	Kolea	E					✓CH		
Myrsine knudsenii	Kolea	PE						pCH	
Myrsine linearifolia (CH)	Kolea	T						✓CH	
Myrsine mezii	Kolea	PE						pCH	
Neraudia angulata var. *angulata* (CH)	No common name	E					✓CH		
Neraudia angulata var. *dentata* (CH)	No common name	E					✓CH		
Neraudia ovata (CH)	No common name	E	✓CH						
Neraudia sericea (CH)	No common name	E		✓CH	✓	✓CH			K*
Nothocestrum breviflorum (CH)	'Aiea	E	✓CH						
Nothocestrum peltatum (CH)	'Aiea	E						✓CH	
Nototrichium humile (CH)	Kulu'i	E		✓*CH			✓CH		
Ochrosia kilaueaensis	Holei	E	✓*						
Panicum fauriei var. *carteri* (CH)	Carter's panic grass	E		✓	✓	✓	✓CH		
Panicum niihauense (CH)	Lau'ehu	E						✓CH	Niihau*
Peucedanum sandwicense (CH)	Makou	T		✓CH		✓CH	✓CH	✓CH	
Phyllostegia glabra var. *lanaiensis*	Ulihi	E			✓*				
Phyllostegia haliakalae (listed as *Phyllostegia mollis*) (CH)	No common name	E		✓CH		✓*	✓*CH		

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Phyllostegia hirsuta (CH)	No common name	E					✓CH		
Phyllostegia hispida	No common name	E				✓			
Phyllostegia kaalaensis (CH)	No common name	E					✓CH		
Phyllostegia knudsenii (CH)	No common name	E						✓CH	
Phyllostegia mannii (CH)	No common name	E		✓*CH		✓CH			
Phyllostegia mollis	No common name	E					✓CH		
Phyllostegia parviflora var. *glabriuscula*	No common name	E	✓						
Phylostegia parviflora var. *lydgatei* (CH)	No common name	E					✓CH		
Phyllostegia parviflora var. *parviflora* (CH)	No common name	E		✓*			✓CH		
Phyllostegia pilosa (listed as *Phyllostegia mollis*)	No common name	E		✓CH		✓*CH			
Phyllostegia racemosa (CH)	Kiponapona	E	✓CH						
Phyllostegia renovans	No common name	PE						pCH	
Phyllostegia velutina (CH)	No common name	E	✓CH						
Phyllostegia waimeae (CH)	No common name	E						✓CH	
Phyllostegia warshaueri (CH)	No common name	E	✓CH						
Phyllostegia wawrana (CH)	No common name	E						✓CH	
Pittosporum napaliense	Hoawa	PE						pCH	
Plantago hawaiensis (CH)	Laukahi kuahiwi	E	✓CH						
Plantago princeps var. *anomala* (CH)	Laukahi kuahiwi	E						✓CH	
Plantago princeps var. *laxiflora* (CH)	Laukahi kuahiwi	E	✓*	✓CH		✓CH			
Plantago princeps var. longibracteata (CH)	Laukahi kuahiwi	E					✓CH	✓CH	
Plantago princeps var. princeps (CH)	Laukahi kuahiwi	E					✓CH		
Platanthera holochila (CH)	No common name	E		✓*CH		✓	✓*CH	✓CH	
Platydesma rostrata	Pilo kea lau lii	PE						pCH	
Pleomele hawaiiensis (CH)	Hala pepe	E	✓CH						
Poa mannii (CH)	No common name	E						✓CH	
Poa sandvicensis (CH)	No common name	E						✓CH	
Poa siphonoglossa (CH)	No common name	E						✓CH	
Portulaca sclerocarpa (CH)	Po'e	E	✓CH		✓CH				
Pritchardia affinis	Loulu	E	✓						
Pritchardia aylmer-robinsonii	Wahane	E							Niihau
Pritchardia hardyi	Loulu	PE						pCH	
Pritchardia kaalae	Loulu	E					✓		
Pritchardia munroi	Loulu	E				✓			
Pritchardia napalie	Loulu	E						✓	

HAWAIIAN ISLANDS PLANTS: Updated April 9, 2009
LISTED SPECIES, AS DESIGNATED UNDER THE U.S. ENDANGERED SPECIES ACT

Species status by island: E= endangered; T= threatened; P= formally proposed as E or T;
(CH)=critical habitat designated; pCH=critical habitat proposed ;*=possibly extirpated in the wild.
‡=N.W. Hawaiian Islands: Frigate; Kure; Laysan; Midway; Necker; Nihoa; PH = Pearl & Hermes.

		STATUS	DISTRIBUTION						
			Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands‡, Kaho'olawe, and Ni'ihau
Pritchardia remota (CH)	Loulu	E							Nihoa CH
Pritchardia schattaueri	Loulu	E	✓						
Pritchardia viscosa	Loulu	E						✓	
Psychotria grandiflora	Kopiko	PE						pCH	
Psychotria hobdyi	Kopiko	PE						pCH	
Pteralyxia kauaiensis (CH)	Kaulu	E						✓CH	
Pteris lidgatei (CH)	No common name	E		✓CH		✓*CH	✓CH		
Remya kauaiensis (CH)	No common name	E						✓CH	
Remya mauiensis (CH)	No common name	E		✓CH					
Remya montgomeryi (CH)	No common name	E						✓CH	
Sanicula mariversa (CH)	No common name	E					✓CH		
Sanicula purpurea (CH)	No common name	E		✓CH			✓CH		
Santalum freycinetianum var. *lanaiense*	'Iliahi	E		✓	✓				
Scaevola coriacea	Dwarf naupaka	E	✓*	✓	✓*	✓	✓*	✓*	Niihau*
Schiedea adamantis	No common name	E					✓		
Schiedea apokremnos (CH)	No common name	E						✓CH	
Schiedea attenuata	No common name	PE						pCH	
Schiedea haleakalensis (CH)	No common name	E		✓CH					
Schiedea helleri (CH)	No common name	E						✓CH	
Schiedea hookeri (CH)	No common name	E		✓*			✓CH		
Schiedea kaalae (CH)	No common name	E					✓CH		
Schiedea kauaiensis (CH)	No common name	E						✓CH	
Schiedea kealiae (CH)	No common name	E					✓CH		
Schiedea laui	No common name	E				✓CH			
Schiedea lychnoides (listed as *Alsinidendron lychnoides*) (CH)	Kuawawaenohu	E						✓CH	
Schiedea lydgatei (CH)	No common name	E				✓CH			
Schiedea membranacea (CH)	No common name	E						✓CH	
Schiedea nuttallii (CH)	No common name	E		✓*		✓	✓CH		
Schiedea obovata (listed as *Alsinidendron obovatum*) (CH)	No common name	E					✓CH		
Schiedea perlmanii (listed as *Schiedea nuttallii*) (CH)	No common name	E						✓CH	
Schiedea sarmentosa (CH)	No common name	E				✓CH			
Schiedea spergulina var. *leiopoda* (listed as *Schiedea spergulina*) (CH)	No common name	E						✓CH	
Schiedea spergulina var. *spergulina* (listed as *Schiedea spergulina*) (CH)	No common name	T						✓CH	
Schiedea stellarioides (CH)	Laulihilihi	E						✓CH	
Schiedea trinervis (listed as *Alsinidendron trinerve*) (CH)	No common name	E					✓CH		

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		STATUS	DISTRIBUTION						
			Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands‡, Kaho'olawe, and Ni'ihau
Schiedea verticillata (CH)	No common name	E							Nihoa CH
Schiedea viscosa (listed as *Alsinidendron viscosum*) (CH)	No common name	E						✓CH	
Sesbania tomentosa (CH)	'Ohai	E	✓CH	✓CH	✓	✓CH	✓CH	✓CH	K, Niihau*, Nc.
Sicyos alba (CH)	'Anunu	E	✓CH						
Silene alexandri (CH)	No common name	E				✓CH			
Silene hawaiiensis (CH)	No common name	T	✓CH						
Silene lanceolata (CH)	No common name	E	✓CH		✓*	✓CH	✓CH	✓*	
Silene perlmanii (CH)	No common name	E					✓*CH		
Solanum incompletum (CH)	Popolo ku mai	E	✓CH	✓*	✓*	✓*		✓*	
Solanum sandwicense (CH)	Popolo 'aiakeakua	E					✓*CH	✓CH	
Spermolepis hawaiiensis (CH)	No common name	E	✓CH	✓CH	✓	✓*CH	✓CH	✓CH	
Stenogyne angustifolia (listed as *Stenogyne angustifolia var. angustifolia*)	No common name	E	✓	✓*		✓*			
Stenogyne bifida (CH)	No common name	E				✓*CH			
Stenogyne campanulata (CH)	No common name	E						✓CH	
Stenogyne kanehoana (CH)	No common name	E					✓CH		
Stenogyne kealiae	No common name	PE						pCH	
Tetramolopium arenarium ssp. *arenarium* (listed as *Tetramolopium arenarium*)	No common name	E	✓	✓*					
Tetramolopium arenarium ssp. *laxum* (listed as *Tetramolopium arenarium*)	No common name	E		✓*					
Tetramolopium arenarium var. *arenarium* (listed as *Tetramolopium arenarium*)	No common name	E	✓	✓*					
Tetramolopium arenarium var. *confertum* (listed as *Tetramolopium arenarium*)	No common name	E	✓						
Tetramolopium capillare (CH)	No common name	E		✓*CH					
Tetramolopium filiforme var. *filiforme* (listed as *Tetramolopium filiforme*) (CH)	No common name	E					✓CH		
Tetramolopium filiforme var. *polyphyllum* (listed as *T. filiforme*) (CH)	No common name	E					✓CH		
Tetramolopium lepidotum ssp. *lepidotum* (CH)	No common name	E			✓*		✓CH		
Tetramolopium remyi (CH)	No common name	E		✓*CH	✓CH				
Tetramolopium rockii var. *calcisabulorum* (listed as *Tetramolopium rockii*) (CH)	No common name	T				✓CH			
Tetramolopium rockii var. *rockii* (listed as *Tetramolopium rockii*) (CH)	No common name	T				✓CH			
Tetraplasandra bisattenuata	No common name	PE						pCH	
Tetraplasandra flynnii	No common name	PE						pCH	
Tetraplasandra gymnocarpa (CH)	'Ohe'ohe	E					✓CH		
Trematolobelia singularis (CH)	No common name	E					✓CH		
Urera kaalae (CH)	Opuhe	E					✓CH		
Vicia menziesii	Hawaiian vetch	E	✓						
Vigna o-wahuensis (CH)	No common name	E	✓CH	✓CH	✓	✓	✓*CH		K, Niihau*
Viola chamissoniana [illegible] *hamissoniana* (CH)	'olopu; pamakani	E					✓CH		

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		STATUS	DISTRIBUTION						
			Hawai'i	Maui	Lāna'i	Moloka'i	O'ahu	Kaua'i	N.W. Islands‡, Kaho'olawe, and Ni'ihau
Viola helenae (CH)	No common name	E						✓CH	
Viola kauaensis var. *wahiawaensis* (CH)	Nani wai'ale'ale	E						✓CH	
Viola lanaiensis	No common name	E			✓				
Viola oahuensis (CH)	No common name	E					✓CH		
Wilkesia hobdyi (CH)	Iliau	E						✓CH	
Xylosma crenatum (CH)	No common name	E						✓CH	
Zanthoxylum dipetalum var. *tomentosum* (CH)	A'e	E	✓CH						
Zanthoxylum hawaiiense (CH)	A'e	E	✓CH	✓CH	✓*	✓CH		✓CH	

APPENDIX E

Conservation

ORDINANCE NO. ____________________________

BILL NO. ____________________________________

A BILL FOR AN ORDINANCE AMENDING TITLE 14
MAUI COUNTY CODE, RELATING TO WATER CONSERVATION

BE IT ORDAINED BY THE PEOPLE OF THE COUNTY OF MAUI

SECTION 1. Section 14.03., Maui County Code, is amended to read as follows:

DRAFT

Chapter 14.03

WATER CONSERVATION

Sections:

14.03.10 Policy Statement

I. 1. Findings

The Maui County Council has found that:

A. The limited supply of County waters are subject to ever increasing demands

B. Maui County is growing in population, and it is important to implement water conservation measures now in order to stretch supplies as long as possible.

C. Maui County's economic prosperity depends upon adequate water supply.

D. Studies have shown that landscape accounts for about fifty percent of all water used in urban areas. Water conserving landscapes can use as little as one third of the water of a traditional non-water-conserving landscape. These savings can be substantial, if projected through the life of a development.

E. Water conservation will save money and can be accomplished without degradation of aesthetic values.

F. State and County policy and Community Plans promote conservation and efficient use of water.

G. Landscapes provide recreation areas, cleaner air and water, prevent erosion, offer fire protection and help to partially replace ecosystems where these have been displaced by development

H. Landscape design, installation and maintenance can and should be water efficient.

I. The high cost of living in Hawaii and the even higher cost of living in Maui leaves our community with less capital for development of new water resources. Water conservation can reduce competition for capital which could otherwise be spent on proper system maintenance and other priorities.

J. Proper landscape conservation prevents waste of drinking water by inefficient use in the landscape.

II. Purpose and Intent

A. Promote the values and benefits of landscapes while recognizing the need to invest water and other resources as efficiently as possible;

B. Establish a structure for designing, installing and maintaining water efficient landscapes in new and refurbished projects;

C. Establish provisions for water management practices and water waste prevention for established landscapes.

D. Reduce supplemental water use through climate-based plant material choices, design, irrigation scheduling, and soil management.

E. Promote the conservation of potable and non-potable water by encouraging the preservation of appropriate native plant communities, the use of site-specific plant materials and to establish techniques for installation and maintenance of landscape materials and irrigation systems.

F. Improve the aesthetic appearance of commercial, industrial and residential areas through the incorporation of appropriate landscape features into development in ways that harmonize and enhance the built environment.

G. Preserve the native and endemic vegetation of the island while encouraging the removal and discouraging the use of species which can damage the watershed or cause other nuisance.

H. Encourage the utilization of readily available water conserving technology to maximize resource efficiency.

D. This Chapter shall be known as the Water Conservation Plan Ordinance

E. The Director of Water Supply shall adopt rules as appropriate to implement the provisions of this section.

14.03.020 Water Conservation Plan *(from council)*

A. The Department of Water Supply shall maintain and periodically update a water conservation plan and program. This plan include regulatory and non-regulatory elements such as prevention of water waste, measures to reduce outdoor water use, measures to insure efficient use of water within the distribution system, measures to maximize plumbing efficiency and other measures as deemed appropriate. The council shall enact regulatory elements of the water conservation plan by ordinance.

B. The regulatory elements of the water conservation plan shall include as a minimum water use regulations relating to outdoor watering, provisions for prevention of water waste, plumbing efficiency and water reuse, as well as provisions to enable budgeting and implementation for non-regulatory measures as deemed appropriate.

C. The Department of Water Supply shall provide to council an annual report on the implementation and effectiveness of its conservation program.

D. The Department's Water Use, Development and Protection Plan shall include analysis of the costs and benefits of implementing various demand and supply side measures, and the conservation program shall be updated accordingly.

E. Private purveyors of water utilizing or conveying more than ½ MGD (500,000 gallons per day) shall be required to maintain and periodically update a water conservation plan and program, to include as a minimum provision for maximizing efficiency and minimizing water waste. A summary of this conservation plan and program shall be submitted and held on file with the Department of Water Supply.

F. Operators of facilities or large landscapes requiring the use of 250,000 gallons per day or more shall also be required to maintain and periodically update a water conservation plan and program, which shall include a description of the water use, and measures instituted to maximize efficiency and minimize waste. A summary of this conservation plan and program shall be submitted and held on file with the Department of Water Supply.

14.03.030 Landscape Conservation

A. General Provisions

1. Periodic Update of Regulations

The Department of Water Supply, after consulting with and considering the recommendations of interested agencies, may from time to time propose to the Administration, Board and Council regulations to establish additional or revised procedures to implement this chapter, and to make more specific the standards and guidelines prescribed in this chapter. Such regulations as are approved by resolution of the Council shall have the force and effect of law unless otherwise indicated.

2. Definitions

The words used in this ordinance have the meaning set forth below:

Agricultural Operation	A business venture in which crops are grown for the purposes of earning a livelihood, as represented and claimed on federal and state tax forms, or a subsistence operation of sufficient size and scope to support the residents of the property on which the agricultural activities take place. A few orchard trees or a vegetable garden do not constitute an agricultural operation.
Amendment	Materials added to the soil, such as compost, leaf mold, peat moss, ground bark or other materials, which improve aeration and percolation of clay soils and may help hold water in sandy soils.
Anti-drain Valve or Check Valve	A valve located under a sprinkler head to hold water in the system so it minimizes drainage from lower elevation sprinkler heads.
Application Rate	The depth of water applied to a given area, usually measured in inches per hour.
Athletic Field	A turf area used primarily for organized sports.
Automatic Control Valve	A device used to control the flow of water at a particular section of the irrigation system.
Automatic Controller	A mechanical or solid state timer, capable of operating valve stations to set the days and length of time of a water application.

Backflow Prevention Device	A safety device used to prevent pollution or contamination of the water supply due to the reverse flow of water from the irrigation system.
Bubblers	Irrigation heads which deliver water to the soil adjacent to the heads.
Check Valve	A valve located under a sprinkler head to hold water in the system so it minimizes drainage from the lower elevation sprinkler heads.
Controller	A device that operates each irrigation zone for a determined time and frequency, based upon irrigation schedule or in some cases feedback of soil moisture content or climatic conditions.
Covenants	Agreements entered into by property owners, leaseholders and renters, which set conditions for the use, maintenance and or sale of property.
Damaged Land Reclamation Project	A parcel or parcels of land which are the subject of plans or efforts to restore or reclaim ecological or other values after that land has been quarried, mined or used for other purposes disruptive to the natural landscape. Such project may have the goals of restoring a site to a condition similar to or compatible with that which existed prior to such use, or to develop the site to some other productive use of the land; to restore forests, pasture, crops, wildlife area, or etc. However, exemptions under this ordinance, shall not apply to projects or efforts to develop a site for subsequent development/construction.
Development	The construction, erection or emplacement of one or more buildings, structures, or surface improvements on land which is a premise in order to establish or expand a principal residential or non-residential use.
Distribution Uniformity	Measure of the uniformity of irrigation water applied over a given area. Sometimes calculated based on the ratio of the average low quarter depth of irrigation water compared to the average depth of irrigation water applied.
Drip Emitter	An irrigation emission device that delivers a measured reduced quantity of water at a consistent rate of discharge.

Drip Irrigation	Low pressure, low volume irrigation applied slowly near or at ground level to minimize runoff and loss to evaporation.
Ecological Restoration Project	A project intended for the restoration of a native ecosystem or area, and not intended for continued irrigation.
Emitter	Drip irrigation fittings that deliver water slowly from the system to the soil.
Established Landscape	The point at which plants in the landscape have developed roots into the soil adjacent to the root ball.
Establishment Period	The period until the plants in the landscape have developed roots in the soil adjacent to the root ball. Generally the first year after installing a plant in the landscape.
ET Controller	Controller that automatically adjusts the watering time and frequency based on local weather conditions such as rain, wind, heat, or estimated evaporation and transpiration rates.
Evapotranspiration	The quantity of water evaporated from adjacent soil surfaces and transpired by plants during a specific time.
Flow Rate	The rate at which water flows through pipes and valves.
Flow Restriction Device	Device applied by the water utility to the customer's meter that restricts the volume of flow to the customer.
Fugitive Water	The pumping, flow, release, escape or leakage of any water from any pipe, valve, faucet, connection, diversion, well or any facility for the purpose of water supply, transport, storage, disposal or delivery to adjacent property or the public right-of-way.
Hand Watering	The application of water for irrigation purposes through a hand-held hose, including hoses moved into position by hand and left to flow freely or through a shut-off nozzle.

Heritage Plants	Any plant or group of plants which meet one or more of the following criteria: 1) having a relationship to an event of cultural or historical significance, 2) is deemed of public interest or special interest by the County's Arborist Committee ? ; 3) a tree having a circumference of 72"; 4) a native species which is classified as rare, endangered , threatened or species of concern, 5) other criteria?
High Water Use Turf	A surface layer of earth containing regularly mowed grass, with its roots, which requires large volumes and or frequent application of water throughout its life. High water use grasses include but are not limited to varieties of bluegrass, varieties of ryegrass, varieties of fescue and bent grass.
High Water Use Plants	High-water-using plants are characterized by high transpiration rates, shallow rooting, and the need for frequent watering. Refer to the Maui County Planting Plan and/or DWS list of plants.
Hydrozone	A portion of the landscaped area having plants with similar water needs that are served by a valve or set of valves with the same schedule. A hydrozone may be irrigated or non-irrigated, but should have similar characteristics in terms of water needs of the plants, precipitation rate of irrigation devices, solar radiation, wind conditions, soil type and slope. A naturalized area planted with native vegetation that will not need supplemental irrigation once established is a non-irrigated hydrozone.
Irrigation Audit	Procedure to collect and present information concerning the design, maintenance, uniformity of application rate, precipitation rate, efficiency, and general condition of an irrigation system and its components.
Infiltration Rate	The rate of water entry into the soil expressed as a depth of water per unit of time in inches per hour.
Irrigation	Intentional application of water for purposes of sustained plant growth and/or optimized production.
Irrigation Efficiency	The measurement of the amount of water beneficially used divided by the amount of water applied. Irrigation efficiency is derived from measurements and estimates of irrigation system characteristics and management practices.
Landscape Irrigation	A process to perform site inspections, evaluate irrigation systems,

Audit	and develop efficient irrigation schedules.
Landscaped Area	The entire parcel less the building footprint, driveways, non-irrigated portions of parking lots, hardscapes (such as decks and patios), and other non-porous areas. Includes the public right-of-way. Water features are included in the calculation of the landscaped area.
Lateral Line	The water delivery pipeline that supplies water to the emitters or sprinklers from the valve. (this definition applies to landscape irrigation only)
Low Head Drainage	A condition in which water siphons out of the lowest head in a sprinkler zone after watering is completed. When the water flow to the zone has been shut off at the end of its cycle, the remaining water in the lines will drain downhill to the lowest point. If a sprinkler head is located in the lowest part of the system, water will flow out of that head until an equilibrium has been reached or all of the water has emptied out of that zone's pipes. This can usually be corrected by adjustments to the system or installation of devices, called drain check valves, that can prevent low head drainage
Low Water Use Plants	Plants which are able to survive without supplemental water once established as specified in ______ plant list.
Main Line	The pressurized pipeline that delivers water from the water source to the valve or outlet. (this definition applies to landscape irrigation only)
Mature Landscape	The point at which plants in the landscape have developed roots into the soil adjacent to the root and are somewhat self-sufficient.
Mister	A device that produces a cooling effect by emitting fine particles of water into the air in the form of a mist.
Moisture Sensing Device	A device that measures the amount of water in the soil
Model Home	A dwelling built first by a developer to allow potential purchasers to see what the finished product will look like once the other homes in the development are completed.

Mulch	Any material such as leaves, bark, straw, wood chips or other materials applied to the soil surface to reduce evaporation.
New Development	Any development approved by Maui County after the effective date of this ordinance, including those developments which have received some approvals prior to the effective date of this ordinance but which have not aleady submitted all construction plans or constructed landscape improvements.
Operating Pressure	The pressure at which a system of sprinklers operates, usually indicated at the base of a sprinkler.
Overhead Sprinkler Irrigation System	A system in which water is distributed by overhead high-pressure sprinklers or guns or by lower-pressure sprays. A system utilizing sprinklers, sprays, or guns mounted overhead on permanently installed risers is often referred to as a solid-set irrigation system.
Overspray	Water which is delivered beyond the landscaped area, wetting pavements, walks, structures, or other non-target landscaped areas.
Percolation	The movement of water through the soil
Practical Turf Areas	The use of turf only in those areas of active play or recreation such as sports fields, school yards, picnic grounds, other areas with intense foot traffic, etc. These shall be planted with drought tolerant and non-invasive varieties of turf. Native grasses are encouraged.
Rain Sensing or Shut-off Device	A system which automatically shuts off the irrigation system when it rains
Recreational Area	An area devoted to active sports, play or picnicking, or to facilities and equipment for recreational purposes, swimming pools, tennis courts, playgrounds, community clubhouses, and other similar uses.
Recycled Water, Reclaimed Water, or Treated Effluent Water	Treated or recycled water of a quality suitable for nonpotable uses such as landscape irrigation, not intended for drinking.

Rotary Nozzle — A rotating, multi-stream, multi-trajectory rotating (MSMTR) sprinkler which distributes water in a number of individual streams of varying trajectories. This helps to uniformly distribute water throughout the radius range. Rotary nozzles are generally the size of the nozzles in fixed spray heads and thread onto pop-up heads just as spray nozzles do. They can also be threaded onto shrub adapters for installation onto risers. Rotary nozzles have variously cut nozzle openings that rotate during use to distribute the water more evenly throughout the watering pattern than spray heads. Rotary nozzles are designed to be installed on the risers of some of the most commonly used spray heads. They can be easily installed by simply unscrewing the existing spray nozzle and screwing on the rotary nozzle. Nozzle adjustment for radius or arc is a simple screw adjustment. The irrigation schedule can then be adjusted to reflect the lower precipitation rate and higher distribution uniformity. Rotary nozzles offer a low cost opportunity to improve the efficiency of many existing systems, particularly on smaller turf areas (approximately half an acre), which are among the highest water using (and wasting) sites. Water turns a small turbine (water wheel or fan) in the base of the unit which drives a series of gears that cause the head to rotate. The gear drive mechanism is sealed from dirt and debris. The nozzle can be installed on a spray head which normally uses conventional fixed pattern and variable arc spray nozzles. The rotary nozzle distributes the water in a pattern similar to a rotor head in the way that it rotates, compared to a normal spray nozzle which does not rotate. Due to their low precipitation rate, highly uniform distribution, and increased radius range, rotary nozzles can use less water than spray nozzles if the irrigation system is designed and installed properly. Rotary nozzles may be inserted into the body of the head after it has been installed. However, uniform and complete coverage depends selection of the appropriate nozzle for the area to be covered. Two different nozzles will cause the same rotary head to vary the distance of throw by 10 feet or more and increase water use by factors of two or three.

Run-off — Water which is not absorbed by the soils or landscape to which it is applied. For example, run-off may result from water that it applied at too great a rate (application rate exceeds infiltration rate) or when there is a severe slope. This section does not apply to stormwater run-off which is created by natural precipitation rather than human-caused or applied water use.

Shut-off Nozzle — Device attached to the end of a hose that completely shuts off the flow, even if left unattended.

Single Family — A lot or premise upon which is established one dwelling only. Of

Residential	the allowable principal uses, such use shall be the only use on that lot or premise.
Smart Controller	Controller that automatically adjusts the watering time and frequency based on soil moisture, rain, wind, evaporation and transpiration rates or plant type.
Soil Moisture Sensing Device	A device, usually either a tensiometer or conductivity based device, used for sensing moisture in soils, and for controlling irrigation systems based on soil moisture. By sensing actual moisture levels in soils, such devices can save water in systems which have been over-irrigating. Preventing over irrigation can increase turf health. The use of automated soil moisture sensors also save labor by eliminating the need for re-programming and temporary rain shut-offs thereby reducing both water and labor costs for owners.
Soil Texture	The classification of soil based on the percentage of sand, silt and clay in the soil
Spray Irrigation	The application of water to landscaping by means of a device that projects water through the air in the form of small particles or droplets.
Sprinkler Head	A device which discharges water through a nozzle.
Static Water Pressure	The pipeline or municipal water supply pressure when water is not flowing.
Station, Circuit or Zone	An area served by one valve or by a set of valves that operate simultaneously.
Temporary Irrigation System	Irrigation systems which are installed and permanently disabled within a period of 36 contiguous months.
Turf	A surface layer of earth containing mowed grass with its roots. Annual bluegrass, Kentucky bluegrass, Perennial ryegrass, Red fescue, and Tall fescue are cool-season grasses. Bermuda grass, Kikuyu grass, Seashore paspallum, St. Augustine grass, Zoysia grass, and Buffalo grass are warm-season grasses.
Uniformity	Describes how evenly water is applied over a given area.

Useable Precipitation or Effective Rainfall	The amount of precipitation that contributes to the water needs of plants. Irrigation scheduling should be adjusted to reflect useable precipitation.
Valve	A device used to control the flow of water in the irrigation system.
Water Conservation Concept Statement	A one page checklist and narrative summary of the project as shown in section ______.
Warm Season Turf	Turf grasses which need warm weather to germinate and grow. Warm season grasses can generally tolerate drought conditions due to root systems which tend to be deeper and more extensive than the root systems of cool season grasses. Zoysia grass, Bermuda grass, St. Augustine grass and other grasses are examples of warm season grasses. See also Turf, above.
Water Waste	The non-beneficial use of water. Non beneficial uses include but are not limited to: 1) landscape water which is applied in such a manner rate and or quantity that it overflows the landscaped area being watered and runs onto adjacent property or public right-of-way; 2) landscape water which leaves a sprinkler, sprinkler system or other application device in such a manner or direction as to spray onto adjacent property or public right-of-way; 3) washing of vehicles, equipment or hard surfaces such as parking lots, aprons, pads, driveways or other surfaced areas when water is applied in sufficient quantity to flow from that surface onto adjacent property or the public right of way; 4) water applied in sufficient quantity to cause ponding on impervious surfaces.

3. Applicability

a.. This section shall apply to:

1. Water conservation landscape requirements shall apply to all new developments, excluding individual single family homes with irrigated area of less than 3,000 square feet.
2. New development or refurbishment projects involving more than two homes.
3. Common areas in new and retrofitted developments
4. Commercial, residential and industrial developments.
5. New development applications shall include landscape documentation packages which require final approval at the time of final project approval. Public parks, with the exception of turf requirements
6. Golf Courses, with the exception of turf requirements.
7. Cemeteries, with the exception of turf requirements.
8. School Grounds, with the exception of turf requirements.

b. This section shall not apply to

1. Non-irrigated landscapes, with the exception that provisions for prevention of run-off, overspray or other water waste shall still apply.
2. Landscapes that are irrigated entirely with reclaimed water.
3. Individual Home-owner provided landscaping of less than 3,000 square feet.
4. Home-owner provided landscaping of individual homes in areas where rainfall exceeds 50"/year.
5. Ecological restoration projects which do not require a permanent irrigation system
6. Damaged-land reclamation projects that do not require a permanent irrigation system.
7. Commercial or subsistence agricultural operations are exempt from provisions of this ordinance except that provisions for prevention of water waste and prohibition of nuisance plants still apply.

14.03.031 Site Design & Plant Selection

A. Hydrozones

1. Plants having similar water use shall be grouped together in different hydrozones.
2. Fire prevention shall be addressed in areas that are fire prone. Information about fire prone areas and appropriate landscaping for fire safety is available from <the Fire Department?

B. Turf Restrictions

1. The maximum allowed turf and or decorative water area (expressed as percent of planted area) shall be 20% for new industrial, commercial, institutional, and public or quasi-public developments, residential developments with common areas, residential lots greater than ¼ acre or located in areas that receive less than 50" of rain per year
2. If turf is an essential part of the development, such as playing fields for schools or public parks, a higher percentage will be allowed, and will be evaluated on an individual basis.
3. No turf shall be allowed in median strips or in areas less than 8' wide.
4. Turf grass perimeters shall be minimized to improve irrigation efficiency. Long narrow strips of turfgrass such as traffic medians and areas between curbs and sidewalks are not permitted, unless the turf selected requires no more water than a low-water use groundcover.
5. No turf shall be allowed in median strips less than 8 feet wide.
6. To minimize runoff, turf shall not be utilized on slopes exceeding 10%.
7. Public parks, golf courses, cemeteries, school grounds and playing fields are exempted from turf limitations.
8. Parks, golf courses, cemeteries, school grounds, and sports fields, though exempt from turf limitations, shall in no circumstance have water requirements that exceed those which would result if the area were planted in 100% warm season turf.

C. Plant Materials

1. Plants shall be selected appropriately based upon their adaptability to the climatic,

geologic and topographical conditions of the site.

2. The planting of trees is encouraged wherever it is consistent with other provisions of this ordinance.
3. Protection and preservation of native species and natural vegetation are encouraged. Wherever practical, native species adapted to the natural rainfall of the area should be selected. Guidance may be found in the Maui County Planting Plan, list additional sites ??, the Department of Water Supply's (landscape brochure, website - or list sites hear, UH, Maui Nui Botanical Garden etc. ?)
4. 85% of the plants in non-turf areas shall be well suited to the natural climatic conditions of the subject area, and require little additional water.
5. No more than ten percent of the plants selected for non-turf areas may be considered high-water use plants.
6. Nothing in this or any other section of this ordinance shall compel removal of heritage plants.
7. Parks, Golf Courses, Cemeteries, and School Grounds, though exempt from turf restrictions applying to other landscapes, shall use drought tolerant turf species and shall use low-water use plants as much as possible.
8. The use of plants listed as nuisance species in either the Maui County Planting Plan, DWS Plant Brochure, Hawaiian Ecosystems At Risk, list of priority species for removal by the Maui Invasive Species Committee, or other list of nuisance species is prohibited. Landscapes shall conform with the provisions of under HRS chapter 152 and HAR Title 4 Subtitle 6 Chapter 68 referring to noxious weeds.
9. Groundcovers other than lawns shall be used on slopes exceeding 10% to reduce runoff

D. Ornamental Water Features (Fountains, Ponds, Pools, Others)

1. Water bodies that are part of the landscaping for new and rehabilitated developments shall be restricted and subject to permit, except where such water bodies are integral to the operations of the development.
2. Decorative water bodies in which potable water is sprayed into the air shall be discouraged.
3. Recirculating water shall be used for decorative water features.
4. Outdoor fountains shall be equipped with wind shutoff valves.
5. Outdoor fountains shall be equipped with rain shutoff controls.
6. Outdoor fountains shall be equipped with automated timers.
7. All ornamental uses of water in the common areas of projects - such as ponds, lakes and fountains - shall be supplied, operated and maintained with alternative sources of water, such as reclaimed water, brackish water, or cooling tower water if they are available.
8. Natural water features are not restricted, but should be clearly identified in the landscape design.
9. Covers for pools and spas are encouraged.

E. Soils & Grading

1. Soil types and infiltration rates shall be considered when designing irrigation systems.
2. Design should include soil analysis to determine
   a. Soil texture, indicating the percentage of organic matter
   b. Approximate soil infiltration rate (measured or derived from soil infiltration rate tables)
   c. pH
   d. Measure of total soluble salts
   e. Grading shall be minimized to avoid soil compaction
   f. Where topsoil layers are thin, mulch shall be added to the soil surface after planting.
   g. Non-porous material shall not be placed under mulch amendments.

14.03.033 Water Source Selection

A. Recycled Water

1. The installation of recycled water irrigation systems shall be required for new developments wherever a reclaimed water distribution system has been installed and can be used in compliance with regulatory requirements, in accordance with 20.30.010 or 14. (reclaimed water provisions) unless a written exemption has been granted and signed by the Departments of Public Works and Water Supply. (revise to match current reclaimed water code)
2. Recycled water irrigation systems shall be designed and operated in accordance with all State and County codes.

B Irrigation systems in commercial, industrial, hotel and motel developments shall make use of recycled or brackish water unless a written exemption has been granted by the County Department of Public Works & Waste Management, stating that non-potable water meeting all health standards is not available and will not be available in the foreseeable future.

C. Notwithstanding other provisions of this section, non-potable water shall be used for irrigation of Golf Courses, according to the provisions of Maui County Code §20.24 or §14.08(reserved).

14.03.034 Equipment

A. . Automatic irrigation systems shall be used for landscapes in which the irrigated area exceeds 2 acres.

B. All irrigation systems shall be equipped with a controller capable of dual or multiple programming for separation of turf and non-turf areas, multiple cycle capabilities and flexible calendar programming.

C. All irrigation controllers shall be equipped with a water percent adjustment feature.

D. Irrigation controllers shall be equipped with a rain shutoff device.

E. All automatically controlled irrigation systems shall utilize SMART controllers capable of responding appropriately for each lawn circuit.

F. Drip systems shall be constructed of non-corrosive materials.

G. Drip irrigation systems shall be utilized wherever trees, shrubs or groundcovers are irrigated

H. Drip and bubbler irrigation systems shall not discharge water in excess of 1.5 gallons per minute per device.

I Irrigation systems shall be designed and equipment selected and maintained to provide a distribution uniformity not less than 85% for drip irrigation, 70% for rotors, and 60% for spray heads.

J Sprinkler heads shall be selected for proper area coverage, application rate, operating pressure, adjustment capability, and ease of maintenance.

K Sprinkler heads which are used on slopes exceeding 10% and which are located within 10 feet of any hardscape shall have a precipitation rate that does not exceed 0.85 inches per hour

L Pop-up sprinklers in turf areas shall be at least 4" high.

M Sprinkler head orientation and throw shall be designed to minimize run-off and overspray into non-irrigated areas.

N Large sprinkler zones shall be equipped with high uniformity rotary nozzles.

O Serviceable check valves are required where elevation differential may cause low head drainage.

P Any irrigation equipment located within 12" of pedestrian and vehicular use shall be located entirely below grade or otherwise adequately protected from potential damage.

Q Where pressure exceeds manufacturers recommendations, pressure regulating nozzles are required on spray heads.

14.03.035 Irrigation Scheduling

A. Irrigation scheduling shall incorporate the use of evapotranspiration data or soil moisture data to apply the appropriate levels of water for different climates and regions.

B. Landscape irrigation shall be scheduled between 7:00 P.M. and 10:00 A.M. to reduce evaporation losses.

C. Irrigation schedules shall be set according to plants actual water needs.

14.03.036 Prevention of Runoff, Overspray or Other Water Waste

A. Irrigation systems shall be designed, installed, operated and maintained so as to prevent run-off, overspray, or low-head-drainage, including but not limited to1 landscape water which is applied in such a manner rate and or quantity that it overflows or sprays the landscaped area being watered and runs onto adjacent property or public right-of-way; 2 washing of vehicles, equipment or hard surfaces such as parking lots, aprons, pads, driveways or other surfaced areas when water is applied in sufficient quantity to flow from that surface onto adjacent property or the public right of way; 3 water applied in sufficient quantity to cause ponding on impervious surfaces.

B. Proper irrigation equipment and schedules, including features such as repeat cycles, shall be used to closely match application rates to infiltration rates thereby minimizing runoff.

C. Sprays shall not be used in areas less than eight feet wide.

D. Water application per cycle shall match soil absorption rates. Avoid runoff by discontinuing the application of water as soon as it occurs. Watering in stages can allow water to soak in between applications, thus improving the efficiency of water use.

E. Conventional sprinklers shall not be used where the perimeter to area ratio (P/A) exceeds 0.25.

F. Drip, low volume spray, or high uniformity rotary nozzles should be used to minimize run-off.

G. Sprinkler heads with a precipitation rate of 0.85" per hour or less shall be used on slopes exceeding 15% to minimize run-off, or exceeding 10% within 8 feet of hardscape.

H. Turf grass perimeters shall be minimized to improve irrigation efficiency. Long narrow strips of turf grass such as traffic medians and areas between curbs and sidewalks are not permitted.

I. This ordinance is intended to prevent water waste, and is not intended to supersede existing County provisions regarding prohibition of Water Waste.

J. No property holder's association may establish criteria for landscaping that prohibit owners from removing turf grass and installing water-efficient landscape plants in compliance with these provisions.

K. Even where hand watering is employed, over-watering as evidenced by soggy soils, continually wet pavement, standing water, run-off into streets or other hardscape shall be prevented and shall be considered a violation of this ordinance.

14.03.037 Maintenance

A. . Landscapes shall be maintained to insure water efficiency. A regular maintenance schedule shall include but not be limited to checking, adjusting and repairing irrigation equipment; resetting or adjusting automatic controllers, aerating and dethatching turf areas, replenishing mulch, soil amending, fertilizing, pruning and weeding in all landscape areas.

B. Whenever possible, repair of irrigation equipment shall be done with the originally specified materials, their equivalents, or compatible materials of greater efficiency.

C. Repairs of leaks, breaks or malfunctioning equipment shall be made promptly. It shall be unlawful to allow leakage or other inefficient condition caused by equipment malfunction to continue beyond a reasonable time. For purposes of this section, a reasonable time shall not exceed 48 hours.

D. Leaking or faulty system elements shall be shut off until repairs can be made.

14.03.038 Monitoring, Meters, Audits, Certification

A Meters

1. Separate landscape water meters shall be installed for all projects except for single family homes or projects with a landscaped area of less than 10,000 square feet.

B Landscape Irrigation Audits & Certification

1. All new non-residential developments, or residential developments with common with landscaped and irrigated areas greater than 10,000 square feet are required to

have a landscape audit prior to (release of bond and) close of sale in which a certified irrigation designer or certified auditor shall conduct a final field observation and certify that the landscape has been designed in accordance with the provisions of this section. The certified irrigation designer or auditor shall specifically indicate that plants were installed as specified, that the irrigation system was installed as designed, that an irrigation audit has been performed, and provide a list of any observed deficiencies.

2. All existing landscaped and irrigated areas which exceed 10,000 square feet , and to which the County provides water including green belts, common areas, multi-family housing, schools, businesses, parks, cemeteries, hotels, motels, golf courses and publicly owned landscapes shall have a landscape irrigation audit at least once every five years. These audits shall reference and be in accordance with the standards set by the Irrigation Association.

14.03.039 Education, Incentives and Enforcement

A. Public Education

1. Information on conservation which is provided by County agencies during the permit process shall be provided by consultants and representatives to each affected applicant.
2. New development shall provide information to all buyers or long-term leaseholders regarding the design, installation and maintenance of water efficient landscapes.
3. If a residential development utilizes model homes during marketing, model homes must abide by the provisions of this section, including the use of non-invasive drought tolerant plants and a maximum of 20% turf or water area..
4. Signs shall be used to identify the water efficient landscape and featuring elements such as hydrozones, irrigation equipment and others which contribute to the overall water efficient theme.
5. Developers shall provide buyers with sample landscape plans using non-invasive plants adapted to the natural rainfall of the area.
6. The developer shall also provide information about water conservation by distributing pamphlets to buyers regarding this subject. Such pamphlets are now available from the Maui County Department of Water Supply and other agencies.

B Incentives

1. The Department of Water Supply may adjust its rate and fee structure as necessary to provide for landscape conservation incentives where these are anticipated to result in economically viable conservation savings.
2. The Department of Water Supply may withdraw incentive programs when these are deemed no longer effective or cost-beneficial.

C Enforcement

1. Inspection
    a. The County shall have the right to inspect new developments for compliance prior to granting final approvals.
    b. Inspection for new development or other inspection shall be carried out with due regard for the convenience and schedule of the owners, the privacy of the occupants, and shall be during business hours unless requested otherwise by the landscape owner and approved by the Department Director.
    c. Where consent to an inspection has been refused, or has been unobtainable within a reasonable period of time, OR where a report of violation has been made to the County, the County shall have the right to make un-announced inspection. Such inspection shall be during normal business hours and shall be conducted with due regard for the privacy of occupants.

2. Penalties
    a. Any responsible party found to violate the provisions of this ordinance shall be subject to progressively higher fees, leading to to County-installed flow restriction and ultimately to meter removal.
    b. In lieu of paying fees for first and second violations only, the responsible party may elect to have a landscape water audit performed by an authorized landscape irrigation auditor, (to be conducted in accordance with the current edition of the landscape auditors handbook). The audit must be performed within 30 days of the violation notice, and the recommendations of the audit must be implemented within 60 days of the violation notice. If these deadlines are met, the fees for violation will be waived. As of the third violation on a premise, the responsible party will be required to have an audit, implement the audit AND pay the fees.
    c. For the purposes of assessing fees or flow restriction for violations, any previous violation shall not be considered if a period of five years has elapsed since the last violation was incurred, or the property is acquired by a new owner.

14.03.040 Leak Detection and Prevention

A.. The Department shall monitor consumers' water consumption and issue high consumption notices to customers when warranted.

B. The Department shall maintain a leak detection program.

C. The Department shall prioritize the replacement of old and leak-prone mains

D. The Department shall assist residents and businesses in detection and prevention of leaks through education, distribution of tablets to detect toilet leaks, or other measures as approrpriate.The department shall encourage members of the public to report water leaks.

14.03.050 Water Waste Prohibitions

A. No person, firm, corporation or government agency shall waste, cause or permit to be wasted any water.

B. No person, firm, corporation or government agency shall cause or permit the flow of fugitive water onto adjacent property or public right of way, except as resulting from firefighting, system flushing or other public need or public facilities maintenance need.

C. No person, firm, corporation or government agency shall utilize potable water for construction dust control.

D. No person, firm, corporation or government agency shall utilize misters except as specifically permitted.

E. Washing of sidewalks, walkways, driveways, parking lots and other hard-surfaced areas by direct hosing of potable water is hereby prohibited, except as may be necessary and appropriate under other regulations specifically to dispose of flammable or otherwise dangerous liquids or substances, or otherwise necessary to prevent or eliminate dangers to public health and safety.

F. The escape of water through breaks or leaks within the customer's plumbing or distribution system for any substantial period of time within which the break or leak should reasonably have been discovered and corrected. It shall be presumed that a period of 48 hours after the customer discovers the break or leak is a reasonable time within which to correct the break or leak.

G. Use of any irrigation in a manner that does not comply with 14.03.030-039 of this chapter is hereby prohibited.

H. Other provisions of this section notwithstanding, the use of water for required flushing to maintain water quality, and for fire training operations as needed is allowed.

14.03.060 Fixture & Facility Performance Standards

14.03.061 General

A. Purpose

The purpose of this section is to reduce unnecessary water consumption, sewer flows and energy use by establishing water conserving standards for plumbing fixtures. Several types of fixtures and appliances for bathroom, kitchen, laundry, cooling and other uses can reduce water consumption and hot water heating needs. The purpose of this section is to provide minimum standards for such appliances, to insure efficient use of water in accordance with the national energy policy act and chapter 16.2 of the Maui County Code.

B. Applicability

1. This section shall apply to
    a. All new structures

b. Retrofit or renovation of existing structures

c. Structures which are undergoing transfer of ownership

2. This section shall not apply to showers faucets or other fixtures which require a higher flow for safety reasons, such as safety showers for hazardous materials removal or etc.

C. Periodic Update

The Department of Water Supply, Department of Environmental Management or Planning Department DSA, after consulting with and considering the recommendations of interested agencies, may from time to time propose to the Administration, Board and Council updates to standards and guidelines prescribed in this chapter. Such regulations as are approved by resolution of the Council shall have the force and effect of law unless otherwise indicated.

D. Conformance with Maui County Code Chapter 16.2 and Uniform Plumbing Code Chapter 10

Low flow fixtures in accordance with Maui County Code 16.20 and chapter 10 of the Uniform Plumbing Code, are hereby required.

14.04.062 Performance Standards

The following performance standards shall apply to all new construction and to replacement of fixtures.

A. The flow rate of toilets shall not be greater than 1.6 gallons per flush.

(US Energy Policy Act) Toilets with a flow rate equal to or less than 1.28 gallons per flush are encouraged, and rebate programs will not be issued for toilet replacement over the 1.28 gpf average recommended by LEED. (US Green Building Council Leadership in Energy and Environmental Design, as well as by EPA Water Sense)

B. The flow rate of showerheads shall not exceed 2.5 gpm at 80 psi or 2.2 gpm at 60 psi (or 1.5)

C. The flow rate of Kitchen Faucets shall not exceed 2.5 gpm at 80 psi, nor 2.2 gpm at 60 psi

D. The flow rate of Bathroom Faucets shall not exceed 2.5 gpm at 80 psi, nor 2.2 gpm at 60 psi (1.5, 1.2, 1 also available and rquired in some places)

E. The flow rate of Urinals shall not exceed 1 gpm (waterless urinals are also available and encouraged ?)

F. Residential Dishwashers shall require no more than 7 gallons per load (? 6.5 by 2011, 6.25 by 2016, 6 by 2025 ?) (Oregon rebates 6.5 or less now) (National Appliance Energy Conservation - Vickers 2001 - check ref- 4.5)

G. Commercial Dish Washers

1. Pre-Rinse Spray Valves on new Commercial dishwashers shall have a flow rate of equal to or less than 1.6 gpm at 60 psi. (Calif code Ttle 20 division 2 chapter 4 article 4 §1605.3) (1.6 - 2.65 at 80 available per a different article)

2. Ware Washing units shall have flow rates of less than 1 gallon per rack

H. Residential Clothes Washers shall have a water factor of 5 or less, and use no more than 27 gallons per load.

(Old washers use4d 32-59 gallons per load, current efficient washers can use 18-25 gallons per load) (Calif code 8.5 effective jan 1, 07)

I. Commercial Clothes Washers shall have a maximum water factor of 9.5 (Effective in California code Jan 1, 2007) (now can be less - 6 or lower)

J. Tunnel washers should have a maximum water factor of 2.

K. Cooling

1. In accordance with §14.25A.040 of the Maui County Code, discharge of cooling system water to the public wastewater system is prohibited, except in cases where reclaimed water is used, or when cooling water is utilized in another on-site process.
2. New water cooling systems must recirculate water. Installing a new non-recirculating (also known as single-pass or once-through) cooling system is prohibited.
3. Commercial Ice makers shall either utilize air or if water is utilized, shall be equipped with re-circulating closed loop chilled water.
4. Evaporative coolers and other cooling systems shall be maintained properly so as to prevent un-necessary overflow into drain lines.

L. Process Water

1. All uses of water for cooling, irrigation, or commercial or industrial processes that exceed 20,000 gallons per day shall be separately metered.
2. New commercial car wash facilities shall recirculate and reuse a minimum of seventy five percent of wash and rinse water.

14.03.063 Submetering Multi-family and Multi-use buildings

All new multifamily and multi-use commercial structures shall be constructed so as to provide for the measurement of water use in each unit through submeters (owned by the property owner) or individual meters (owned by the Utility).

14.03.070 Retrofit on Resale Provisions

A. Definitions

The following definitions are applicable to this section only

Bathroom Alteration	means any alteration of or addition to a bathroom in any structure which would require a plumbing permit for replacement of a toilet.
Bathroom Alteration Retrofit Certificate	means a certificate that certifies that any responsible person who has completed a bathroom alteration has replaced any existing plumbing fixture in the altered bathroom with a water-conserving plumbing fixture.

Change of Ownership	means a transfer, sale, or exchange of the fee interest in any real property.
Existing Plumbing Fixture	means the following: (1) any toilet manufactured to use more than 1.6 gallons of water per flush; (2) any urinal manufactured to use more than one gallon of water per flush; (3) any showerhead manufactured to have a flow capacity of more than 2.5 gallons of water per minute; (4) any faucet that emits more than 2.2 gallons of water per minute; or (5) any residential reverse osmosis system that does not have a shutoff valve.
Existing Structure	means either of the following: (1) any structure served by the County of Maui and equipped with toilets manufactured to use more than 1.6 gallons of water per flush, or urinals manufactured to use more than 1 gallon of water per flush; or (2) any structure served by the County of Maui and equipped with showerheads that have a flow capacity of more than 2.5 gallons of water per minute, faucets that emit more than 2.2 gallons of water per minute, or residential reverse osmosis systems that do not have a shutoff valves.
Retrofit	means to replace any existing plumbing fixture in an exiting structure with a water-conserving plumbing fixture.
Transfer of Responsibility to Retrofit	means a certificate filed by a transferor of any existing structure before a change of Certificateownership that certifies that the transferor and the transferee mutually agree that responsibility for compliance with this Section is assumed by the transferee of the existing structure.
Low Flush Toilet Rebate Program	means a County-sponsored water conservation program that offers a financial incentive to water customers who replace a toilet that is manufactured to use more than or equal to 1.6 gallons of water per flush with a toilet manufactured to use less than 1.6 gallons of water per flush.
Water Conservation Certificate	means a certificate filed by a transferor or transferee of any structure or existing structurebefore a change of ownership that certifies any structure or existing structure is equipped or retrofitted only with water-conserving plumbing fixtures or toilets manufactured to use no more than 1.6 gallons of water per flush.
Water Conserving Plumbing Fixture	means: (1) any toilet manufactured to use no more than 1.6 gallons of water per flush, tha meets performance standards established by American Societyof Mechanical Engineers Standards A112.19.2-1990 and A112.19.6-1990;

(2) any urinal manufactured to use no more than 1 gallon of water per flush, that meets performance standards established by American Society of Mechanical Engineers Standards A112.19.2-1990 and A112.19.6-1990;

(3) any showerhead manufactured to have a flow capacity of no more than 2.5 gallons of water per minute;

(4) any faucet that emits no more than 2.2 gallons of water per minute; or

(5) any residential reverse osmosis system that has a shutoff valve.

B. Requirements for Retrofit upon Change of Ownership

1. Before a change of ownership, the transferor of any existing structure shall replace any existing plumbing fixture with a water-conserving plumbing fixture.
2. Before a change of ownership, the transferor and the transferee of any existing structure may agree to transfer responsibility for compliance with this section to the transferee. If the transferee assumes responsibility for retrofitting, the transferee shall complete the retrofit within at least 90 calendar days of the change of ownership.
3 The transferor and the transferee of any existing structure may agree to have compliance with this section included as a condition of escrow, have the responsibility for retrofitting assumed by the transferee, and have the retrofit paid for from the proceeds of the sale of the existing structure.
4. If the transferor and the transferee agree to have compliance with this section included as a condition of escrow, the escrow agent shall retain a sufficient sum of money, agreed upon by the transferor and the transferee, to be retained from the proceeds of the sale to complete the retrofit.
5. The transferee shall complete the retrofit within at least 90 calendar days of the close of escrow.
6. After the transferee has completed the retrofit, the transferee shall submit proof of completion of the retrofit to the escrow agent. The escrow agent may release the retained funds from the proceeds of the sale upon receiving reasonable, satisfactory proof of completion of the retrofit from the transferee.
7. The Department of Water Supply / DSA ? shall establish administrative regulations for the procedures to be followed by the transferor, the transferee, and the escrow agent for complying with this section.

.C. The transferor of any existing structure shall not be required to retrofit when a change of ownership occurs as a result of the following.

a. A court order, including an order by a probate court in the administration of an estate;
b. A foreclosure or voluntary or involuntary bankruptcy;
c. The exercise of eminent domain;
d. The administration of a deceased person's estate, guardianship, conservatorship, or trust;

e. One title co-holder of real property transferring, selling, or exchanging with one or more other title co- holders;

f. A transfer, without consideration, from one family member to another family member; or

g. A decree of dissolution of marriage, a decree of legal separation, or from a property settlement agreement incidental to such a decree.

D. Retrofit upon Bathroom Alteration

Upon bathroom alteration, the responsible person shall replace any existing plumbing fixture in the bathroom being altered with a water-conserving plumbing fixture.

E. Retrofit Exemptions

An exemption to the provisions of this section may be granted if under the following conditions :

1. A water-conserving plumbing fixture would be installed in an existing structure that has been identified by a local, state, or federal government entity as an historical site, and an historically accurate water-conserving plumbing fixture is not available;
2. Installation of a water-conserving plumbing fixture would require modifications to plumbing system components located beneath a finished wall or surface; or
3. The unique configuration of a building drainage system or portions of a public sewer, or both, require a greater quantity of water to flush the system in a manner consistent with public health.

F. Self-verification

1. Before a change of ownership, the transferor and the transferee of any structure or any existing structure shall complete the following procedures:
2. The transferor shall sign a Water Conservation Certificate certifying that the transferor has complied with the requirements of this section or is exempt from retrofitting as defined in _ above
3. After signing the Water Conservation Certificate, the transferor shall forward the Water Conservation Certificate to the transferee for review and signature.
4. .The transferee shall sign the Water Conservation Certificate, thereby acknowledging awareness and understanding of the requirements of this section.
5. . After the transferee has signed the Water Conservation Certificate, the transferor shall file the Water Conservation Certificate with the Department of Water Supply.
6. . If the structure or existing structure goes through escrow, the transferor also shall file a copy of the Water Conservation Certificate with the escrow agent before the close of escrow.

G. In the event the transferor and transferee of an existing structure agree that the transferee shall have responsibility for the retrofit upon change of ownership pursuant to this section, before the change of ownership, the transferor and the transferee shall complete the following procedures:

1. The transferor and the transferee shall sign a Transfer of Responsibility to Retrofit

Certificate certifying that the transferee has assumed responsibility for the retrofit.

2. After the transferor and the transferee have signed the Transfer of Responsibility to Retrofit Certificate, the transferor shall file the Transfer of Responsibility to Retrofit Certificate with the Department of Water Supply.
3. If the existing structure goes through escrow, the transferor also shall file a copy of the Transfer of Responsibility to Retrofit Certificate with the escrow agent before the close of escrow.
4. Upon completing the retrofit, the transferee shall sign a Water Conservation Certificate certifying that the transferee has complied with the requirements of this section.
5. Within at least 30 calendar days of the completion of the retrofit, the transferee shall file the signed Water Conservation Certificate with the Department of Water Supply.

F. If the transferor and the transferee have agreed to have compliance with this section included as a condition of escrow, have the responsibility for retrofitting assumed by the transferee, and have the retrofit paid for from the proceeds of the sale of the existing structure, then the transferor and the transferee shall complete the following procedures:

1. The transferor and the transferee shall sign a Transfer of Responsibility to Retrofit Certificate certifying that the transferee has assumed responsibility for the retrofit.
2. After the transferor and the transferee have signed the Transfer of Responsibility to Retrofit Certificate, and before the close of escrow, the transferor shall file the Transfer of Responsibility to Retrofit Certificate with the Building Official and a copy thereof with the escrow agent.
3. Upon completing the retrofit, the transferee shall sign a Water Conservation Certificate certifying that the transferee has complied with the requirements of this division.
4. Within at least 30 calendar days of the completion of the retrofit, the transferee, or the escrow agent on the transferee's behalf, shall file the signed Water Conservation Certificate with the Building Official.
5. The transferor of any structure that is in compliance with the requirements of this divisionshall not be required to file a Water Conservation Certificate with the Building Official before a change of ownership if a Water Conservation Certificate has been filed with the Water Department / DSA ? by a previous owner of the structure.

G.. Upon completing the retrofit of a bathroom, the responsible person shall complete the following procedures:

1. The responsible person shall sign a Bathroom Alteration Retrofit Certificate certifying that the responsible person has complied with the requirements of this section.

2. Within at least 30 calendar days following completion of any bathroom alteration, the responsible person shall file the signed Bathroom Alteration Retrofit Certificate with the Building Official.

H.. Agent

Nothing in this division is intended to create any duty upon the agent of a transferor or a transferee of any structure or any existing structure, unless otherwise mutually agreed to in writing.

14.03.080 Water Re-use

A. Commercial properties within 100' of R-1 distribution systems are required to provide for use of reclaimed water in irrigation as prescribed in chapter §20.30 of the Maui County Code.

14.03.090 Reserved

APPENDIX F

Draft Wellhead Protection Ordinance

Draft Wellhead Protection Ordinance, County of Maui, Hawaii

1. PURPOSE AND INTENT

The jurisdiction of Maui County recognizes that many residents rely on groundwater for their safe drinking water supply, and that certain land uses can contaminate groundwater. To ensure the protection of these drinking water supplies, this ordinance establishes a zoning overlay district to be known as the Wellhead Protection Overlay District.

The purpose of the Wellhead Protection Overlay District is to protect public health and safety by minimizing contamination of aquifers and preserving and protecting existing and potential sources of drinking water supplies. It is the intent to accomplish this through both public education and public cooperation, as well as by creating appropriate land use regulations that may be imposed in addition to those currently imposed by existing zoning districts or other county regulations.

The Wellhead Protection Overlay District is superimposed on current zoning districts and shall apply to all new construction, reconstruction, or expansion of existing buildings and new or expanded uses. Applicable activities/ uses allowed in a portion of one of the underlying zoning districts which fall within the

Wellhead Protection Overlay District must additionally comply with the requirements of this district. Uses prohibited in the underlying zoning districts shall not be permitted in the Wellhead Protection Overlay District.

2. DEFINITIONS

For the purposes of this section, the following terms are defined below:

AQUIFER. A geological formation, group of formations or part of a formation composed of rock, sand or gravel capable of storing and yielding groundwater to wells and springs.

CONTAMINATION. An impairment of water quality by chemicals, radionuclides, biologic organisms, or other extraneous matter whether or not it affects the potential or intended beneficial use of water.

DEVELOPMENT. The carrying out of any construction, reconstruction, alteration of surface or structure or change of land use or intensity of use.

FACILITY. Something that is built, installed, or established for a particular purpose.

HAZARDOUS MATERIAL. A material which is defined in one or more of the following categories:

Ignitable: A gas, liquid or solid which may cause fires through friction, absorption of moisture, or which has low flash points. Examples: white phosphorous and gasoline.

Carcinogenic: A gas, liquid, or solid which is normally considered to be cancer causing or mutagenic. Examples: PCB's in some waste oils.

Explosive: A reactive gas, liquid or solid which will vigorously and energetically react uncontrollably if exposed to heat, shock, pressure or combinations thereof. Examples: dynamite, organic peroxides and ammonium nitrate.

Highly Toxic: A gas, liquid, or solid so dangerous to man as to afford an unusual hazard to life. Example: chlorine gas.

Moderately Toxic: A gas, liquid or solid which through repeated exposure or in a single large dose can be hazardous to man.

Corrosive: Any material, whether acid or alkaline, which will cause severe damage to human tissue, or in case of leakage might damage or destroy other containers of hazardous materials and cause the release of their contents. Examples: battery acid and phosphoric acid

PRIMARY CONTAINMENT FACILITY. A tank, pit, container, pipe or vessel of first containment of a liquid or chemical.

RELEASE. Any unplanned or improper discharge, leak, or spill of a potential contaminant including a hazardous material.

SECONDARY CONTAINMENT FACILITY. A second tank, catchment pit, pipe, or vessel that limits and contains liquid or chemical leaking or leaching from a primary containment area; monitoring and recovery are required,

TIME-OF-TRAVEL DISTANCE. The distance that groundwater will travel in a specified time. This distance is generally a function of the permeability and slope of the aquifer.

WELLHEAD PROTECTION AREA. The surface and subsurface area surrounding a water well or wellfield, that supplies a public water supply system, through which contaminants are reasonably likely to move toward and reach the water well or wellfield.

WELLHEAD PROTECTION OVERLAY DISTRICT: The zoning district defined to overlay other zoning districts in Maui County. This district may includes the designated wellhead protection areas as identified on Land Zoning Maps.

3. ZONES WITHIN THE WELLHEAD PROTECTION OVERLAY DISTRICT

3.1 ZONE A1 – 50 FEET DIRECT CHEMICAL CONTAMINATION ZONE.

Zone A1 is defined as the fixed 50 feet radius around each well. The purpose of this zone is to provide protection from vandalism, tampering, or other threats at the well site.

a. Permitted Uses.
The following uses are allowed within Zone A1 provided they meet the appropriate performance standards outlined in 3.1.b below and are designed so as to prevent any groundwater contamination.

Necessary public utilities/facilities including the construction, maintenance, repair, and enlargement of drinking water supply related facilities such as, but not limited to, wells, pipelines, aqueducts, and tunnels.

b. Performance Standards:
Vehicles shall not be parked in the immediate well area, even when working on well maintenance or repair, unless required for power supply

Motor oil, fuel, paints, and any maintenance chemicals shall not be stored in the pump house or Zone A1.

Any underground storage tanks, hazardous materials, and septic systems shall be removed or relocated from this zone, where possible

Hazardous materials shall be stored in a secure building on an impermeable surface with adequate spill containment

Propane gas shall be used for power pumps

Any non-water supply activities shall be kept out of the Zone A1 area

3.2 ZONE A2 – 1,000 FEET DIRECT CHEMICAL CONTAMINATION ZONE.

Zone A2 is defined as the intersection of the modeled Wellhead Protection Area and the fixed 1,000 feet radius around each well. The purpose of this zone is to provide minimum distance from sources of pollution consistent with Hawaii Well Construction and Pump Installation Standards.

a. Prohibited Uses:
The following uses are prohibited within Zone A2:

Cesspool, septic tank, or subsurface sewage leaching field

Hazardous waste landfills and ponds, or chemical storage

Treated effluent injection well

3.3 ZONE B – INDIRECT MICROBIAL CONTAMINATION ZONE: 2 YEAR TRAVEL TIME.

Zone B consists of the surface area overlying the portion of the aquifer(s) that contributes water to the well within a two-year time-of-travel.

a. Permitted Uses:
All other uses permitted in the underlying zoning districts, unless prohibited under 3.3 b. provided that they can meet the Performance Standards as outlined for the Wellhead Protection Overlay District under 3.3.e.

Minimum lot size for unsewered residential uses shall be two acres, except for; a) existing lots of record on the effective date of this Ordinance and b) developments which will be served by municipal sewer within five years of the approval of the development. In order to provide for efficiently serving these developments with municipal sewer, lots smaller than two acres can be approved, provided that sufficient land area will be maintained in an undeveloped state such that no more than one residence is allowed for each two acres of the overall development.

New development construction shall implement best management practices described in 3.3.e.

b. Prohibited Uses.
The following uses are prohibited within Zone B, the two-year time-of-travel zone.

Electrical/electronic manufacturing facility;

Funeral services/graveyards

Golf courses

Metal plating/finishing/fabricating facility;

Chemical processing/storage facility;

Plastics/synthetic production facility;

Junk/scrap/salvage yard;

Major transportation corridors/highways/freeways/turnpikes;

Mines/gravel pit

Landfills/dumps

Injection wells/dry wells/sumps;

Artificial recharge projects (non-potable water)

Reclaimed wastewater irrigation class R2 and R3

Sewage sludge land application

Underground storage tanks, (except those with spill, overfill, and corrosion protection requirements in place);

All uses not permitted in the underlying zone district

c. Prohibited Uses Subject To Exception:
The following uses, unless granted an exception under 3.3.d., are prohibited within Zone B, the two-year time-of-travel zone.

Automobile body/repair shop;

Car washes;

Cement/concrete plants;

Gas station;

Fleet/trucking/bus terminal;

Dry cleaner;

Irrigated crops using soil fumigants (> 50 acres) or pesticides with high leachability;

Land divisions resulting in high density (>1 unit/2 acre) septic systems;

Machine shop;

Wood preserving/treating facility;

Confined animal feeding operations

Equipment maintenance/fueling areas;

Hospitals;

Parking lots/malls (>50 spaces);

Reclaimed wastewater irrigation R1 or better;

Waste transfer/recycling stations;

Above ground storage tanks;

All other facilities involving collection, handling, manufacture, use, storage, transfer or disposal of any solid or liquid material or waste having potentially harmful impact on groundwater quality;

d. Exceptions:
Where the underlying zoning permits a use that would be prohibited by this ordinance, a wellhead area exception may be granted by the County Department of Water Supply, provided that the use conforms to provisions of the underlying zoning district as certified by the County Department of Planning, meets the performance standards outlined in 3.3.e below, follows design guidelines outlined in section 4, that any concerns of the State Department of Health have been addressed, and that adequate information to evaluate the project has been provided.

Exception may be approved by the County Department of Water Supply for expansion of existing non-conforming uses to the extent allowed by the underlying district. The applicant should consult the local zoning plan to confirm nonconforming uses. The County Department of Water Supply reserves the right to review all applications and shall not grant approval unless it finds such expansion does not pose greater potential contamination of groundwater than the existing use.

e. Performance Standards:
The following standards shall apply to uses in Zones B and C of the Wellhead Protection Overlay District:

Any facility involving the collection, handling, manufacture, use, storage, transfer or disposal of any solid or liquid material or wastes, unless granted a special exception either through permit or another ordinance, must have a secondary containment system which is easily inspected and whose purpose is to intercept any leak or release from the primary containment vessel or structure. Underground tanks must be in compliance with underground storage tank rules adopted January 28,2000 in HAR Title 11 Chapter 281.

Open liquid waste ponds containing materials referred to in item (1) above will not be permitted without a secondary containment system.

All permitted facilities must adhere to appropriate federal and state standards for storage, handling and disposal of any hazardous waste materials.

All abandoned wells should be properly plugged according to local and state regulations.

Confined animal facilities should meet “Management Measure for Wastewater and Runoff from Confined Animal Facilities” as set in Hawaii’s Coastal Nonpoint Pollution Control Program Management Plan, Volume 1, 1996.

Irrigated crops should implement Integrated Pest Management in accordance with US Department of Agriculture Natural Resources Conservation Service Technical Guide 1989.

Construction activities shall be in accordance to County Code Chapter 20.08 and these standards:

There shall be a designated person on site during operating hours who is responsible for supervising the use, storage, and handling of hazardous material and who shall take appropriate mitigating actions necessary in the event of fire or spill.

.Hazardous materials left on site when the site is unsupervised must be inaccessible to the public. Locked storage sheds, locked fencing, locked fuel tanks on construction vehicles, or other techniques may be used if they will preclude access.

Construction vehicles and stationary equipment that are found to be leaking fuel, hydraulic fluid, and/or other hazardous materials shall be removed from the site and from Wellhead Protection Zones A, B or C. The vehicle or equipment may be repaired in place, provided the leakage is completely contained.

Storage and dispensing of flammable and combustible liquids from tanks, containers, and tank vehicles into the fuel and fluid reservoirs of construction vehicles or stationary equipment on the construction site shall be in accordance with these standards and County Fire Code Chapter 16.04A

Hazardous materials and other deleterious substances shall not be allowed to enter stormwater systems.

3.4 ZONE C – INDIRECT CHEMICAL CONTAMINATION ZONE: 10 YEAR TRAVEL TIME.

Zone C consists of the surface area overlying the portion of the aquifer(s) that contributes water to the well within a ten-year time-of-travel.

a. Permitted Uses:
All other uses permitted in the underlying zoning districts, unless prohibited under 3.3 b. provided that they can meet the Performance Standards as outlined for the Wellhead Protection Overlay District under 3.3.e.

b. Prohibited Uses.
The following uses are prohibited within Zone C, the ten-year time-of-travel zone.

Electrical/electronic manufacturing facility;

Chemical processing/storage facility;

Plastics/synthetic production facility;

Junk/scrap/salvage yard;

Metal plating/finishing/fabricating facility;

Mines/gravel pit

Landfills/dumps

Injection wells/dry wells/sumps;

Underground storage tanks, (except those with spill, overfill, and corrosion protection requirements in place);

All uses not permitted in the underlying zone district

c. Prohibited Uses Subject To Exception:
The following uses, unless granted an exception under 3.4.d., are prohibited within Zone B, the ten-year time-of-travel zone.

Automobile body/repair shop;

Gas station;

Fleet/trucking/bus terminal;

Dry cleaner;

Golf courses;

Machine shop;

Wood preserving/treating facility;

Confined animal feeding operations

Land divisions resulting in high density (>1 unit/acre) septic systems;

Equipment maintenance/fueling areas;

All other facilities involving collection, handling, manufacture, use, storage, transfer or disposal of any solid or liquid material or waste having potentially harmful impact on groundwater quality;

d. Exceptions:
Where the underlying zoning permits a use that would be prohibited by this ordinance, a wellhead area exception may be granted by the County Department of Water Supply, provided that the use conforms to provisions of the underlying zoning district as certified by the County Department of Planning, meets the performance standards outlined in 3.3.e below, follows design guidelines outlined in section 4, that any concerns of the State Department of Health have been addressed, and that adequate information to evaluate the project has been provided.

Exception may be approved by the County Department of Water Supply for expansion of existing nonconforming uses to the extent allowed by the underlying district. The applicant should consult the local zoning plan to confirm nonconforming uses. The County Department of Water Supply reserves the right to review all applications and shall not grant approval unless it finds such expansion does not pose greater potential contamination of groundwater than the existing use.

4. DEVELOPMENT GUIDELINES

The following design guidelines are encouraged for all new commercial, residential or mixed use development projects, excluding residential subdivisions of 2 lots or less in the 2-year time of travel Zone B:

Commercial and high-density residential development should be minimized and located at as far distance from the wellhead as possible.

Appropriate uses are open space, passive parks, schools and low density residential (minimum 2-acre lots)

The following design guidelines are encouraged for all new commercial, residential or mixed use development projects, excluding residential subdivisions of 2 lots or less in the 10 year time of travel Zone C:

High risk commercial and high-density residential development should be minimized and located at as far distance from the wellhead as possible.

Appropriate uses are open space, passive parks, schools, low risk commercial and low density residential (minimum 1-acre lots)

The following design guidelines are encouraged for all new commercial, residential or mixed use development projects, excluding residential subdivisions of 2 lots or less in Zone B and C:

Storm-water infiltration basins should be located outside the WHPA where feasible.

Active parks and schools should implement Integrated Pest Management.

Where development is proposed on property extending both inside and outside the WHPA, and where sufficient buildable land area exists on the portion of the property outside the WHPA boundary to accommodate the proposed development, and where applicable setbacks permit, that area in its entirety should be utilized before any land within the WHPA should be used. Where insufficient buildable land area exists on the portion of the property outside the WHPA to accommodate the proposed development, as much of the development as possible should be sited outside the WHPA.

Proposed development entirely within the WHPA should be grouped and sited on the subject parcel at as far distance as possible from the wellhead.

Expansions of existing uses should at least conform to these guidelines where the use is expanding beyond its’ property boundaries.

Vegetative cover should be provided on all disturbed land areas, excluding fallow agricultural fields, not covered by paving, stone or other solid material. The maintenance or use of native plant materials with lower water and nutrient requirements is encouraged.

5. LIABILITY

Nothing in this ordinance shall be construed to imply that the County of Maui has accepted any of an owner/developer's liability if a permitted facility or use contaminates groundwater in any aquifer.

6. DISTRICT BOUNDARY DISPUTES

If the location of the Wellhead Protection Overlay District boundary in relation to a particular parcel is in doubt, the rules in Chapter 19.06 apply.

7. ENFORCEMENT

a. Any person may submit a verbal or written complaint alleging a violation of this ordinance.

b. Any approval or permit issued pursuant to the provisions of this ordinance shall comply with all applicable requirements of Chapter 19.530.

c. Where an exception to a prohibited use is granted condition to performance standards, the appropriate enforcement agency of the applicable performance standard shall be notified to follow up with inspection as needed.

8. SAVING CLAUSE

Should any section or provision of this ordinance be declared invalid, such decision shall not affect the validity of the ordinance as a whole or any other part thereof. A determination that any portion or provision of this overlay protection district is invalid shall not invalidate any special permit previously issued thereunder.

Approved by: ______________________________

Date: ______________________________

APPENDIX G

Resolution Establishing The Lana'i Water Advisory Committee

COUNTY OF MAUI BOARD OF WATER SUPPLY
RESOLUTION NO. 05 (1999)

ESTABLISHING THE LANAI WATER ADVISORY COMMITTEE

WHEREAS, the preparation of the Maui County Water Use and Development Plan (WUDP) is the responsibility of the Board of Water Supply (Board); and

WHEREAS, Board Rule §16-02-17 enables the Board to appoint standing committees and select committees to discharge its responsibilities and functions; and

WHEREAS, the Board wishes to formalize and establish consistent guidelines for implementation of community participation in Water Use and Development Planning; and

WHEREAS, water use issues on the island of Lanai have arisen because the island has limited water resources; and

WHEREAS, the Board is committed to public involvement in planning and decision-making efforts as it relates to the Lanai WUDP; and

WHEREAS, the establishment of the Lanai Water Advisory Committee (LWAC) will enable the Board to complete the WUDP for the island of Lanai;

NOW, THEREFORE, BE IT RESOLVED by the Board of Water Supply and the County of Maui:

1. The Lanai Water Advisory Committee (LWAC) is hereby established. The LWAC shall consist of the following members selected by their respective organization (where appropriate):

    (1) Two (2) voting members from Lanai Company;

    (2) Two (2) voting members from Lanai'ians for Sensible Growth;

    (3) One (1) voting member from the Lanai Planning Commission;

    (4) Councilmember from the island of Lanai, or his representative, with voting rights on the LWAC;

(5) Three (3) residents of Lanai who are not affiliated with any of the above referenced organizations and who are entitled to vote on LWAC matters. The residents shall be selected by six (6) affirmative votes cast by the LWAC voting members from Lanai Company, Lanai'ians for Sensible Growth, the member of the Lanai Planning Commission, and the Lanai Councilmember or his representative. In the event that six (6) votes can not be obtained as to any resident, the Director is hereby authorized to make the selection of the resident(s) from among those considered. The Director's decision shall be final.

(6) One (1) non-voting member from Lanaiians for Economic Growth and Stability.

2. The Department of Water Supply, through the Director, shall be the lead agency and shall provide appropriate staffing for the LWAC. The Department of Planning, Department of Public Works and Waste Management, Commission on Water Resources Management, Department of Land and Natural Resources, and other appropriate county or state agencies shall be consulted and may participate in the Lanai WUDP process. Staff personnel from these departments or agencies shall not have any vote in any LWAC proceedings.

3. The purpose and intent of the LWAC is to provide public input and involvement during the development of the Lanai WUDP and to monitor the Lanai WUDP implementation. The LWAC may organize itself as it deems appropriate to accomplish its purpose, including the adoption of by-laws for its own internal governance.

4. The LWAC is established and shall remain in existence until otherwise determined by the Board by subsequent resolution.

5. In consultation with the LWAC, the Director shall determine the meeting dates of the LWAC.

6. All communications between the Board and the LWAC shall only be through the Director.

7. The Director may propose amendments to the composition, purpose, and term of the LWAC, which may be approved by the Board by resolution. The Director shall notify the LWAC members prior to proposing any such amendments to the Board.

8. The Director is authorized to take any and all appropriate action necessary to carry out the purpose and intent of this Resolution that does not require Board approval.

9. That this resolution shall apply only to the process of drafting, reviewing, updating and implementing Water Use and Development Plans, and does not supersede any powers the Board, Administration, or other agencies already have to appoint advisory committees.

10. The Director shall notify each member of their selection to the LWAC.

IN WITNESS WHEREOF, and by proper vote of the Board of Water Supply, I have hereunto subscribed my name and affixed the seal of the Board of Water Supply this 16th day of March, 1999.

Robert K. Takitani, Chairman
Maui County Board of Water Supply

Approved as to form and legality:

Gary W. Zakian, Deputy
Corporation Counsel

Resolution No. 05 (1999)

CERTIFICATION

The undersigned hereby certifies that the foregoing Resolution is a true and correct copy of Resolution No. 05 (1999) adopted at the meeting of the Board of Water Supply, County of Maui, duly held on the 16th day of March, 1999.

David Craddick, Director
Department of Water Supply

APPENDIX H

Establishing Water Advisory Committees

LWAC DISCUSSION DRAFT

A BILL FOR AN ORDINANCE
TO ESTABLISH COMMUNITY PARTICIPATION
IN THE FORM OF WATER ADVISORY COMMITTEES
FOR DEVELOPMENT AND REVIEW OF
WATER USE AND DEVELOPMENT PLANS

BE IT ORDAINED BY THE PEOPLE OF THE COUNTY OF MAUI:

Chapter 2.88 A of the Maui County Code is amended as follows:

I. Section 2.88A.010 Sections:

Section 2.88A.010 is amended to include definitions provided herein. Section 2.88A.020 is amended to include language provided herein. A new section 2.88A.030 is added, and the current Sections 2.88A.030 through 2.88A.050 are re-numbered as Sections 2.88A.040 through 2.88A.060. A new Section 2.88A.070 is added. The Sections of the amended Chapter are as follows:

Sections:

Section 2.88A.010	**Definitions**
Section 2.88A.020	**Purpose & Intent**
Section 2.88A.030	**Water Advisory Committees**
Section 2.88A.050	**Adoption of the Plan**
Section 2.88A.060	**Application of the Plan**
Section 2.88A.070	**Amendment**
Section 2.88A.080	**Severability**

II. Section 2.88A.020 Definitions:

For purposes of this chapter, unless it is plainly evident from the context that a different meaning is intended, certain terms and words are defined as follows:

“Board” means the board of water supply of the county of Maui

“Commission” means the commission on water resource management of the State of Hawaii

“Council” means the council of the county of Maui

“County” means the County of Maui, a political subdivision of the State of Hawaii

“Department” means the Department of Water Supply of the County of Maui

“Director” means the director of water supply of the county of Maui

“DWS” means the Department of Water Supply of the County of Maui

“Plan” means the water use and development plan for the County of Maui, comprised of the technical report and executive summary.

“State Water Code” means chapter 174C, Hawaii Revised Statutes. (Ord 1948 §2, 1990)

A new definition is hereby added:

"Water Planning Districts" means areas served by a common mix of sources, connected such that sources are shared, or a distinct region or area served by small separate systems. They are defined as the following broad service areas, and shall include both DWS and non-DWS facilities:

1) Central Maui

Including but not limited to the area along the north from Waihee to Kuau, across the central isthmus, and along the south from Maalaea to Makena

2) Upcountry

Including but not limited to the current system areas known as Upper Kula, (incl. Ulupalakua-Kanaio), Lower Kula, and Makawao (incl. Pukalani through Makawao and Haiku to Ulumalu).

3) Lahaina

Including but not limited to the current system areas known as Honokohau, Mahinahina/Alaeloa, and Lahaina

4) Hana

Including but not limited to Kailua, Keanae, Nahiku, Hana and Kaupo

5) Molokai

Including the entire island of Molokai

6) Lanai

Including the entire island of Lanai

III. **Section 2.88A.020** **Purpose and Intent**

Section 2.88A.020 is hereby amended as follows.

The purpose of the plan is to meet the mandate of the state water code relative to statewide water resources planning, more specifically to aid the commission and the county of Maui in the conservation, development and use of the water resources of the county. (Ord. 1948 §2, 1990)

The intent of this ordinance is to insure effective community participation in Water Use & Development Planning, and to acknowledge the direction taken by the State in publishing its *Framework for Updating the Hawaii Water Plan* to involve the public in planning & decision making and to practice integrated resources planning.

IV. **Section 2.88A.030** **Water Advisory Committees**

Section 2.88A.030 is hereby added

2.88A.030 Water Advisory Committees

A. A Water Advisory Committee shall be established in each Water Planning District.

B. Water Advisory Committees shall be composed of residents, purveyors and resource managers in the district served by the committee. In addition, at least one member of the Water Advisory Committee may be a Planning Commission representative for that district, (provided that person is willing to serve) and at least one shall be a County Council members serving the affected region, or that person's appointed representative

C. The membership of Each Water Advisory Committee shall be proposed by the Director, with review by the Board, and approval by the Mayor.

D In recruiting and selecting members for each Water Advisory Committee, The Department shall follow the principles in the Statewide Framework For Updating the Hawaii Water Plan, striving to be inclusive of stakeholders and achieve balanced participation.

E If deemed advisable by the Department and Mayor, a substantial and balanced mailing list may substitute for a defined number of committee participants, provided that the mailing list is greater than 25 people, the opportunity to participate is advertised for at least a month, and the Mayor and Council have opportunity to contribute to the mailing list.

F To allow for flexibility and recognition of the unique character of each district, various particulars of the committees, including but not limited to composition, membership, terms, meeting schedule, sunset, functions and other items described in 2.88A.030 D through J, contained herein, will be defined by the Director as specified in attachments for each district. These attachments are hereby incorporated into this rule, may be revised by the Director as needed to optimize implementation of the Water Use & Development Planning Functions without need for additional ordinance or rule-making proceedings.

G Each Water Advisory Committee shall meet at a schedule determined by the Director, to discuss and make recommendations for update and development of the Draft Water Use and Development Plan, or for review of plan status and implementation.

H In the event that the Director finds it necessary, Water Advisory Committees may be asked to select representatives to meet with Water Advisory Committees of other regions, to work toward resolution of inter-regional disputes.

I Upon completion of the Water Use and Development Plan the Water Advisory Committees may continue to meet to review status and implementation of the Water Use and Development Plan, as deemed advisable by the Director.

J The purpose of the Water Advisory Committees pertains specifically to the process of drafting, reviewing, updating and monitoring the implementation of the Water Use & Development Plans, and the establishment of these committees does not supersede any existing powers of the Board, Administration, Planning Commission, Council or other agencies.

K The Director may waive the provisions of this section to the extent that they prevent obtaining or granting of federal aid on any project or the prosecution of work thereunder.

2.88A.040 Adoption of the Plan

The council hereby adopts the plan, and any future revision, amendment or modification of the same, pursuant to section 2.88A.050 of this chapter, shall be deemed part of the plan without further adoption or amendment to this chapter and will be incorporated into this chapter by reference. (Ord. 1948 §2 1990)

2.88A.050 Application of the Plan

Section 2.88A.020 is hereby amended as follows.

The plan shall serve as a guideline to the council, the board and all other agencies or departments of the County (a) in approving or recommending to other agencies the use or commitment of the water resources in the County, ~~and~~ (b) in using public funds to develop water resources to meet existing or projected future demands on the public water systems as set forth in the plan, and (c) in establishing or recommending for consideration policies or protective measures for water resource management as appropriate to meet critical concerns of individual or collective water districts. (Ord. 1948 §2 1990)

2.88A.050 Amendment

Section 2.88A.020 is hereby amended as follows.

If a proposed community plan amendment will impact the plan, the director shall initiate any necessary plan amendments.

An amendment to the plan proposed by the council, the director or any agency shall be referred to the Department for its review and recommendation. The Department shall hold appropriate public hearings on proposed revisions or amendments and shall transmit them, with its findings and recommendations to the council. Within forty-five days of receipt of a proposed amendment, the council shall approve the amendment by ordinance. If the council fails to act within forty-five days, the amendment shall be deemed disapproved.

~~The mayor shall appoint a nine-member task force to be chaired by the director to assist the Department with the review and amendment of the plan whenever the planning director recommends the revisions to the general plan pursuant to section 8-8.3.3 of the revised charter of the county of Maui. The task force shall recommend to the Department amendments to the plan so as to be consistent with any community plan amendment. (Ord. 1948 §2, 1990)~~

The Water Advisory Committees shall be established and serve as described in Section 2.88A.040 above, and shall recommend updates or changes as necessary based on community plan amendments, status of water resources or other critical factors. The Water Advisory committees shall recommend to the Department amendments as necessary to be consistent with general and community plan amendments. (Ord. 1948 §2, 1990)(Ord. 1948 §2, 1990)

VIII.2.88A.070 Severability

Section 2.88A.070 is hereby added:

The invalidity of any word, section, clause, paragraph, sentence part, or provision of this chapter shall not affect the validity of any other part of this chapter which can be given effect without such invalid part or parts.

IX.Effective Date

This ordinance shall take effect upon its approval.

Attachment A

Water Use & Development Plan - Water Advisory Committee for Lana`i

I. Establishment of the Lana`i Water Advisory Committee.

There shall be a Lana`i Water Advisory Committee (LWAC).

II. Special Provisions:

A. Balance of Membership

Membership and representation on the Lana`i Water Advisory Committee shall be as follows:

Organization or Entity	**Number of Representatives**
Lana`i Company	2
Lana`ians for Sensible Growth	2
At Large Lana`i Residents	3
Member of Lana`i Planning Commission	1
Council Member Residing on Island	1
Lead Agency - Department of Water Supply Staff	1 Ex Officio
Advising Agency - Commission on Water Resources Management	1 Ex Officio
Advising Agency - Department of Land & Natural Resources	1 Ex Officio
Advising Agency - Maui County Planning Department	1 Ex Officio
Advising Agency - Maui County Department of Public Works & Environmental Management	1 Ex Officio

B. Meeting Frequency & Triggers for Calling a Meeting

The LWAC shall meet bimonthly during drafting and update of the Water Use and Development Plan, and quarterly thereafter. Additional meetings may be held on an as-needed basis, if one or more of the following conditions apply:

1) DWS receives a development proposal for review for the island of Lana`i which is inconsistent with the Water Use and Development Plan.

2) DWS receives a development proposal for review for the island of Lana`i which is anticipated to utilize more than 60,000 gpd, or which will cause pumpage to exceed designation triggers set by the Commission on Water Resource Management.

3) DWS receives a development proposal for review which may cause pumpage to exceed operational guidelines.

4) DWS receives a development proposal for review which involves a community plan amendment.

5) Status of the aquifer or watershed has been altered, implementation of source water protection is in question, or monitoring shows that implementation is ineffective and discussion is deemed advisable.

6) LWAC members or other supporting agencies request a meeting due to questions regarding implementation of Water Use and Development Plan measures, or status of water source & supply, or other unforeseen issues pertaining to the status of the water supply, or the drafting, implementation, and consistency of the Water Use and Development Plan with the Community Plan.

C. Coordination with Planning

If a proposed land use is heard by the planning department and or council, and if said land use could be contrary to the information in the Water Use and Development Plan, exceed consumption triggers based on standards for source and system viability as set by the Department, have potential for significant adverse affect on source or systems, or be contrary to any policy or resource protective measure contained in the plan, the Department may request to the Planning Department that the project be reviewed by the water advisory committee.

The Planning Director will determine whether such request for referral is to be granted. In the case of such referrals, the Planning Department, Planning Commission or Council shall consider the recommendations of the Water Advisory Committee for the record.

The results of these reviews shall be forwarded to the Director. The Director will in turn forward these recommendations to the Director of the Planning Department of the County of Maui.

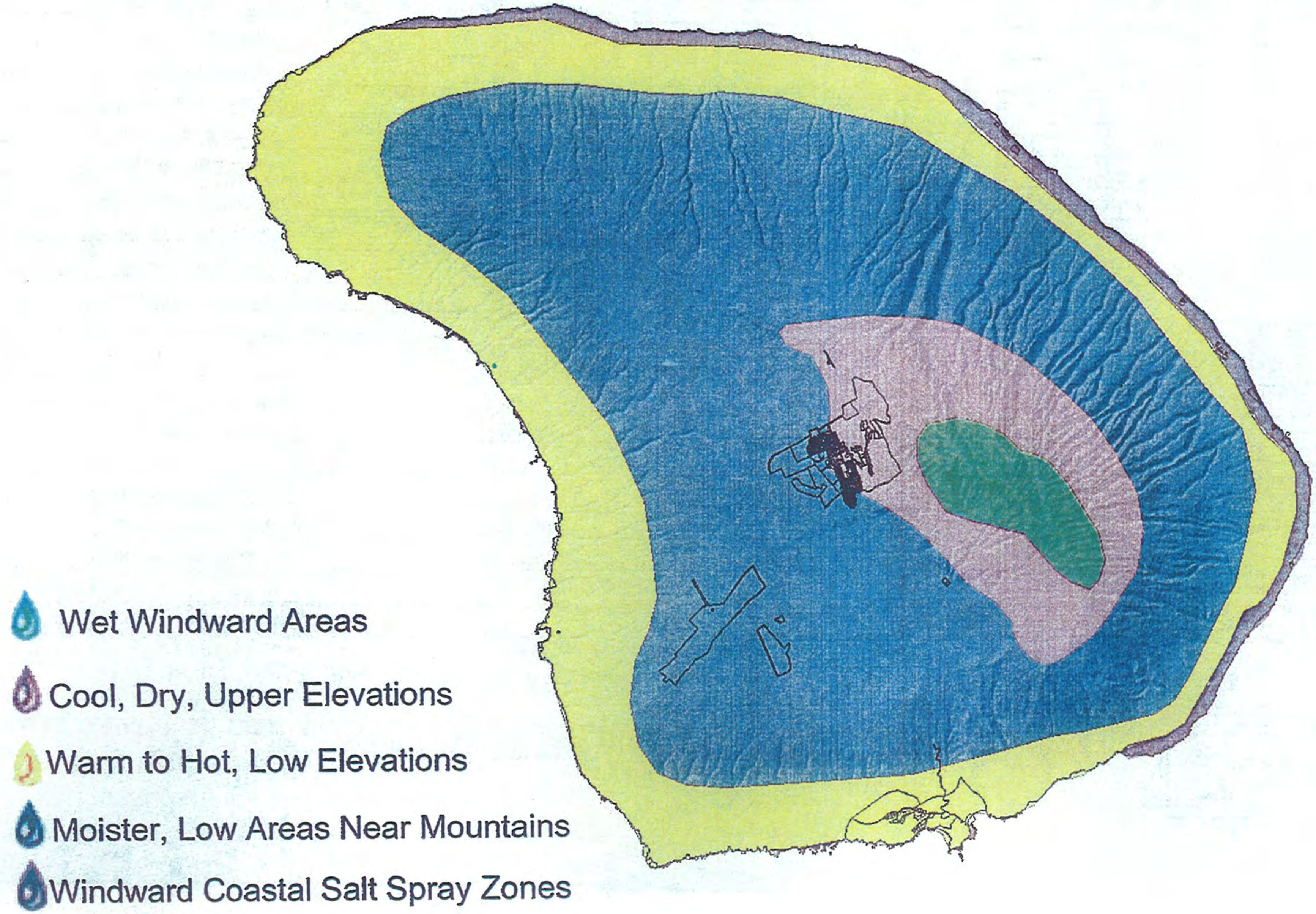
The land use decision making body may over-ride the recommendations of the Department and Water Advisory Committee, except where this would conflict with the but should state the reason for such action on the record.

APPENDIX I

Saving Water In The Yard: What & How To Plant In Your Area & Other Conservation Materials

Saving Water in The Yard

What and How to Plant in Your Area



Zone-specific Native and Polynesian plants for Maui County

Zone 1

TYPE: **F** Fern **G** Grass **Gr** Ground Cover **Sh** Shrub **P** Palm **S** Sedge **Tr** Tree **V** Vine

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
F	Psilotum nudum	moa, moa kula	1'	1'	sea to 3,000'	Dry to Wet
F	Sadleria cyatheoides	'ama'u, ama'uma'u				
Gr - Sh	Lipochaeta succulenta	nehe	2'	5'	sea to 1,000'	Dry to Wet
P	Cocos nucifera	coconut, niu	100'	30'	sea to 1,000'	Dry to Wet
P	Pritchardia arecina	lo'ulu, hawane	40'	10'	1,000' to 3,000'	Dry to Wet
P	Pritchardia forbesiana	lo'ulu	15'			
P	Pritchardia hillebrandii	lo'ulu, fan palm	25'	15'	sea to 1,000'	Dry to Wet
S	Mariscus javanicus	marsh cypress, 'ahu'awa	0.5'	0.5'	sea to 1,000'	Dry to Medium
Sh	Bidens hillebrandiana ssp. hillebrandiana	ko'oko'olau	1'	2'	sea to 1,000'	Dry to Wet
Sh	Cordyline fruticosa	ti, ki	6			
Sh	Hedyotis spp.	au, pilo	3'	2'	1,000' to 3,000'	Dry to Wet
Sh - Tr	Broussonetia papyrifera	wauke, paper mulberry	8'	6'	sea to 1,000'	Dry to Medium
Tr	Acacia koa	koa	50' - 100'	40' - 80'	1,500' to 4,000'	Dry to Medium
Tr	Aleurites moluccana	candlenut, kukui	50'	50'	sea to 3,000'	Medium to Wet
Tr	Calophyllum inophyllum	kamani, alexandrian laurel	60'	40'	sea to 3,000'	Medium to Wet
Tr	Charpentiera obovata		15'			
Tr	Cordia subcordata	kou	30'	25'	sea to 1,000'	Dry to Wet
Tr	Hibiscus furcellatus	'akiohala, hau-hele	8'			
Tr	Metrosideros polymorpha var. macrophylla	ohi'a lehua	25'	25'	sea to 1,000'	Dry to Wet
Tr	Morinda citrifolia	indian mulberry, noni	20'	15'	sea to 1,000'	Dry to Wet
Tr	Pandanus tectorius	hala, puhala (HALELIST)	35'	25'	sea to 1,000'	Dry to Wet
V	Alyxia oliviformis	maile	Vine		sea to 6,000'	Medium to Wet

Zone-specific Native and Polynesian plants for Maui County

Zone 2

TYPE: **F** Fern **G** Grass **Gr** Ground Cover **Sh** Shrub **P** Palm **S** Sedge **Tr** Tree **V** Vine

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
F	Psilotum nudum	moa, moa kula	1'	1'	sea to 3,000'	Dry to Wet
F	Sadleria cyatheoides	'ama'u, ama'uma'u				
G	Eragrostis monticola	kalamalo	1'	2'	sea to 3,000'	Dry to Medium
Gr	Ipomoea tuboides	Hawaiian moon flower, 'uala	1'	10'	sea to 3,000'	Dry to Medium
Gr	Peperomia leptostachya	'ala'ala-wai-nui	1'	1'	sea to 3,000'	Dry to Medium
Gr	Plumbago zeylanica	'ilie'e	1'			
Gr - Sh	Hibiscus calyphyllus	ma'o hau hele, Rock's hibiscus	3'	2'	sea to 3,000'	Dry to Medium
Gr - Sh	Lipochaeta rockii	nehe	2'	2'	sea to 3,000'	Dry to Medium
Sh	Argemone glauca var. decipiens	pua kala	3'	2'	sea to 3,000'	Dry to Medium
Sh	Artemisia mauiensis var. diffusa	Maui wormwood, 'ahinahina	2'	3'	1,000' to higher	Dry to Medium
Sh	Chenopodium oahuense	'aheahea, 'aweoweo	6'		sea to higher	Dry to Medium
Sh	Dianella sandwicensis	'uki	2'	2'	1,000' to higher	Dry to Medium
Sh	Lipochaeta lavarum	nehe	3'	3'	sea to 3,000'	Dry to Medium
Sh	Osteomeles anthyllidifolia	'ulei, eluehe	4'	6'	sea to 3,000'	Dry to Medium
Sh	Senna gaudichaudii	kolomana	5'	5'	sea to 3,000'	Dry to Medium
Sh	Styphelia tameiameiae	pukiawe	6'	6'	1,000' to higher	Dry to Medium
Sh	Vitex rotundifolia	pohinahina	3'	4'	sea to 1,000'	Dry to Medium
Sh - Tr	Myoporum sandwicense	naio, false sandalwood	10'	10'	sea to higher	Dry to Medium
Sh - Tr	Nototrichium sandwicense	kulu'i	8'	8'	sea to 3,000'	Dry to Medium
Sh-Tr	Dodonaea viscosa	'a'ali'i	6'	8'	sea to higher	Dry to Medium
Tr	Acacia koa	koa	50' - 100'	40' - 80'	1,500' to 4,000'	Dry to Medium
Tr	Charpentiera obovata		15'			
Tr	Erythrina sandwicensis	wiliwili	20'	20'	sea to 1,000'	Dry
Tr	Metrosideros polymorpha var. macrophylla	ohi'a lehua	25'	25'	sea to 1,000'	Dry to Wet

Zone-specific Native and Polynesian plants for Maui County

Zone 2

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
Tr	Nestegis sandwicensis	olopua	15'	15'	1,000' to 3,000'	Dry to Medium
Tr	Pleomele auwahiensis	halapepe	20'			
Tr	Rauvolfia sandwicensis	hao	20'	15'	sea to 3,000'	Dry to Medium
Tr	Santalum ellipticum	coastal sandalwood, 'ili-ahi	8'	8'	sea to 3,000'	Dry to Medium
Tr	Sophora chrysophylla	mamane	15'	15'	1,000' to 3,000'	Medium
V	Alyxia oliviformis	maile	Vine		sea to 6,000'	Medium to Wet

Zone-specific Native and Polynesian plants for Maui County

Zone 3

TYPE: **F** Fern **G** Grass **Gr** Ground Cover **Sh** Shrub **P** Palm **S** Sedge **Tr** Tree **V** Vine

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
F	Psilotum nudum	moa, moa kula	1'	1'	sea to 3,000'	Dry to Wet
G	Colubrina asiatica	'anapanapa	3'	10'	sea to 1,000'	Dry to Wet
G	Eragrostis monticola	kalamalo	1'	2'	sea to 3,000'	Dry to Medium
G	Eragrostis variabilis	'emo-loa	1'	2'	sea to 3,000'	Dry to Medium
G	Fimbristylis cymosa ssp. spathacea	mau'u'aki'aki fimbristylis	0.5'	1'	sea to 1,000'	Dry to Medium
Gr	Boerhavia repens	alena	0.5'	4'	sea to 1,000'	Dry to Medium
Gr	Chamaesyce celastroides var. laehiensis	'akoko	2'	3'	sea to 1,000'	Dry to Medium
Gr	Cressa truxillensis	cressa	0.5'	1'	sea to 1,000'	Dry to Medium
Gr	Heliotropium anomalum var. argenteum	hinahina ku kahakai	1'	2'	sea to 1,000'	Dry to Medium
Gr	Ipomoea tuboides	Hawaiian moon flower, uala	1'	10'	sea to 3,000'	Dry to Medium
Gr	Jacquemontia ovalifolia ssp. sandwicensis	pa'u o hi'iaka	0.5'	6'	sea to 1,000'	Dry to Medium
Gr	Lipochaeta integrifolia	nehe	1'	5'	sea to 1,00'	Dry to Medium
Gr	Peperomia leptostachya	'ala'ala-wai-nui	1'	1'	sea to 3,000'	Dry to Medium
Gr	Plumbago zeylanica	'ilie'e	1'			
Gr	Sesuvium portulacastrum	'akulikuli, sea-purslane	0.5'	2'	sea to 1,000'	Dry to Wet
Gr	Sida fallax	'ilima	0.5'	3'	sea to 1,000'	Dry to Medium
Gr	Tephrosia purpurea var. purpurea	'auhuhu	2'	2'	sea to 1,000'	Dry to Medium
Gr - Sh	Hibiscus calyphyllus	ma'o hau hele, Rock's hibiscus	3'	2'	sea to 3,000'	Dry to Medium
Gr - Sh	Lipochaeta rockii	nehe	2'	2'	sea to 3,000'	Dry to Medium
Gr - Sh	Lipochaeta succulenta	nehe	2'	5'	sea to 1,000'	Dry to Wet
Gr - Sh	Lycium sandwicense	'ohelo-kai, 'ae'ae	2'	2'	sea to 1,000'	Dry to Medium
P	Cocos nucifera	coconut, niu	100'	30'	sea to 1,000'	Dry to Wet
P	Pritchardia hillebrandii	lo'ulu, fan palm	25'	15'	sea to 1,000'	Dry to Wet
S	Mariscus javanicus	marsh cypress, 'ahu'awa	0.5'	0.5'	sea to 1,000'	Dry to Medium

Zone 3

Zone-specific Native and Polynesian plants for Maui County

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
Sh	Argemone glauca var. decipiens	pua kala	3'	2'	sea to 3,000'	Dry to Medium
Sh	Bidens mauiensis	ko'oko'olau	1'	3'	sea to 1,000'	Dry to Medium
Sh	Bidens menziesii ssp. menziesii	ko'oko'olau	1'	3'		
Sh	Bidens micrantha ssp. micrantha	ko'oko'olau	1'	3'		
Sh	Chenopodium oahuense	'aheahea, 'aweoweo	6'		sea to higher	Dry to Medium
Sh	Dianella sandwicensis	'uki	2'	2'	1,000' to higher	Dry to Medium
Sh	Gossypium tomentosum	mao, Hawaiian cotton	5'	8'	sea to 1,000'	Dry to Medium
Sh	Hedyotis spp.	au, pilo	3'	2'	1,000' to 3,000'	Dry to Wet
Sh	Lipochaeta lavarum	nehe	3'	3'	sea to 3,000'	Dry to Medium
Sh	Osteomeles anthyllidifolia	'ulei, eluehe	4'	6'	sea to 3,000'	Dry to Medium
Sh	Scaevola sericea	naupaka, naupaka-kahakai	6'	8'	sea to 1,000'	Dry to Medium
Sh	Senna gaudichaudii	kolomana	5'	5'	sea to 3,000'	Dry to Medium
Sh	Solanum nelsonii	'akia, beach solanum	3'	3'	sea to 1,00'	Dry to Medium
Sh	Styphelia tameiameiae	pukiawe	6'	6'	1,000' to higher	Dry to Medium
Sh	Vitex rotundifolia	pohinahina	3'	4'	sea to 1,000'	Dry to Medium
Sh	Wikstroemia uva-ursi kauaiensis kauaiensis	'akia, Molokai osmanthus				
Sh - Tr	Broussonetia papyrifera	wauke, paper mulberry	8'	6'	sea to 1,000'	Dry to Medium
Sh - Tr	Myoporum sandwicense	naio, false sandalwood	10'	10'	sea to higher	Dry to Medium
Sh - Tr	Nototrichium sandwicense	kulu'i	8'	8'	sea to 3,000'	Dry to Medium
Sh-Tr	Dodonaea viscosa	'a'ali'i	6'	8'	sea to higher	Dry to Medium
Tr	Aleurites moluccana	candlenut, kukui	50'	50'	sea to 3,000'	Medium to Wet
Tr	Calophyllum inophyllum	kamani, alexandrian laurel	60'	40'	sea to 3,000'	Medium to Wet
Tr	Canthium odoratum	Alahe'e, 'ohe'e, walahe'e	12'	8'	sea to 3,000'	Dry to Medium
Tr	Cordia subcordata	kou	30'	25'	sea to 1,000'	Dry to Wet
Tr	Diospyros sandwicensis	lama	12'	15'	sea to 3,000'	Dry to Medium
Tr	Erythrina sandwicensis	wiliwili	20'	20'	sea to 1,000'	Dry
Tr	etrosideros polymorpha var. macrophylla	ohi'a lehua	25'	25'	sea to 1,000'	Dry to Wet

Zone-specific Native and Polynesian plants for Maui County

Zone 3

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
Tr	Morinda citrifolia	indian mulberry, noni	20'	15'	sea to 1,000'	Dry to Wet
Tr	Nesoluma polynesicum	keahi	15'	15'	sea to 3,00'	Dry
Tr	Nestegis sandwicensis	olopua	15'	15'	1,000' to 3,000'	Dry to Medium
Tr	Pandanus tectorius	hala, puhala (HALELIST)	35'	25'	sea to 1,000'	Dry to Wet
Tr	Pleomele auwahiensis	halapepe	20'			
Tr	Rauvolfia sandwicensis	hao	20'	15'	sea to 3,000'	Dry to Medium
Tr	Reynoldsia sandwicensis	'ohe makai	20'	20'	1,000' to 3,000'	Dry
Tr	Santalum ellipticum	coastal sandalwood, 'ili-ahi	8'	8'	sea to 3,000'	Dry to Medium
Tr	Thespesia populnea	milo	30'	30'	sea to 3,000'	Dry to Wet

Zone-specific Native and Polynesian plants for Maui County

Zone 4

TYPE: F Fern G Grass Gr Ground Cover Sh Shrub P Palm S Sedge Tr Tree V Vine

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
F	Psilotum nudum	moa, moa kula	1'	1'	sea to 3,000'	Dry to Wet
F	Sadleria cyatheoides	'ama'u, ama'uma'u				
G	Colubrina asiatica	'anapanapa	3'	10'	sea to 1,000'	Dry to Wet
G	Eragrostis monticola	kalamalo	1'	2'	sea to 3,000'	Dry to Medium
G	Eragrostis variabilis	'emo-loa	1'	2'	sea to 3,000'	Dry to Medium
G	Fimbristylis cymosa ssp. spathacea	mau'u'aki'aki fimbristylis	0.5'	1'	sea to 1,000'	Dry to Medium
Gr	Chamaesyce celastroides var. laehiensis	'akoko	2'	3'	sea to 1,000'	Dry to Medium
Gr	Ipomoea tuboides	Hawaiian moon flower, 'uala	1'	10'	sea to 3,000'	Dry to Medium
Gr	Jacquemontia ovalifolia ssp. sandwicensis	pa'u o hi'iaka	0.5'	6'	sea to 1,000'	Dry to Medium
Gr	Lipochaeta integrifolia	nehe	1'	5'	sea to 1,00'	Dry to Medium
Gr	Peperomia leptostachya	'ala'ala-wai-nui	1'	1'	sea to 3,000'	Dry to Medium
Gr	Plumbago zeylanica	'ilie'e	1'			
Gr	Sida fallax	'ilima	0.5'	3'	sea to 1,000'	Dry to Medium
Gr	Tephrosia purpurea var. purpurea	'auhuhu	2'	2'	sea to 1,000'	Dry to Medium
Gr - Sh	Hibiscus calyphyllus	ma'o hau hele, Rock's hibiscus	3'	2'	sea to 3,000'	Dry to Medium
Gr - Sh	Lipochaeta rockii	nehe	2'	2'	sea to 3,000'	Dry to Medium
Gr - Sh	Lipochaeta succulenta	nehe	2'	5'	sea to 1,000'	Dry to Wet
P	Cocos nucifera	coconut, niu	100'	30'	sea to 1,000'	Dry to Wet
P	Pritchardia arecina	lo'ulu, hawane	40'	10'	1,000' to 3,000'	Dry to Wet
P	Pritchardia forbesiana	lo'ulu	15'			
P	Pritchardia hillebrandii	lo'ulu, fan palm	25'	15'	sea to 1,000'	Dry to Wet
S	Mariscus javanicus	marsh cypress, 'ahu'awa	0.5'	0.5'	sea to 1,000'	Dry to Medium
Sh	Argemone glauca var. decipiens	pua kala	3'	2'	sea to 3,000'	Dry to Medium
Sh	Artemisia australis	'ahinahina	2'	3'	sea to 3,000'	Dry to Medium

Zone-specific Native and Polynesian plants for Maui County

Zone 4

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
Sh	Artemisia mauiensis var. diffusa	Maui wormwood, 'ahinahina	2'	3'	1,000' to higher	Dry to Medium
Sh	Bidens hillebrandiana ssp. hillebrandiana	ko'oko'olau	1'	2'	sea to 1,000'	Dry to Wet
Sh	Bidens menziesii ssp. menziesii	ko'oko'olau	1'	3'		
Sh	Bidens micrantha ssp. micrantha	ko'oko'olau	1'	3'		
Sh	Cordyline fruticosa	ti, ki	6			
Sh	Dianella sandwicensis	'uki	2'	2'	1,000' to higher	Dry to Medium
Sh	Lipochaeta lavarum	nehe	3'	3'	sea to 3,000'	Dry to Medium
Sh	Osteomeles anthyllidifolia	'ulei, eluehe	4'	6'	sea to 3,000'	Dry to Medium
Sh	Scaevola sericea	naupaka, naupaka-kahakai	6'	8'	sea to 1,000'	Dry to Medium
Sh	Solanum nelsonii	'akia, beach solanum	3'	3'	sea to 1,00'	Dry to Medium
Sh	Styphelia tameiameiae	pukiawe	6'	6'	1,000' to higher	Dry to Medium
Sh	Vitex rotundifolia	pohinahina	3'	4'	sea to 1,000'	Dry to Medium
Sh	Wikstroemia uva-ursi kauaiensis kauaiensis	'akia, Molokai osmanthus				
Sh - Tr	Broussonetia papyrifera	wauke, paper mulberry	8'	6'	sea to 1,000'	Dry to Medium
Sh - Tr	Myoporum sandwicense	naio, false sandalwood	10'	10'	sea to higher	Dry to Medium
Sh - Tr	Nototrichium sandwicense	kulu'i	8'	8'	sea to 3,000'	Dry to Medium
Sh-Tr	Dodonaea viscosa	'a'ali'i	6'	8'	sea to higher	Dry to Medium
Tr	Acacia koa	koa	50' - 100'	40' - 80'	1,500' to 4,000'	Dry to Medium
Tr	Aleurites moluccana	candlenut, kukui	50'	50'	sea to 3,000'	Medium to Wet
Tr	Calophyllum inophyllum	kamani, alexandrian laurel	60'	40'	sea to 3,000'	Medium to Wet
Tr	Canthium odoratum	Alahe'e, 'ohe'e, walahe'e	12'	8'	sea to 3,000'	Dry to Medium
Tr	Charpentiera obovata		15'			
Tr	Cordia subcordata	kou	30'	25'	sea to 1,000'	Dry to Wet
Tr	Diospyros sandwicensis	lama	12'	15'	sea to 3,000'	Dry to Medium
Tr	Hibiscus furcellatus	'akiohala, hau-hele	8'			
Tr	Metrosideros polymorpha var. macrophylla	ohi'a lehua	25'	25'	sea to 1,000'	Dry to Wet
Tr	Morinda citrifolia	indian mulberry, noni	20'	15'	sea to 1,000'	Dry to Wet

Zone-specific Native and Polynesian plants for Maui County

Zone 4

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
Tr	Nestegis sandwicensis	olopua	15'	15'	1,000' to 3,000'	Dry to Medium
Tr	Pandanus tectorius	hala, puhala (HALELIST)	35'	25'	sea to 1,000'	Dry to Wet
Tr	Pleomele auwahiensis	halapepe	20'			
Tr	Rauvolfia sandwicensis	hao	20'	15'	sea to 3,000'	Dry to Medium
Tr	Santalum ellipticum	coastal sandalwood, 'ili-ahi	8'	8'	sea to 3,000'	Dry to Medium
Tr	Sophora chrysophylla	mamane	15'	15'	1,000' to 3,000'	Medium
Tr	Thespesia populnea	milo	30'	30'	sea to 3,000'	Dry to Wet
V	Alyxia oliviformis	maile	Vine		sea to 6,000'	Medium to Wet

Zone-specific Native and Polynesian plants for Maui County

Zone 5

TYPE: **F** Fern **G** Grass **Gr** Ground Cover **Sh** Shrub **P** Palm **S** Sedge **Tr** Tree **V** Vine

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
G	Colubrina asiatica	'anapanapa	3'	10'	sea to 1,000'	Dry to Wet
G	Eragrostis variabilis	'emo-loa	1'	2'	sea to 3,000'	Dry to Medium
G	Fimbristylis cymosa ssp. spathacea	mau'u'aki'aki fimbristylis	0.5'	1'	sea to 1,000'	Dry to Medium
Gr	Boerhavia repens	alena	0.5'	4'	sea to 1,000'	Dry to Medium
Gr	Chamaesyce celastroides var. laehiensis	'akoko	2'	3'	sea to 1,000'	Dry to Medium
Gr	Cressa truxillensis	cressa	0.5'	1'	sea to 1,000'	Dry to Medium
Gr	Heliotropium anomalum var. argenteum	hinahina ku kahakai	1'	2'	sea to 1,000'	Dry to Medium
Gr	Jacquemontia ovalifolia ssp. sandwicensis	pa'u o hi'iaka	0.5'	6'	sea to 1,000'	Dry to Medium
Gr	Lipochaeta integrifolia	nehe	1'	5'	sea to 1,00'	Dry to Medium
Gr	Sesuvium portulacastrum	'akulikuli, sea-purslane	0.5'	2'	sea to 1,000'	Dry to Wet
Gr	Sida fallax	'ilima	0.5'	3'	sea to 1,000'	Dry to Medium
Gr	Tephrosia purpurea var. purpurea	'auhuhu	2'	2'	sea to 1,000'	Dry to Medium
Gr - Sh	Hibiscus calyphyllus	ma'o hau hele, Rock's hibiscus	3'	2'	sea to 3,000'	Dry to Medium
Gr - Sh	Lycium sandwicense	'ohelo-kai, 'ae'ae	2'	2'	sea to 1,000'	Dry to Medium
P	Cocos nucifera	coconut, niu	100'	30'	sea to 1,000'	Dry to Wet
P	Pritchardia hillebrandii	lo'ulu, fan palm	25'	15'	sea to 1,000'	Dry to Wet
S	Mariscus javanicus	marsh cypress, 'ahu'awa	0.5'	0.5'	sea to 1,000'	Dry to Medium
Sh	Argemone glauca var. decipiens	pua kala	3'	2'	sea to 3,000'	Dry to Medium
Sh	Artemisia australis	'ahinahina	2'	3'	sea to 3,000'	Dry to Medium
Sh	Bidens hillebrandiana ssp. hillebrandiana	ko'oko'olau	1'	2'	sea to 1,000'	Dry to Wet
Sh	Bidens mauiensis	ko'oko'olau	1'	3'	sea to 1,000'	Dry to Medium
Sh	Chenopodium oahuense	'aheahea, 'aweoweo	6'		sea to higher	Dry to Medium
Sh	Dianella sandwicensis	'uki	2'	2'	1,000' to higher	Dry to Medium
Sh	Gossypium tomentosum	mao, Hawaiian cotton	5'	8'	sea to 1,000'	Dry to Medium

Zone-specific Native and Polynesian plants for Maui County

Zone 5

Type	Scientific Name	Common Name	Height	Spread	Elevation	Water req.
Sh	Hedyotis spp.	au, pilo	3'	2'	1,000' to 3,000'	Dry to Wet
Sh	Lipochaeta lavarum	nehe	3'	3'	sea to 3,000'	Dry to Medium
Sh	Osteomeles anthyllidifolia	'ulei, eluehe	4'	6'	sea to 3,000'	Dry to Medium
Sh	Scaevola sericea	naupaka, naupaka-kahakai	6'	8'	sea to 1,000'	Dry to Medium
Sh	Senna gaudichaudii	kolomana	5'	5'	sea to 3,000'	Dry to Medium
Sh	Solanum nelsonii	'akia, beach solanum	3'	3'	sea to 1,00'	Dry to Medium
Sh	Vitex rotundifolia	pohinahina	3'	4'	sea to 1,000'	Dry to Medium
Sh	Wikstroemia uva-ursi kauaiensis kauaiensis	'akia, Molokai osmanthus				
Sh - Tr	Myoporum sandwicense	naio, false sandalwood	10'	10'	sea to higher	Dry to Medium
Sh-Tr	Dodonaea viscosa	'a'ali'i	6'	8'	sea to higher	Dry to Medium
Tr	Aleurites moluccana	candlenut, kukui	50'	50'	sea to 3,000'	Medium to Wet
Tr	Calophyllum inophyllum	kamani, alexandrian laurel	60'	40'	sea to 3,000'	Medium to Wet
Tr	Cordia subcordata	kou	30'	25'	sea to 1,000'	Dry to Wet
Tr	Hibiscus furcellatus	'akiohala, hau-hele	8'			
Tr	Morinda citrifolia	indian mulberry, noni	20'	15'	sea to 1,000'	Dry to Wet
Tr	Pandanus tectorius	hala, puhala (HALELIST)	35'	25'	sea to 1,000'	Dry to Wet
Tr	Thespesia populnea	milo	30'	30'	sea to 3,000'	Dry to Wet
V	Ipomoea pes-caprae	beach morning glory, pohuehue	1'			

DO NOT PLANT THESE PLANTS !!!

Common name	Scientific name	Plant family
black wattle	Acacia mearnsii	Mimosaceae
blackberry	Rubus argutus	Rosaceae
blue gum	Eucalyptus globulus	Myrtaceae
bocconia	Bocconia frutescens	Papaveraceae
broad-leaved cordia	Cordia glabra	Boraginaceae
broomsedge, yellow bluestem	Andropogon virginicus	Poaceae
buffelgrass	Cenchrus ciliaris	Poaceae
butterfly bush, smoke bush	Buddleja madagascariensis	Buddlejaceae
cats claw, Mysore thorn, wait-a-bit	Caesalpinia decapetala	Caesalpiniaceae
common ironwood	Casuarina equisetifolia	Casuarinaceae
common velvet grass, Yorkshire fog	Holcus lanatus	Poaceae
fiddlewood	Citharexylum spinosum	Verbenaceae
fire tree, faya tree	Myrica faya	Myricaceae
glorybower	Clerodendrum japonicum	Verbenaceae
hairy cat's ear, gosmore	Hypochoeris radicata	Asteraceae
haole koa	Leucaena leucocephala	Fabaceae
ivy gourd, scarlet-fruited gourd	Coccinia grandis	Cucurbitaceae
juniper berry	Citharexylum caudatum	Verbenaceae
kahili flower	Grevillea banksii	Proteaceae
klu, popinac	Acacia farnesiana	Mimosaceae
logwood, bloodwood tree	Haematoxylon campechianum	Caesalpiniaceae
loquat	Eriobotrya japonica	Rosaceae
meadow ricegrass	Ehrharta stipoides	Poaceae
melaleuca	Melaleuca quinquenervia	Myrtaceae
miconia, velvet leaf	Miconia calvescens	Melastomataceae
narrow-leaved carpetgrass	Axonopus fissifolius	Poaceae
oleaster	Elaeagnus umbellata	Elaeagnaceae
oriental mangrove	Bruguiera gymnorrhiza	Rhizophoraceae
padang cassia	Cinnamomum burmanii	Lauraceae
palmgrass	Setaria palmifolia	Poaceae
pearl flower	Heterocentron subtriplinervium	Melastomataceae
quinine tree	Cinchona pubesens	Rubiaceae
satin leaf, caimitillo	Chrysophyllum oliviforme	Sapotaceae
silkwood, Queensland maple	Flindersia brayleyana	Rutaceae
silky oak, silver oak	Grevillea robusta	Proteaceae
strawberry guava	Psidium cattleianum	Myrtaceae
swamp oak, saltmarsh, longleaf ironwood	Casuarina glauca	Casuarinaceae
sweet vernalgrass	Anthoxanthum odoratum	Poaceae
tree of heaven	Ailanthus altissima	Simaroubaceae
trumpet tree, guarumo	Cecropia obtusifolia	Cecropiaceae
white ginger	Hedychium coronarium	Zingiberaceae
white moho	Heliocarpus popayanensis	Tiliaceae
yellow ginger	Hedychium flavescens	Zingiberaceae

DO NOT PLANT THESE PLANTS !!!

Common name	Scientific name	Plant family
	Jasminum fluminense	Oleaceae
	Arthrostema ciliatum	Melastomataceae
	Dissotis rotundifolia	Melastomataceae
	Erigeron karvinskianus	Asteraceae
	Eucalyptus robusta	Myrtaceae
	Hedychium gardnerianum	Zingiberaceae
	Juncus planifolius	Juncaceae
	Lophostemon confertus	Myrtaceae
	Medinilla cumingii	Melastomataceae
	Medinilla magnifica	Melastomataceae
	Medinilla venosa	Melastomataceae
	Melastoma candidum	Melastomataceae
	Melinis minutiflora	Poaceae
	Olea europaea	
	Oxyspora paniculata	Melastomataceae
	Panicum maximum	Poaceae
	Paspalum urvillei	Poaceae
	Passiflora edulis	Passifloraceae
	Phormium tenax	Agavaceae
	Pinus taeda	Pinaceae
	Prosopis pallida	Fabaceae
	Pterolepis glomerata	Melastomataceae
	Rhodomyrtus tomentosa	Myrtaceae
	Schefflera actinophylla	Araliaceae
	Syzygium jambos	Myrtaceae
Australian blackwood	Acacia melanoxylon	Mimosaceae
Australian tree fern	Cyathea cooperi	Cyatheaceae
Australian tree fern	Sphaeropteris cooperi	Cyatheaceae
Beggar's tick, Spanish needle	Bidens pilosa	Asteraceae
California grass	Brachiaria mutica	Poaceae
Chinese banyon, Maylayan banyon	Ficus mirocarpa	Moraceae
Chinese violet	Asystasia gangetica	Acanthaceae
Christmasberry, Brazilian pepper	Schinus terebinthifolius	Anacardiaceae
Formosan koa	Acacia confusa	Mimosaceae
German ivy	Senecio mikanioides	Asteraceae
Japanese honeysuckle	Lonicera japonica	Caprifoliaceae
Koster's curse	Clidemia hirta	Melastomataceae
Lantana	Lantana camara	Verbenaceae
Mauritius hemp	Furcraea foetida	Agavaceae
Mexican ash, tropical ash	Fraxinus uhdei	Oleaceae
Mexican tulip poppy	Hunnemannia fumariifolia	Papaveraceae
Mules foot, Madagascar tree fern	Angiopteris evecta	Marattiaceae
New Zealand laurel, karakaranut	Corynocarpus laevigatus	Corynocarpaceae
New Zealand tea	Leptospermum scoparium	Myrtaceae
Pampas grass	Cortaderia jubata	Poaceae
Panama rubber tree, Mexican rubber tree	Castilloa elastica	Moraceae
Shoe[illegible]on ardisia	Ardisia elliptica	Myrsinaceae
banan[illegible]oka	Passiflora mollissima	Passifloraceae

Selection

As a general rule, it is best to select the largest and healthiest specimens. However, be sure to note that they are not pot-bound. Smaller, younger plants may result in a low rate of plant survival.[1] When selecting native species, consider the site they are to be planted in, and the space that you have to plant. For example: Mountain species such as koa and maile will not grow well in hot coastal areas exposed to strong ocean breezes. Lowland and coastal species such as wiliwili and Kou require abundant sunshine and porus soil. They will not grow well with frequent cloud cover, high rainfall and heavy soil.

Consider too, the size that the species will grow to be. It is not wise to plant trees that will grow too large.[2] Overplanting tends to be a big problem in the landscape due to the underestimation of a species' height, width or spread.

A large, dense canopied tree such as the kukui is a good shade tree for a lawn. However, it's canopy size and density of shade will limit what can be planted in the surrounding area. Shade cast by a koa and ohia lehua is relatively light and will not inhibit growth beneath it.

Keep seasons in mind when you are selecting your plants. Not all plants look good year round, some plants such as ilima will look scraggly after they have flowered and formed seeds. Avoid planting large areas with only one native plant. Mixing plants which naturally grow together will ensure the garden will look good all year round.[3] Looking at natural habitats helps to show how plants grow naturally in the landscape.

When planting an area with a mixed-ecosystem, keep in mind the size and ecological requirements of each plant. Start with the hardiest and most easily grown species, but allow space for fragile ones in subsequent plantings.

Acquiring natives

Plants in their wild habitat must be protected and maintained. It is best and easiest to get your plants from nurseries (see list), or friend's gardens. Obtain proper permits from landowners and make sure you follow a few common sense rules:

- collect sparingly from each plant or area.
- some plants are on the state or Federal Endangered Species list. Make sure you get permits (see app. A,B)

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[1] K. Nagata, P.6

[2] K. Nagata, P.9

[3] Nagata, P.9

Soil

Once you have selected your site and the plants you wish to establish there, you must look at the soil conditions on the site. Proper soil is necessary for the successful growth of most native plants, which preform poorly in hard pan, clay or adobe soils. If natives are to be planted in these types of soil, it would be wise to dig planting holes several times the size of the rootball and backfill with 50-75% compost.[4] A large planting hole ensures the development of a strong root system. The plant will have a headstart before the roots penetrate the surrounding poor soil.[5]

It is recommended that native plants not be planted in ground that is more dense than potting soil. If there is no alternative, dig a hole in a mound of soil mixed with volcanic cinder which encourages maximum root development. Fill the hole with water, if the water tends to puddle or drain too slowly, dig a deeper hole until the water does not puddle longer than 1 or 2 minutes.[6] Well-drained soil is one of the most important things when planting natives as you will see in the next section.

Irrigation

Most natives do very poorly in waterlogged conditions. Do not water if the soil is damp. Water when the soil is dry and the plants are wilting. Once established, a good soaking twice a week should suffice. Deep soaking encourages the development of stronger, and deeper root systems. This is better than frequent and shallow watering which encourage weaker, more shallow root systems.

The following is a watering schedule from Kenneth Nagata's Booklet, *How To Plant A Native Hawaiian Garden*:

WATER REQUIREMENT	WATERING FREQUENCY
Heavy	3x / week
Moderate	2x / week
Light	1x / week

Red clay soils hold more water for a longer period of time than sandy soils do. If your area is very sunny or near a beach, things will dry out faster. Even in the area of one garden, there are parts that will need more or less water. Soils can vary and amount of shade and wind differ. After plants are established (a month or two for most plants, up to a year for some trees), you can back off watering.

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[4] Nagata, p. 6

[5] Nagata, p. 8

[6] Nagata, p. 8

Automatic sprinkler systems are expensive to install and must be checked and adjusted regularly. Above-ground systems allow you to monitor how much water is being put out, but you lose a lot due to malfunctioning of sprinkler heads and wind. The most efficient way to save water and make sure your plants get enough water, is to hand-water. This way you are getting our precious water to the right places in the right amounts.[7]

Fertilizer

An all-purpose fertilizer 10-10-10 is adequate for most species. They should be applied at planting time, 3 months later, and 6 months thereafter. Use half the dosage recommended for ornamentals and pay special attention to native ferns which are sensitive to strong fertilizers. Use of organic composts and aged animal manures is suggested instead of chemical fertilizers. In addition, use of cinders for providing trace minerals is strongly recommended.[8]

Natives are plants which were here hundreds of years before the polynesians inhabited the Hawaiian Islands. They were brought here by birds, or survived the harsh ocean conditions to float here. They are well-adapted to Hawaii's varying soil and environmental conditions. This is why they make prime specimens for a xeriscape garden. However, natives will not thrive on their own, especially under harsh conditions. On the other hand, like any other plant, if you over-water and over-fertilize them, they will die. Follow the instructions given to you by the nursery you buy the plant from, or from this booklet. Better yet, buy a book (suggested readings can be found in the bibliography in the back of this pamphlet), read it, and learn more about native plants. I guarantee that you will be pleased with the results.

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[7] Bornhorst, p. 19-20

[8] Nagata, p. 6

Propagation

There are many ways to propagate and plant-out native Hawaiian species. One of the most thourough and helpful book is Heidi Bornhorst's book, *Growing Native Hawaiian Plants.* The easiest, and best way to obtain natives for the novice gardener is to get them from a reputable nursery (see appendix c). That way all you will have to do is know how to transplant (if necessary) and plant-out when you are ready. These are the two methods I have listed here.

Transplanting

1. Use pots that are one size bigger than the potted plant is in
2. Get your potting medium ready

Good potting medium is a ½, ½ mixture of peat moss and perlite. If the plant is from a dry or coastal area, add chunks of cinder or extra perlite. If it is a wet forest species, add more peat moss or compost. Be aware that peat moss is very acidic and certain plants react severely to acidity.

If the plant is to eventually be planted into the ground, make a mix of equal parts peat moss, perlite, and soil from the area in which the plant is to be planted. Slow-release fertilizer can be mixed into the potting medium.

3. Once pots, potting medium, fertilizer and water are ready, you can begin re-potting. Keep the plant stem at the same depth it was in the original pot. Avoid putting the plant in too large a pot, as the plant may not be able to soak up all the water in the soil and the roots may drown and rot.

Mix potting medium and add slow-release fertilizer at this time. Pre-wet the medium to keep dust down and lessen shock to the plant. Put medium in bottom of pot. Measure for the correct depth in the new pot. Make sure there is from ½ to 2 inches from the top of the pot so the plant can get adequate water. Try to stand the plant upright and center the stem in the middle of the pot.

Water the plant thoroughly after transplanting. A vitamin B-1 transplanting solution can help to lessen the transplant shock. Keep the plant in the same type of environment as it was before, sun or shade. If roots were broken, trimm off some of the leaves to compensate for the loss.[9]

Planting out

1. Plant most native Hawaiian plants in a sunny location in soil that is well-drained.
2. Make the planting hole twice as wide as the root ball or present pot, and just as deep. If the soil is clay-like, and drains slowly, mix in some coarse red or bland cinder, coarse perlite or

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[9] Bornhorst, p.20-21

coarse compost. Place some slow-release fertilizer at the bottom of the hole.

3. Carefully remove the plant from the container and place it in the hole. The top of the soil should be at the same level as the top of the hole, if it is too high or too low, adjust the soil level so that the plant is at the right depth.

4. Water thoroughly after you transplant.

Mulch

Most natives cannot compete with weeds, and therefore must be weeded around constantly in order to thrive. Mulch is a practical alternative, which discourages and prevents weeds from growing.

Hawaii's hot, humid climate leads to the breaking down of organic mulches. Thick organic mulches such as wood chips and leaves, may also be hiding places for pests.

Stone mulches are attractive, permanent and can help to improve soil quality. Red or black cinder, blue rock chips, smooth river rocks and coral chips are some natural choices.[10] Macadamia nut hulls are also easy to find and can make a nice mulch.[11]

Never pile up mulch right next to the stem or trunk of a plant, keep it a few inches away.

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[10] Bornhorst, p. 24

[11] Nagata, p. 7

ZONES

The Maui County Planting Plan has compiled a system of 5 zones of plant growth for Maui County. The descriptions of zones and maps for these zones are as follows:

Zone 1:
Wet areas on the windward side of the island. More than 40 inches of rain per year. Higher than 3,000 feet.

Zone 2:
Cool, dry areas in higher elevations (above 1,000 feet). 20 to 40 inches of rain per year.

Zone 3:
Low, drier areas, warm to hot. Less than 20 inches of rain per year. Sea level to 1,000 feet.

Zone 4:
Lower elevations which are wetter due to proximity of mountains. 1,000 to 3,000 feet.

Zone 5:
Salt spray zones in coastal areas on the windward side.

These zones are to be used as a general guide to planting for Maui County. In addition to lookir at the maps, read the descriptions of the zones and decide which zone best fits your area. Plants can be listed in more than one zone and can be planted in a variety of conditions. For best results, take notes on the rainfall, wind, sun and salt conditions of your site. Use the zones as a general guide for selection and read about the plants to decide which best fits your needs as far as care and or function.

PLACES TO SEE NATIVES ON MAUI:

The following places propagate native Hawaiian plants from seeds and/or cuttings. Their purpose is to protect and preserve these native plants. Please contact them before going to view the sites, they can provide valuable information and referral to other sources.

1. Hoolawa Farms — 575-5099
   P O Box 731
   Haiku HI 96708

2. The Hawaiian Collection — 878-1701
   1127 Manu Street
   Kula HI 96790

3. Kula Botanical Gardens — 878-1715
   RR4, Box 228
   Kula HI 96790

4. Maui Botanical Gardens — 249-2798
   Kanaloa Avenue, Kahului
   across from stadium

5. Kula Forest Reserve
   access road at the end of Waipoli Rd
   Call the Maui District Office — 984-8100

6. Wailea Point, Private Condominium residence — 875-9557
   4000 Wailea Alanui, Kihei
   public access points at Four Seasons Resort or
   Polo Beach

7. Kahanu Gardens, National Tropical Botanical Garden — 248-8912
   Alau Place, Hana HI 96713

8. Kahului Library Courtyard — 873-3097
   20 School Street
   Kahului HI 96732

PLACES TO BUY NATIVE PLANTS ON MAUI

1. Ho'olawa Farms
   Anna Palomino
   P O Box 731
   Haiku HI 96708
   575-5099

   * The largest and best collection of natives in the state. They will deliver, but worth the drive to go and see! Will propagate upon request

2. Kahanu Gardens
   National Tropical Botanical Garden
   Alau Place, Hana
   248-8912

3. Kihana Nursery
   1708 South Kihei Road
   Kihei HI 96753
   879-1165

4. Kihei Garden and Landscape
   Waiko Road, Wailuku
   P O Box 1058
   Puunene HI 96784
   244-3804

5. Kula Ace Hardware and Nursery
   3600 Lower Kula Road
   Kula HI 96790
   876-0734
   * many natives in stock
   * get most of their plants from Ho'olawa Farms
   * they take special requests

6. Kulamanu Farms - Ann Carter
   Kula HI 96790
   878-1801

7. Maui Nui Botanical Gardens
   Kanaloa Avenue
   (Across from stadium)
   Kahului HI 96732
   249-2798

8. Native Gardenscapes
   Robin McMillan
   1330 Lower Kimo Drive
   Kula HI 96790
   870-1421

   * grows native plants and installs landscapes including irrigation.

9. Native Hawaiian Tree Source
   1630 Piiholo Road
   Makawao HI 96768
   572-6180

10. Native Nursery, LLC
    Jonathan Keyser
    250-3341

11. New Moon Enterprises - Pat Bily
    47 Kahoea Place
    Kula HI 96790
    878-2441

12. Waiakoa Tree Farm - Kua Rogoff
    Pukalani HI 96768
    Cell - 264-4166

A Checklist of Water Conservation Ideas For

Golf Courses & Industrial Landscapes

This checklist provides water conservation tips successfully implemented by industrial and commercial users. This list has been revised from the original copy first published and distributed by the Los Angeles Department of Water and Power and the Water Efficiency Manual by the North Carolina Department of Environment and Natural Resources.

START A WATER CONSERVATION PROGRAM

- Increase employee awareness of water conservation.
- Install signs encouraging water conservation in employee and customer restrooms.
- When cleaning with water is necessary, use budgeted amounts.
- Read water meter weekly to monitor success of water conservation efforts.
- Assign an employee to monitor water use and waste.
- Seek employee suggestions on water conservation; put suggestion boxes in prominent areas.
- Determine the quantity and purpose of water being used.
- Determine other methods of water conservation.
- Conduct contests for employees (e.g., posters, slogans, or conservation ideas).

PLANNING AND DESIGN

- Consider the following:
  - Physical conditions (drainage, soil type, sun/shade, etc.) and the use of the site (foot traffic, recreation, viewing, etc.)
  - Creating shade areas, which can be 20 degrees cooler than non-shaded areas, decreasing evaporation.
  - Grass areas only where needed; avoid small areas under 10 feet wide.
  - Permeable materials such as porous concrete or permeable paving methods.
  - Grading and directing surface run-off and rainfall gutters to landscaped areas as opposed to drainageways that exit the property.

- Incorporate high water demanding plants at the bottom of slopes, and maintain the use of existing trees, plants, and wildlife in the area during planning.
- Minimize the use of impermeable surfaces to lessen runoff and resulting stormwater pollution.
- Identify water source points.

- Develop a schematic of all water entry points (know where your faucets, time clocks, solenoids, booster pumps, sprinklers and bubblers are located).
- Identify capacity of each water-carrying unit and frequency of use.
- Determine specific use for each entry source.

ANALYZE AND IMPROVE SOIL CONDITIONS

- Test the soil quality, nutrients and absorptive capacity, and then select plants based on findings. Adjust the pH level if necessary.
- Use organic matter (compost, mulch or manure) to increase the soil's water holding capacity. This helps improve water distribution and lowers levels of evaporation.
- When improving the soil of a given area, remember to treat a larger area around the planting to allow ample space for root systems.
- Prevent heavy construction equipment from compacting soil in areas around trees or other sensitive habitats.

PLANT SELECTION

- Choose native, climate-appropriate species.
- Consider plants' water demand, pest tolerance, soil nutrient and drainage requirements.

INTERIOR AREAS

- Discontinue continuous flow.
- Use ponded water where available.
- Adjust flows to reduce discharge of water.
- Install water-saving devices to decrease water consumption – restrooms (toilet dams and flappers), faucets (aerators), cooling systems.
- Use recycling systems for chillers and cooling towers.
- Consider installing energy-and-water-efficient air conditioning equipment.

MAINTENANCE PROCEDURES

- Sweep materials from floor instead of washing down whenever possible.
- Instruct clean-up crews to use less water where appropriate.
- Check water supply system for leaks.
- Repair dripping faucets and continuously-running or leaking toilets.

DESIGN CRITERIA FOR TURF AND LANDSCAPE AREAS

- Contact the Department of Water Resources or your local water supplier about possible landscape water auditor classes for your golf course managers.
- Hire a golf course and/or landscape architect with water conservation and xeriscape experience.
- Use turf only where actually necessary: Immediate picnic areas/outside lunch areas and gold course target areas (greens, tees, landing areas).
- Turfgrass should be cut to the maximum recommended height for its type (generally a minimum of two inches to a maximum of four inches) for most efficient water use.
- Limit or exclude turf from roughs.

- Use only low-water use plant material in non-turf areas.

- Drip irrigation and microsprays place water at the base of the plant. This reduces evaporation and saves water by not soaking the entire ground surface. This works for trees, shrubs, and groundcovers.
- Use automatic irrigation systems monitored by moisture probes (i.e. tensiometers), and rain shut-off devices to cut power off during rain.
- Design dual watering systems with sprinklers for turf and low-volume irrigation for plants, trees, and shrubs. Operate sprinkler system before sunrise and after sunset. Amount of irrigation can be determined by the evapotranspiration rate, which DWR can help you determine.
- Use properly-treated waste water for irrigation where available.

EXTERIOR AREAS

- Regular aeration of clay soils will improve water holding capabilities and prevent runoff.
- Discontinue using water to clean sidewalks, tennis courts, pool decks, driveways, and parking lots.
- Make sure irrigation water does not run onto streets or into alleys. Adjust sprinklers to water only plants and not sidewalks or roads.
- Use the same size nozzle when replacement is needed. Sprinklers should be replaced with the same brand of sprinklers. Spray heads are aligned with grade.
- Replace worn spray nozzles.
- Regulate pressure properly for system demands.

- Make sure rotors or spray heads are mounted correctly. Replace with proper unit for the job.
- Post a current controller schedule inside the door of the controller.
- Check for leaking valves.
- Adjust the operating time (runtimes) of the sprinklers to meet appropriate seasonal or monthly requirements.
- Check plant leaves and take soil samples to confirm proper system functioning.
- Look into alternative sources for irrigation water (i.e. the use of wells as opposed to city water, water reuse operations from air conditioning condensate, storm water retention ponds, or cisterns, non-contact cooling water).
- Use dedicated water meters to monitor landscaping water use.
- Have a catchment/distribution uniformity test performed on-site to determine how evenly water is applied when sprinklers are in use.

For more information, contact:
Maui County Department of Water Supply
Water Resources and Planning Division
59 Kanoa Street Wailuku, HI 96793
Telephone: (808) 244-8550
FAX: (808) 244-6701

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- Assign an employee to monitor water use and waste.
- Seek employee suggestions on water conservation; put suggestion boxes in prominent areas.
- Determine the quantity and purpose of water being used.
- Determine other methods of water conservation.
- Conduct contests for employees (e.g., posters, slogans, or conservation ideas).

PLANNING AND DESIGN

- Consider the following:
  - Physical conditions (drainage, soil type, sun/shade, etc.) and the use of the site (foot traffic, recreation, viewing, etc.)
  - Creating shade areas, which can be 20 degrees cooler than non-shaded areas, decreasing evaporation.
  - Grass areas only where needed; avoid small areas under 10 feet wide.
  - Permeable materials such as porous concrete or permeable paving methods.

  - Grading and directing surface run-off and rainfall gutters to landscaped areas as opposed to drainageways that exit the property.
- Incorporate high water demanding plants at the bottom of slopes, and maintain the use of existing trees, plants, and wildlife in the area during planning.
- Minimize the use of impermeable surfaces to lessen runoff and resulting stormwater pollution.
- Identify water source points.
- Develop a schematic of all water entry points (know where your faucets, time clocks, solenoids, booster pumps, sprinklers and bubblers are located).

- Identify capacity of each water-carrying unit and frequency of use.
- Determine specific use for each entry source.

ANALYZE AND IMPROVE SOIL CONDITIONS

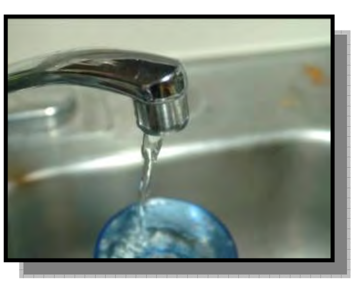
- Test the soil quality, nutrients and absorptive capacity, and then select plants based on findings. Adjust the pH level if necessary.
- Use organic matter (compost, mulch or manure) to increase the soil's water holding capacity. This helps improve water distribution and lowers levels of evaporation.
- When improving the soil of a given area, remember to treat a larger area around the planting to allow ample space for root systems.
- Prevent heavy construction equipment from compacting soil in areas around trees or other sensitive habitats.

PLANT SELECTION

- Choose native, climate-appropriate species.
- Consider plants' water demand, pest tolerance, soil nutrient and drainage requirements.

INTERIOR AREAS

- Discontinue continuous flow.
- Use ponded water where available.
- Adjust flows to reduce discharge of water.
- Install water-saving devices to decrease water consumption – restrooms (toilet dams and flappers), faucets (aerators), cooling systems.



  - Retrofit toilets with high efficiency models that use 1.28 gallons per flush or less.
  - Retrofit urinals with high efficiency models that use 0.5 gallons per flush.
  - Install showerheads with a flow rate of 1.5 gpm at 60 psi or less in all units.
  - Retrofit bathroom sink faucets with fixtures that do not exceed 1 gpm at 60 psi.
- Use recycling systems for chillers and cooling towers.
- Consider installing energy-and-water-efficient air conditioning equipment.

MAINTENANCE PROCEDURES

- Sweep materials from floor instead of washing down whenever possible.
- Instruct clean-up crews to use less water where appropriate.
- Check water supply system for leaks.
- Repair dripping faucets and continuously-running or leaking toilets.

DESIGN CRITERIA FOR TURF AND LANDSCAPE AREAS

- Contact the Department of Water Resources or your local water supplier about possible landscape water auditor classes for managers.
- Hire a landscape architect with water conservation and xeriscape experience.
- Use turf only where actually necessary: Immediate picnic areas/outside lunch areas and gold course target areas (greens, tees, landing areas).
- Turfgrass should be cut to the maximum recommended height for its type (generally a minimum of two inches to a maximum of four inches) for most efficient water use.
- Use only low-water use plant material in non-turf areas.

- Drip irrigation and microsprays place water at the base of the plant. This reduces evaporation and saves water by not soaking the entire ground surface. This works for trees, shrubs, and groundcovers.

- Use automatic irrigation systems monitored by moisture probes (i.e. tensiometers), and rain shut-off devices to cut power off during rain.
- Design dual watering systems with sprinklers for turf and low-volume irrigation for plants, trees, and shrubs. Operate sprinkler system before sunrise and after sunset. Amount of irrigation can be determined by the evapotranspiration rate, which DWR can help you determine.
- Use properly-treated waste water for irrigation where available.

EXTERIOR AREAS

- Regular aeration of clay soils will improve water holding capabilities and prevent runoff.
- Discontinue using water to clean sidewalks, tennis courts, pool decks, driveways, and parking lots.
- Make sure irrigation water does not run onto streets or into alleys. Adjust sprinklers to water only plants and not sidewalks or roads.
- Use the same size nozzle when replacement is needed. Sprinklers should be replaced with the same brand of sprinklers. Spray heads are aligned with grade.

- Replace worn spray nozzles.
- Regulate pressure properly for system demands.
- Make sure rotors or spray heads are mounted correctly. Replace with proper unit for the job.
- Post a current controller schedule inside the door of the controller.
- Check for leaking valves.
- Adjust the operating time (runtimes) of the sprinklers to meet appropriate seasonal or monthly requirements.
- Check plant leaves and take soil samples to confirm proper system functioning.
- Look into alternative sources for irrigation water (i.e. the use of wells as opposed to city water, water reuse operations from air conditioning condensate, storm water retention ponds, or cisterns, non-contact cooling water).
- Use dedicated water meters to monitor landscaping water use.
- Have a catchment/distribution uniformity test performed on-site to determine how evenly water is applied when sprinklers are in use.

For more information, contact:
Maui County Department of Water Supply
Water Resources and Planning Division
59 Kanoa Street Wailuku, HI 96793
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A Checklist of Water Conservation Ideas For Hotels & Motels

This checklist provides water conservation tips successfully implemented by industrial and commercial users. This list has been revised from the original copy first published and distributed by the Los Angeles Department of Water and Power and information provided by WaterSense.

START A WATER CONSERVATION PROGRAM

- Increase employee awareness of water conservation.
- Install signs encouraging water conservation in employee and guest restrooms.
- When cleaning with water is necessary, use budgeted amounts.
- Determine the quantity and purpose of water being used.
- Read water meter weekly to monitor success of water conservation efforts.
- Assign an employee to monitor water use and waste.
- Seek employee suggestions on water conservation; put suggestion boxes in prominent areas.
- Determine other methods of water conservation.
- Conduct contests for employees (e.g., posters, slogans, or conservation ideas.

BUILDING MAINTENANCE

- Check water supply for leaks and turn off any unnecessary flows.
- Repair dripping faucets and showers and continuously-running or leaking toilets.
- Install flow reducers and faucet aerators in all plumbing fixtures where-ever possible.
  - Retrofit toilets with high efficiency models that use 1.28 gallons per flush or less.
  - Retrofit urinals with high efficiency models that use 0.5 gallons per flush.
  - Install showerheads with a flow rate of 1.5 gpm at 60 psi or less in all units.
  - Retrofit bathroom sink faucets with fixtures that do not exceed 1 gpm at 60 psi.

- Reduce water used in toilet flushing by adjusting the vacuum flush mechanism or installing toilet tank displacement devices (dams, bottles, or bags).
- As appliances or fixtures wear out, replace them with water-saving models.
- Shut off water supply to equipment rooms not in use.
- Minimize the water used in cooling equipment in accordance with manufacturers' recommendations. Shut off cooling units when not needed.

- Keep hot water pipes insulated.
- Avoid excessive air conditioner blow-down. (Monitor total dissolved solids levels and blow-down only when needed). Utilize cooling/HVAC systems that conserve water and energy. Single-pass cooling should not be permitted.
- Install appropriate treatment systems to manage cooling tower make-up water quality.
- Instruct clean-up crews to use less water for mopping.
- Switch from wet or steam carpet cleaning methods to dry powder methods.
- Change window cleaning schedule from periodic to an on-call/as required basis.

POOLS AND FOUNTAINS

- Channel splashed-out pool water onto landscaping.
- Lower pool water level to reduce amount of water splashed out.
- Use a pool cover to reduce evaporation when pool is not being used.
- Reduce the amount of water used to clean pool filters.

- Designate a separate meter for fountains to monitor for use, leaks, and onset of malfunctions
- Prohibit use of potable water in water decorations
- Use a re-circulating water system and monitor evaporation
- Limit the hours of operation to only when the facility is in use, and shut system off during times of drought

KITCHEN AREA

- Turn off the continuous flow used to clean the drain trays of the coffee/milk/soda beverage island: clean the trays only as needed.
- Turn dishwasher off when not in use. Wash full loads only.
- Use water-conserving ice makers. Replace water-cooled ice machines with efficient air-cooled models.
- Recycle water where feasible, consistent with state and county requirements.
- Recycle rinse water from the dishwater or re-circulate it to the garbage disposal.

- Consider using "waterless woks."
- Presoak utensils and dishes in ponded water instead of using a running water rinse.
- Wash vegetables in ponded water; do not let water run in preparation sink.
- Use air-cooled or closed-system re-circulating refrigeration systems.
- Use water from steam tables to wash down cooking area.
- Do not use running water to melt ice or frozen

BAR

- Do not use running water to melt ice in the sink strainers.

LAUNDRY

- Encourage guests to re-use sheets and towels by placing tent cards in rooms.
- Reprogram machines to eliminate a rinse or suds cycle, if possible, and if not restricted by health regulations.
- Wash full loads only.
- Evaluate wash formula and machine cycles for water use efficiency.
- Adequate towel rack space enables and encourages guests to hang towels neatly. This can result in less required daily washing.

- Use Tunnel washers or multi-load washer extractors that should utilize no more than 2 gallons of water per pounds of laundry. Energy Star and WaterSense certified regular commercial clothes washers use no more than 6 gallons per cubic foot of laundry.

EXTERIOR AREAS

- Convert from high-water using lawns, trees, and shrubs to xeriscape: Plan landscapes that require less water by using native, zone-appropriate plants.
- Inventory outdoor water use for landscaped areas.
- Do not water landscape everyday; two-to-three times a week is usually sufficient.

- Stop hosing down sidewalks, driveways, and parking lots.
- Wash autos, buses, and trucks less often.
- Avoid plant fertilizing and pruning that would stimulate excessive growth. Install good control systems to monitor and manage values referred to in the following points.
- Remove weeds and unhealthy plants so remaining plants can benefit from the water saved.
- In many cases, older established plants require only infrequent irrigation. Look for indications of water need such as wilt, change of color, or dry soil.
- Install soil moisture overrides or timers on sprinkler systems. Smart controllers self-adjust depending on moisture conditions, and of multiple programming to separate turf and non-turf areas.
- Time watering, when possible, to occur in the early morning or evening when evaporation and discourage weeds.
- Remove thatch and aerate turf to encourage the movement of water to the root zone.
- Avoid run-off and make sure sprinklers cover just the lawn or garden, not sidewalks, driveways, or gutters.
- In winter, water only during prolonged hot and dry periods (During spring and fall, most plants need approximately half the amount needed during the summer.)

For more information, contact:

Maui County Department of Water Supply
Water Resources and Planning Division
59 Kanoa Street Wailuku, HI 96793
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A Checklist of Water Conservation Ideas For Multi-pass Cooling Towers & Chillers

MULTI-PASS COOLING

Conduct an Analysis and Audit of Cooling Towers

- Number of Towers
- Number of Passes
- Area, equipment or processes to be cooled
- Minimum cooling requirements (temperature, volume, duration, hours)
- Existence and location of meters in cooling towers
- Historical water use records for a minimum of three years
- Meter reading for make-up water
- Evaporative and other losses
- Total Dissolved Solids (TDS) Concentration in make-up and blow-down water
- Concentration ratios
- All health, safety, operational, regulatory, administrative and other requirements or policies that apply to the site

Consider Water Conservation in Selection and Contracting for Cooling Systems

- Design, specify and bid cooling systems as models to comply with.
- Include a cycles of concentration, corrosion and microbial KPI specification in the contract for a water service treatment provider. This will help to result in prompt identification and repair of leaks.
- Ensure that the cooling tower sump or holding tank is sized to accommodate any water returning from system pipe work when re-circulating pumps are shut down.
- Install a non-return valve on the pump delivery side to minimize water loss during tower shut-down.

Cooling Tower or Chiller Blow-down: *Water that is removed from re-circulating cooling water to reduce contaminant build-up.*

Typical Amounts: Amounts vary with water quality and other factors, but optimization of blow-down represents the greatest opportunity for water efficiency improvement in cooling tower systems.

- Install good control systems to monitor and manage values referred to in the following points.
- Keep the ratio of make-up water quality to blow-down with water quality high. This ratio is called the "concentration ratio," or "cycle of concentration."
- Typical past concentration ratios were 2 to 3. These ratios can be raised to six or more, depending upon make-up water quality as well as the use and sensitivity of the cooling system.

- Maintain a high initial make-up water quality.

- Install treatment systems designed to maximize make-up water quality and/or improve quality of re-circulating water. NOTE: Selection of treatment options and best management for water quality for treatment systems and operations are also important factors to consider.

- Install sub-meters on the make-up water feed line and the blow-down line.

- If loads allow, design towers and adequate controls to allow for proportional or continuous make-up rather than batching, to avoid saw-tooth patterns and increase overall cycles

Make-up: *Water that is added to cooling towers to replace evaporation, blow-down and drift losses.*
Typical Amounts of Make-up: blow-down + evaporation + drift losses

- Maintain a high initial make-up water quality.

- Install treatment systems designed to maximize make-up water quality and/or improve quality of re-circulating water.

- Install sub-meters on the make-up water feed line and the blow-down line to enable careful monitoring and control of water use.

Evaporation: *Water evaporated to cool the temperature of the remaining water. Loss of heat by evaporation is about 1,000 BTU per pound of water evaporated.*
Typical Amounts of Evaporation: 1% of the rate of flow of re-circulating water for every 10° drop in temperature achieved by the tower, or -3 gpm per 100 tons of cooling load. (A ton, when used to describe cooling tower capacity, is about 12,000 BTU per hour of heat removal). Dew points also affect cooling. Cooling reduced when dew points are high. The lower the dew point, the greater temperature difference between water flowing into and out of the tower.

- Install good control systems so that when the dew point temperatures are low, fans can be slowed by using motor speed controls or cycled on and off, saving energy and evaporative losses.

Drift Losses: *Water lost from the cooling tower in the form of mist carried out by air drafts.*
Typical Amounts of Drift Losses: 0.2 – 0.5% of total circulation rate.

- Reduce drift through baffles or drift eliminators

MAINTENANCE

Routine Check:

- Test water sample of cooling towers for proper concentration of dissolved solids. Adjust blow-down flows as necessary.
- Measure water treatment chemical residue in circulating water.
- Check strainers on bottom of collection basins.
- Check switches on make-up water controls.
- Inspect all moving parts.
- Check for excessive vibration in motors, fans, pumps, etc.
- Manually test the vibration limit switch by jarring it.
- Look for oil leaks in gearboxes.
- Check seals in cooling tower circulating pump for leaks.
- Insure the ball float is set and operating properly.
- Check for any structural deteriorating, loose connectors, water leaks, signs of drift, or openings in casings.
- Ensure that fill media within the cooling tower, if fitted, is in good condition to obtain optimum cooling. Fill which can be easily removed and cleaned will reduce build-up and increase efficiency.
- Seek and repair any unwanted flows in the cooling tower system.
- Maintain a log and watch for changes in:
  - Meter readings for make-up water
  - Meter readings for blow down water
  - Evaporative and other losses
  - Total Dissolved Solids (TDS) concentration in make-up and blow-down water
  - Concentration ratios

For more information, contact:
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A Checklist of Water Conservation Ideas For

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GENERAL SUGGESTION

- Increase employee awareness of water conservation.
- Install signs encouraging water conservation in employee and customer restrooms.
- When cleaning with water is necessary, use budgeted amounts.
- Read water meter weekly to monitor success of water conservation efforts.
- Assign an employee to monitor water use and waste.
- Seek employee suggestions on water conservation; put suggestion boxes in prominent areas.
- Determine the quantity and purpose of water being used.
- Determine other methods of water conservation.
- Conduct contests for employees (e.g., posters, slogans, or conservation ideas).
- Provide table signs urging water conservation.
- Serve water only when requested by the customer.

BUILDING MAINTENANCE

- Reduce the load on air conditioning units by shutting off air conditioning when and where it is not needed.
- Check the water supply system for leaks and turn off any unnecessary flows.

- Repair dripping faucets and showers and continuously-running or leaking toilets.
- Install flow reducers and faucet aerators in all plumbing fixtures where-ever possible.
- Reduce water used in toilet flushing by adjusting the vacuum flush mechanism or installing toilet tank displacement devices (dams, bottles, or bags).
- As appliances or fixtures wear out, replace them with water-saving models.
- Shut off water supply to equipment rooms not in use.
- Minimize the water used in cooling equipment in accordance with manufacturers' recommendations. Shut off cooling units when not needed.
- Keep hot water pipes insulated.
- Avoid excessive air conditioner blow-down. (Monitor total dissolved solids levels and blow-down only when needed).

- Instruct clean-up crews to use less water for mopping.
- Switch from wet or steam carpet cleaning methods to dry powder methods.
- Change window cleaning schedule from periodic to an on-call/as required basis.

KITCHEN AREA

- Turn off the continuous flow used to clean the drain trays of the coffee/milk/soda beverage island: clean the trays only as needed.
- Consider using a "waterless wok."
- Dishwashers
  - Promote hand-scraping the dishes before loading a dishwasher.
  - Turn dishwasher off when not in use. Wash full loads only and try to fill racks to maximum capacity.
  - Keep flow rates as close to manufacturer's specifications as possible.
  - Install advanced rinse nozzles.
  - Install door switches for convenient on/off access.
  - Check voltage of boosters heater to make sure it fits the machine.
  - Use "steam doors" to prevent loss of water due to evaporation.
  - Check volumes of service and estimate facility needs. A better option may be a larger machine that has a lower water flow per rack rate.

- Faucets
  - Do not leave faucets on to thaw vegetables and other frozen foods.
  - Post water conservation literature and reminders to staff around work areas.
  - Educate staff to look for leaks and broken faucets in their area.
  - Replace spray heads with high- efficiency sprayers to reduce water flow.
  - Adjust flow valve to reduce water flow.
  - Check for leaks and worn gaskets.
  - Install a flow restrictor to limit maximum flow rate to 2.5 gpm or less.
  - Install a 2.5 gpm faucet aerator, maximizing flow efficiency by increasing air-flow to the stream.
  - Consider infrared or ultrasonic sensors that activate water flow only in the presence of hands or some other object.
  - Install pedal operated faucet controllers to ensure valves are closed when not in use.

- Use water from steam tables to wash down cooking area.
- Use water-conserving ice makers, one that uses an air-cooled compressor if possible.
- Recycle water where feasible, consistent with state and county requirements.
- Recycle rinse water from the dishwater or re-circulate it to the garbage disposal.
- Minimize use of a garbage disposal by using a strainer/trap and disposal in trash or compost.
- Presoak utensils and dishes in ponded water instead of using a running-water rinse.
- Wash vegetables in ponded water; do not let water run in preparation sink.

BAR

- Do not use running water to melt ice in the sink strainers.

EXTERIOR AREAS

- Convert from high-water using lawns, trees, and shrubs to xeriscape: Landscape design incorporating plants providing beautiful color and requiring less water. Plan landscapes that require less water.

- Inventory outdoor water use for landscaped areas.
- Do not water landscape everyday; two-to-three times a week is usually sufficient.
- Stop hosing down sidewalks, driveways, and parking lots.
- Wash autos, buses, and trucks less often.
- Avoid plant fertilizing and pruning that would stimulate excessive growth. Install good control systems to monitor and manage values referred to in the following points.

- Remove weeds and unhealthy plants so remaining plants can benefit from the water saved.
- In many cases, older established plants require only infrequent irrigation. Look for indications of water need such as wilt, change of color, or dry soil.
- Install soil moisture overrides or timers on sprinkler systems.
- Time watering, when possible, to occur in the early morning or evening when evaporation is lowest.
- Mulch around plants to reduce evaporation and discourage weeds.
- Remove thatch and aerate turf to encourage the movement of water to the root zone.
- Avoid run-off and make sure sprinklers cover just the lawn or garden, not sidewalks, driveways, or gutters.
- Throughout winter, water only during prolonged hot and dry periods (During spring and fall, most plants need approximately half the amount needed during the summer.)

For more information, contact:
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Water Resources and Planning Division
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This checklist provides water conservation tips successfully implemented by industrial and commercial users. Adapted from original material by: the Los Angeles Department of Water and Power; Amy Vickers "Handbook of Water Use & Conservation" and the North Carolina Division of Pollution Prevention.

GENERAL SUGGESTIONS

- Increase employee awareness of water conservation. Seek employee suggestions on water conservation; put suggestion boxes in prominent areas. Conduct contests for employees (posters, slogans, ideas, etc.)
- Install signs encouraging water conservation in employee and customer restrooms..
- Determine the quantity and purpose of water being used. Read water meters weekly to monitor success of water conservation efforts.
- Assign an employee to monitor water use and waste.

BUILDING MAINTENANCE

- Check water supply for leaks and turn off any unnecessary flows.
- Repair dripping faucets, continuously-running or leaking toilets and other leaking fixtures.
- Install flow reducers and faucet aerators in all plumbing fixtures where-ever possible.
- Install High Efficiency Toilets, or reduce water used in toilet flushing by adjusting the vacuum flush mechanism or installing toilet tank displacement devices (dams, bottles, or bags).
- As appliances or fixtures wear out, replace them with high efficiency water-saving models., ideally with *WaterSense* labels.
- Install high efficiency commercial washers.
- Shut off water supply to equipment rooms not in use.
- Keep hot water pipes insulated.
- Avoid excessive filter or softener back flush. Back flush only when needed.
- Avoid excessive air conditioner blow-down. (Monitor total dissolved solids levels and blow-down only when needed).
- Minimize the water used in cooling equipment in accordance with manufacturers recommendations. Shut off cooling units when not needed.
- When cleaning with water is necessary, use budgeted amounts

OPERATIONS

- Evaluate wash formula and machine wash cycles for water use efficiency.
- Operate equipment with full loads only.

- Reduce water levels if possible for partial loads to minimize required water per load.
- Replace or modify existing conventional laundry equipment to reduce water use.
- Replace traditional commercial clothes washers with high efficiency commercial washers, which can save as much as two thirds of the energy and water used by traditional models.
- Install a computer-controlled rinse water reclamation system. These can save as much as 25% of wash load's water demand by diverting rinse water to a storage tank for later re-use as wash water.
- Install a wash and rinse water treatment and reclamation system , except where prohibited by health codes in specialized situations. Recycling both wash and rinse water can reduce a laundry's water demand by as much as 50%.
- Install a continuous batch (or tunnel) washer, which can reduce water demand by about 60% compared with that of washer extractors.
- Install an electrically generated ozone laundry system, which can reduce water use by about 10% compared with that of traditional laundering systems. The ozone acts as a cleaning agent and reduces detergent use by 30 to 90 percent.
- Consult service personnel and the laundry's supplier of chemicals for the washer extractors to ensure that equipment is operating at optimal efficiency.
- Avoid excessive back-flushing of filters or softeners; back-flush only when necessary.
- Place "save water" notices in hotel and motel guest rooms, urging guests to save water by minimizing the amount of water that needs to be laundered.

EXTERIOR AREAS

- Convert from high-water using lawns, trees, and shrubs to *xeriscape*: Landscape design incorporating plants providing beautiful color and requiring less water. Plan landscapes that require less water.
- Inventory outdoor water use for landscaped areas.
- Make sure irrigation water does not run into gutters, streets or alleys. Use controllers on sprinkler systems.
- Do not water landscape everyday; two-to-three times a week is usually sufficient.
- Stop using water to clean sidewalks, driveways, loading docks and parking lots. Consider using brooms or motorized sweepers instead.
- Wash autos, buses, and trucks less often.
- Avoid plant fertilizing and pruning that would stimulate excessive growth. Install good control systems to monitor and manage values referred to in the following points.
- Remove weeds and unhealthy plants so remaining plants can benefit from the water saved.
- In many cases, older established plants require only infrequent irrigation. Look for indications of water need such as wilt, change of color, or dry soil.
- Install soil moisture overrides or timers on sprinkler systems.
- Time watering, when possible, to occur in the early morning or evening when evaporation and discourage weeds.
- Remove thatch and aerate turf to encourage the movement of water to the root zone.
- Avoid run-off and make sure sprinklers cover just the lawn or garden, not sidewalks, driveways, or gutters.
- Ensure that irrigation systems are equipped with a rain shut-off device.
- Install smart controllers capable of responding appropriately to weather or soil moisture conditions.

For more information, contact:
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A Checklist of Water Conservation Ideas For Schools & Colleges

This checklist provides water conservation tips successfully implemented by industrial and commercial users. This list has been revised from the original copy first published and distributed by the Los Angeles Department of Water and Power.

GENERAL SUGGESTIONS

- Increase employee awareness of water conservation.
- Install signs encouraging water conservation in employee and student restrooms.
- When cleaning with water is necessary, use budgeted amounts.
- Read water meter weekly to monitor success of water conservation efforts.
- Assign an employee to monitor water use and waste.
- Seek employee and student suggestions on water conservation; put suggestion boxes in prominent areas.
- Determine the quantity and purpose of water being used.
- Determine other methods of water conservation.
- Conduct contests for employees and students (e.g., posters, slogans, or conservation ideas).
- Make up-to-date reading materials available for students and employees in the library and classroom.

BUILDING MAINTENANCE

- Check water supply system for leaks.
- Turn off any unnecessary flows.

- Repair dripping faucets and showers and continuously-running or leaking toilets.
- Install flow reducers and faucet aerators in all plumbing fixtures where possible.
  - Retrofit toilets with high efficiency models that use 1.28 gallons per flush or less.
  - Retrofit urinals with high efficiency models that use 0.5 gallons per flush.
  - Install showerheads with a flow rate of 1.5 gpm at 60 psi or less in all units.
  - Retrofit bathroom sink faucets with fixtures that do not exceed 1 gpm at 60 psi.
- Reduce the water used in toilet flushing by either adjusting the vacuum flush mechanism or installing toilet tank displacement devices (dams, bottles, or bags).
- As appliance or fixtures wear out, replace them with water-saving models.

- Shut off water supply to equipment rooms not in use.
- Minimize the water used in cooling equipment, such as air compressors, in accordance with manufacturer recommendations.
- Reduce the load on air conditioning units by shutting air conditioning off when and where it is not needed.
- Keep hot water pipes insulated.
- Avoid excessive boiler and air conditioner blow-down. (Monitor total dissolved solids levels, and blow-down only when needed.)
- Instruct clean-up crews to use less water for mopping.
- Change window cleaning schedule from periodic to an on-call/as-required basis.

KITCHEN AND LAUNDRY AREAS

- Turn off the continuous flow used to clean the drain trays of the coffee/milk/soda beverage island; clean the trays only as needed.
- Turn dishwasher off when not in use. Wash full loads only.
- Make sure "electric eye" sensors are installed in your dishwasher to monitor dirt circulating in the water.
- Replace spray heads to reduce water flow.
- Recycle rinse water from the dishwater or re-circulate it to the garbage disposal.
- Do not use running water to melt ice or frozen foods. If necessary, use ponded water.
- Use water conserving ice makers.
- Presoak utensils and dishes in ponded water instead of using a running water rinse.
- Wash vegetables in ponded water; do not let water run in preparation sink.
- Use water from steam tables in place of fresh water to wash down cooking area.
- Reprogram washing machines to eliminate a rinse or suds cycles when possible and if not restricted by health regulations.
- Reduce water levels, where possible, to minimize water required per load of washing.
- Only wash full loads of clothes.
- Evaluate wash formula and machine cycles for water use efficiency.

POOL

- Lower pool water to reduce amount of water splashed out.
- Use a pool cover to reduce evaporation when pool is not in use.
- Reduce amount of water used to clean pool filters.

EXTERIOR AREAS

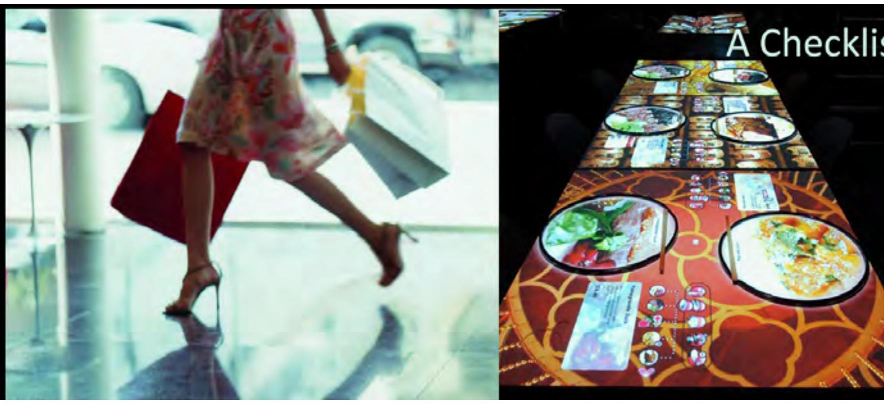
- Convert from high-water using lawns, trees, and shrubs to xeriscape – Landscape design incorporating plants that provide beautiful color and requiring less water. In the future, design landscapes that require less water, such as drought-resistant grass on playing fields.
- Inventory outdoor water use for landscaped areas.

- Water landscape only when needed: two-to-three times a week is usually sufficient.
- Wash autos, buses, and trucks less often.
- Discontinue using water to clean sidewalks, driveways, loading docks, and parking lots. Consider using brooms or motorized sweepers.
- Avoid landscape fertilizing and pruning that may stimulate excessive growth.

- Remove weeds and unhealthy plants so remaining plants can benefit from the water saved.
- In many cases, older, established plants require only infrequent irrigation. Look for indications of water needs such as wilt, change of color, or dry soils.
- Install soil moisture overrides or timers on sprinkler systems.
- When possible, time watering to occur in the morning or evening when evaporation is lowest.
- Make sure irrigation equipment applies water uniformly.
- Investigate the advantages of installing drip irrigation systems.
- Mulch around plants reducing evaporation and discouraging weeds.
- Remove thatch and aerate turf to encourage the movement of water to the root zone.
- Avoid run-off and make sure sprinklers cover just the lawn or garden, not sidewalks, driveways, or gutters.

- In winter, water only during prolonged hot and dry periods (During spring and fall, most plants need approximately half the amount needed during the summer.)

For more information, contact:
Maui County Department of Water Supply
Water Resources and Planning Division
59 Kanoa Street Wailuku, HI 96793
Telephone: (808) 244-8550
FAX: (808) 244-6701



A Checklist of Conservation Ideas for MIXED-USE SHOPPING CENTERS

It's Easier To Save What You Measure & Watch

- Prepare an inventory of anticipated fixture units and counts, water uses and water using appliances and equipment, including landscapes, laundries, kitchens, cooling and other areas throughout the facility, locations and purposes of controls, sub-meters, water filters or recycling systems, locations and amounts of irrigated acreage, irrigation system elements, controllers, circuits and settings, acreage and volume of pools, filtration equipment, etc.
- Design structures such that individual units and or operations can be metered separately or at least sub-metered.
- Once an inventory of water uses and conservation opportunities has been made, and measures undertaken, it is important to take stock of the actual performance of conserving measures. A useful tool is an annual tally of what has been done, the goal of each measure taken, and how the results panned out. Document the recorded savings or reductions in peak factors, to assist in fine-tuning facility management for conservation as time goes on. An annual inventory of uses, performance, and changes made to fixtures or processes such as treatment, recycling, or other measures to conserve, as well as water use impacts of each, should become a regular practice.
- A regular, pro-active maintenance program should be established for all areas of the complex. This should include checking for and repairing leaks, both indoors and out. It should also include checking valves, water pressures etc. where specific water using operations call for this as part of normal maintenance.
- Inspect steam lines and traps, all plumbing fixtures, hot and cold water lines, drinking fountains, and water-using appliances routinely in order to catch problems early and to keep these devices operating optimally.
- Shut off the water supply to equipment in areas that are not currently in use.

Fixtures and Appliances

- Specify, select and or require tenants to utilize efficient fixtures and appliances. Efficient water use can save on electricity as well. A list of WaterSense certified high-efficiency toilets and other fixtures may be found at http://www.epa.gov/WaterSense/pp/index.htm .
- Toilets should be high efficiency models that use 1.28 gallons per flush or less
- Urinals should be high efficiency models that use 0.5 gallons per flush or less.
- Showerheads, if any, should have a flow rate of 2 gpm at 60 psi or less in all units.
- Bathroom sink faucets with fixtures should not exceed 1 gpm at 60 psi. (even more efficient models are available)

Cooling

- Cooling / HVAC systems should be constructed, commissioned and operated in a manner that conserves water as well as energy.
- Single pass cooling should not be permitted.
- Recent data indicate that increasing energy efficiency in coolers can also increase water efficiency. Consider ordering units that comply with LEED specifications for energy efficiency and

controllability, as well as the specific water conservation measures listed below for multi-pass systems:

- Install control systems and sub-metering to monitor and manage water quality and other parameters in make-up water and blow-down.
- Install appropriate treatment systems to manage water quality in cooling tower make-up water.
- Operate cooling towers with greater than 5 cycles of concentration if possible.
- Minimize drift losses with baffles or drift eliminators.
- Establish a proactive cooling system maintenance and monitoring program.

Kitchens, Restaurants, Snack Shops, Ice Making, Cooking and Washing

- Select efficient air cooled ice machines.
- Refrigeration systems should be air-cooled or closed-system recirculating systems.
- Pre-rinse spray valves on dishwashers shall have a flow rate equal to or less than 1.6 gpm at 60 psi.
- Food steamers should be self-contained "boilerless" or "connectionless" models.
- Wok stoves should be "waterless woks".
- Ware washing units should have flow rates of less than 1 gallon per rack.
- Install an on-demand water heater near sinks and other places where warm water is needed to avoid having customers and employees run water while waiting for hot water.
- Use water from steam tables to wash down cooking area.
- If it is necessary to use water (e.g., grocery store meat cutting rooms, commercial kitchens, and medical facilities), employ high pressure, low-volume sprays (which work better than lowpressure, high volume sprays). Use portable high pressure pumps where needed to reduce the amount of water used for cleaning by up to 40 percent. When cleaning with water, stick to budgeted amounts for each job.
- Do not use running water to thaw food.
- Place tent cards in restaurants informing guests that water is available upon request, rather than automatically serving it.

Laundries and Washing Services

- If tunnel washers or multi-load washer extractors are used, they should utilize no more than 2 gallons of water per pound of laundry.
- If regular commercial clothes washers are used, install washers that are Energy Star and WaterSense certified, or have a water factor (gallons/cubic foot of laundry) of not more than 6.

Landscape

- All irrigated areas shall be equipped with smart controllers capable of self-adjusting to account for moisture conditions, and of multiple programming for separation of turf and non-turf areas.
- Irrigation valves and circuits should be arranged such that plants with different water requirements are watered separately and appropriately. (hydrozones).
- Select native plant species that are adapted to the natural rainfall and salt conditions in the area. The use of climate-adapted native plants conserves water and protects watersheds from the spread of invasive plant species.
- Install spring-loaded valves or timers on all manually operated hoses.
- Water features are discouraged in general. However, even water features can be made more efficient. High efficiency filtration systems are available fountains.

Employee Involvement

- Aside from a regular pro-active inspection and maintenance, encourage employees to be conscious of water use. Think about how floors and other areas are cleaned. Is water necessary? Would brooms or wet wash rags work as well as hoses?
- Set up an easy procedure for employees to report leaks.
- Repair leaks and malfunctions promptly, not only to save water but to show employees that their reports of leaks are taken seriously.
- Place a “Water Conservation Suggestion Box” in a conspicuous place and ask for employee suggestions.

APPENDIX J

Conistency with the 1998 Community Plan

Community Plan Consistency

The last version of the Lana`i Community Plan was adopted by the Maui County Council on December 8th, 1998. The Maui County Charter, §8-11.2(3) requires that the Water Department's Long Range Plan conform with the County's general and community plans. For that reason, the entire Lana`i Community Plan has relevance for the Lana`i Water Use and Development Plan, and the reader is encouraged to review both plans. An update of the plan is expected shortly, However, some of the key goals, objectives, policies and implementing actions that pertain to water issues within that plan are noted, with comments as to how the WUDP addressed thse items.

Economic Activity:

Objectives and Policies:

Item 4: **Promote diversified agriculture as a means of establishing job and income stability.**

Implementing Actions

Item 5: **Establish and reserve a minimum water allocation to meet the needs of diversified agriculture, consistent with the Water Use and Development Plan for Lana`i as approved by law.**

WUDP Response: LWAC made pro-active efforts to identify current and future agricultural needs during the drafting of the Working Group Report. The allocation agreed to at that time, in the amount of a 500,000 GPD reserve has remained the recommended allocation of LWAC.

Land Use:

Objectives and Policies:

Item 6: Continue to encourage the development of a regulatory review process which encourages and facilitates public participation in all major land development activities.

WUDP Response: Establishment and implementation of Lana`i Water Advisory Committee by the Board of Water Supply, allowed for an additional community mechanism to discuss and resolve water issues involved in land use decisions, and make recommendations to the Lana`i Planning Commission or other governmental bodies regarding water aspects of land use decisions.

Item 11: Preserve and maintain lands used for hunting or which are designated as game management areas.

WUDP Response: LWAC discussion of need for watershed protection as primary need of the WUDP, efforts to obtain peer review on watershed protection priorities, discussion and review of fencing options and needs, public presentation of such options, DWS and LWAC participation in the development and on-going implementation of a Lana`i Forest and Watershed Partnership, support by DWS for acquisition of grant funding, and incorporation of a watershed protection chapter in the WUDP, with provision for continued game management.

Item 13: Ensure that coastal land uses are compatible with management, protection and restoration needs of Lana`i's coastal resources.

WUDP Response: Watershed protection chapter in the WUDP includes provision for fire prevention and erosion control measures among others that should help protect coastal resources as well as Lanaihale, also support by DWS for acquisition of grant funding for same during WUDP process.

Environment

Objectives and Policies: Ecosystems can not effectively be broken into constituent parts, but are rather intricately interconnected systems. Therefore, all of the environmental objectives, policies and implementing actions are listed herein, as all have at least some relation to water issues. Items specifically addressed in the WUDP are noted by explanations beneath.

Item 1: Manage, protect, and where appropriate, restore Lana`i's Coastal Resources.

Item 2: Protect and manage coastal water quality through best management land treatment practices.

WUDP Response: The watershed protection chapter in the WUDP includes provision for fire prevention and erosion control measures among others that should help protect coastal resources as well as Lanaihale, also support by DWS for acquisition of grant funding for same during WUDP process.

Item 3: Incorporate waste recycling and reuse as major elements of the island's environmental resource management and protection program.

Item 4: Ensure the long-term availability of low-cost water for agricultural purposes consistent with the Water Use and Development Plan for Lana`i as approved by law.

Item 5: Establish agricultural water needs as a priority in developing and allocating the island's limited water resources consistent with the Water Use and Development Plan for Lana`i as approved by law.

WUDP Response: LWAC made pro-active efforts to identify current and future agricultural needs during the drafting of the Working Group Report. The allocation agreed to at that time, in the amount of a 500,000 GPD reserve has remained the recommended allocation of LWAC.

Item 6: Protect, preserve restore and enhance Lana`i's existing and potential water recharge areas.

WUDP Response: In addition to watershed chapter, partnership, fencing and management efforts on Lanaihale prescribed in plan, the plan includes modeled wellhead protection areas as suggested by the University of Hawaii's Water Resources Research Center.

Item 7: Recognize and preserve traditional uses of the environment to address subsistence needs of the residents of Lana`i.

Item 8: Protect and restore native habitats through conservation, land management and educational programs.

Item 9: Restore the environmental integrity of Lana`i's terrestrial resources through development of a comprehensive forest management and reforestation program utilizing native species.

WUDP Response: LWAC discussion of need for watershed protection as primary need of the WUDP, efforts to obtain peer review on watershed protection priorities, discussion and review of fencing options and needs, public presentation of such options, DWS and LWAC participation in the development and on-going implementation of a Lana`i Forest and Watershed Partnership, support by DWS for acquisition of grant funding, and incorporation of a watershed protection chapter in the WUDP, with provision for continued forest management.

Item 10: Protect and enhance the island's native plant and animal species by prohibiting the importation of alien species.

WUDP Response: List of plants to avoid is attached as appendix to WUDP watershed chapter.

Item 11: Recognize and support agriculture, forestry and game management as key elements in maintaining, preserving and protecting Lanai's land, water and marine resources.

WUDP Response: Same as listed for items 8 and 9 above.

<u>Implementing Actions:</u>

WUDP response (general) to all 10 items below: WUDP Response items provided below are abbreviated because, except where otherwise noted, the response for most of these Environmental Implementing actions may be found within the WUDP in the watershed protection chapter, as well as supporting documentation such as the partnership MOU and in allocations for agricultural use as defined in consensus-based allocation tables.

Item 1: Update and implement watershed, flood prevention and soil conservation programs.

WUDP Response: See watershed chapter & funding applications to support management.

Item 2: Establish and reserve a minimum water allocation to meet the needs of diversified agriculture consistent with the Water Use and Development Plan as approved by law.

WUDP Response: See allocation tables.

Item 3: Maintain the Marine Life Conservation District at Manele/Hulopoe Bays

Item 4: Maintain the existing boundaries of the Kanepu`u Dryland Forest

WUDP Response: Lana`i Forest and Watershed Partnership formalizing MOU specifies continued protection of the dryland Kanepu`u preserve as well as Lanaihale.

Item 5: Identify coastal access opportunities through former agricultural roads and trails, including: Community Plan published as ordinance 2738 in county clerk's office lists 101 trails and roads on page 42

Item 6: Prohibit the use of high level aquifer water for golf course irrigation purposes, consistent with the Water Use and Development Plan for Lana`i, as approved by law.

WUDP Response: See allocation tables.

Item 7: Conduct a regional land resource assessment to:

Identify areas suitable for revegetation and reforestation with native plant species; and

Identify areas suitable for designation as groundwater recharge expansion areas.

WUDP Response: See watershed chapter AND Wellhead protection / groundwater recharge areas delineated by UH Water Resources Research Center.

Item 8: Establish a feral animal control program and apply appropriate game management techiniques (e.g. provision of feed and water stations) for purposes of protecting and preserving groundwater recharge areas.

WUDP Response: See watershed chapter, partnership activity, and periodic reports from conservation and game management divisions of CCR to LWAC.

Item 9: Develop a system of floating preserves (e.g. a "konohiki system") as a means of managing nearshore coastal resources.

Item 10: Encourage and support the establishment and/or expansion of native Lana`i plant species, utilizing appropriate practices and techniques for propagation, planting, and distribution of native plant species. Support the development of approval processes for nursery sources of native plant species.

WUDP Response: See watershed chapter, partnership and grant acquisition activity.

Cultural Resources

<u>Objectives and Policies:</u>

Item 3: Recognize the importance of historically and archaeologically sensitive sites and encourage their preservation.

Item 8: Preserve and protect native Hawaiian rights customarily and traditionally exercised for subsistence, cultural and religious purposes in accordance with Article XII, §7 of the Hawaii State Constitution, and the Hawaii Supreme Court's PASH opinion, 79 Haw. 425 (1995).

Implementing Actions:

Item 13: Stabilize the hillside at Luahiwa to protect petroglyphs from erosion. Consider the potential effects of increased foot traffic on erosion in the vicinity of the petroglyphs before deciding to develop and interpretive trail or other access.

WUDP Response to Cultural Resources Items: WUDP is only tangentially related, but response should be noted here. Watershed Protection Chapter and plans of the Forest and Watershed Partnership support protection of Native Hawaiian gathering rights to the extent that they are designed to protect the natural heritage of the island. Archaeologically sensitive sites and trails are protected inasmuch as the watershed protection chapter recommends survey of site to avoid inadvertent destruction of natural or cultural treasures in fence building, planting, erosion management or other maintenance activities. Finally, while erosion control efforts supported by the watershed protection chapter will not be enough to stabilize any specific hillside in the short term, over the longer term management efforts should support general stabilization of lands which are currently severely denuded, eroded and prone to further destabilization by erosion.

Indigenous Architecture:

WUDP Response: No items directly related to WUDP listed in Community Plan. However, indigenous architecture can only be enhanced by native endemic and indigenous landscaping. Use of native species for landscaping are mentioned in the WUDP. Suggest that provision encouraging use of native plants for landscaping be included in the event that an ordinance for indigenous architecture proposed by Community Plan is developed and passed.

Urban Design:

Objectives and Policies:

Item 2: Provide additional landscaping in Lana`i City to enhance the environment, utilizing native and non-invasive climate-adapted plants appropriate for the region..

WUDP Response: The DWS Brochure lists native plants appropriate for various climate zones adapted from the Maui County Planting Plan. This list is being peer-reviewed for its applicability and appropriateness to Lana`i, and is included in the WUDP appendices.

Implementing Actions:

Item 5: Prohibit the removal of plant material necessary for water recharge. Plant material necessary for water recharge shall not be used as a source of landscape planting materials.

WUDP Response: Watershed Chapter encourages establishment / enlargement of nursery with appropriate propagation techniques, and with limited, well-guided gathering of seed or cuttings as needed under supervision or in coordination with resource management agencies such as DOFAW, US F&WS, or other qualified specialists in native species preservation. Without proper guidance or expertise, gathering from key areas is discouraged in watershed chapter, and will be further discouraged by fence.

Physical Infrastructure- Water:

<u>Objectives and Policies:</u>

Item 1: Encourage and support comprehensive planning and management of Lana`i's water resources, consistent with the Water Use and Development Plan for Lana`i as approved by law, to ensure long-term economic stability and diversification, and sufficient water allocated for, but not limited to:

a. the agricultural park;

b. the Hawaiian Home Lands;

c. those lands designated for affordable housing;

d. the community gardens;

e. the Lana`i Horse Owner's Association paddock.

WUDP Response: Each of these items has a consensus allocation in the allocation table.

Item 2: Complete and properly maintain the existing potable water distribution system to provide sufficient water pressure throughout Lana`i City.

WUDP Response: CCR owns the only utility serving municipal water supply needs on the island. They were unwilling to provide maps or capital plans for their systems, nor to have these included in the WUDP. The Water Advisory Group did not insist on this.

Item 3: Use recycled or brackish water for irrigation.

WUDP Response: This recommendation is noted in the plan, and a year of reclaimed water use data is included. Data on reclaimed water use are reviewed regularly by the LWAC.

Item 4: Encourage comprehensive water resources planning and management for domestic and agricultural water systems prior to urban development outside of Lana`i City.

WUDP Response: This is the purpose of the Lana`i Water Advisory Committee, and the Water Use & Development Plan effort. The Resolution Establishing LWAC has been provided elsewhere in this document.

Item 5: Improve the quality of potable water

WUDP Response: Source water protection chapters of the WUDP, watershed protection, wellhead protection zone monitoring and others are aimed at improving the quality of potable water.

Item 6: Promote a water conservation program.

WUDP Response: A conservation program is included in the proposed plan.

Item 7: Support the creation of a permanent Lana`i Water Advisory Board comprised of Lana`i Residents.

WUDP Response: The Lana`i Water Advisory Committee was formally approved by the Board and established indefinitely by Resolution dated March 16, 1999. This Resolution is included as an appendix to the WUDP.

Item 8: Encourage, support and ensure protection and restoration of watershed and critical recharge areas.

WUDP Response: The watershed chapter, MOU of the Lana`i Forest and Watershed Partnership, and community efforts described in the *Watershed* chapter meet the intent of this item.

Implementing Actions:

Item 1: Provide incentives for water conservation practices.

WUDP Response: Provision for incentives is included in the proposed rate structure. Final program details will be the decision of the LWCI.

Item 2: Prepare a comprehensive water resource management plan for the island of Lana`i to establish priorities and allocations for water use.

WUDP Response: Entire WUDP for Lana`i is response to this question, particularly allocation tables.

Item 3: Implement a Lana`i Water Advisory Board as a mechanism for monitoring water conservation practices on the island as may be adopted by the Board of Water Supply.

WUDP Response: Resolution of March 16th, 1999 is included herein

Item 4: Include provisions for the protection of the watershed and recharge in the Water Use and Development Plan.

WUDP Response: Watershed chapter and wellhead protection/recharge protection zones in document.

Item 5: Include a proposal for continued community representation on water issues in the Water Use and Development Plan.

WUDP Response: Resolution of March 16th, 1999, as well as implementation guidelines drafted by LWAC are attached. DWS proposes quarterly meetings, with provision to increase to 6 if necessary. LWAC has been operating since 1997, formally established in 1999. Possible changes to frequency of meetings and establishment of subcommittees are issues of ongoing discussion as this plan is finalized.

Item 6: Ensure that water allocations as defined in the community plan are incorporated in the Water Use and Development Plan.

WUDP Response: No specific water allocations appear to have been set within the Community Plan, other than provision of “adequate” water for the following:

- the agricultural park;
- Hawaiian Home Lands;
- those lands designated for affordable housing;
- the Community Gardens;

- the Lana`i Horse Owner's Association paddock.

Elsewhere in the document, desire for allocation for the following facilities was listed, though without specific reference to allocation.

- Cavendish Golf Course
- Emergency medical facilities, public health facilities, medical service facility at Manele, and helipad transport site for medical purposes
- Maui Community College site
- Satellite government facility
- New Police Station
- 10 acre Light Industrial area above Kaumalapau Quarry (TMK 4-9-002:001 por) - half of which is to be sold in fee simple
- 10 acre Light Industrial area at the Shuttle Station (TMK 4-9-002:001 por) - half of which to be sold in fee simple
- 20 acre Heavy Industrial area at Miki Road (TMK 4-9-002:001 por and 050 por), half of which to be sold in fee simple
- 3.4 acre business-commercial area at Lana`i City shop area, (TMK 4-9-005:090 por), half of which to be sold in fee simple.
- 1 acre Hotel area behind Hotel Lana`i (TMK 4-9-011:001 por) from which no trees are to be removed.
- 10 acre business-commercial area at police station (TMK 4-9-006:004) for which no new zoning is to be filed until new police station has been built and courthouse relocated.

WUDP Response: Above items are included in the allocation table.

Item 7: Include suggestions for demand management opportunities in the Water Use and Development Plan..

WUDP Response: These are included in the *Supply Options* chapter.

Physical Infrastructure - Liquid and Solid Waste

Objectives and Policies:

Item 2: Support improvements to the wastewater collection and treatment system to ensure full and adequate service to Lana`i City and its immediate surrounding environs.

Item 3: Encourage a conservation ethic which supports wastewater reclamation and utilization of alternative resource conservation technologies.

Implementing Actions:

Item 1: Prepare a wastewater system master plan for Lana`i as a basis for programming and implementing facilities improvements which will meet the needs of the island's residents in a timely manner.

Item 2: Connect existing residences within the mauka portion of Lana`i City to the County's wastewater collection and treatment system.

Item 3: Conduct a wastewater reuse feasibility study for Lana`i

WUDP Response: Reclaimed water is in use on Lanaʻi and potential increases to that use are projejcted within the Water Use & Develpoment Plan.

Item 4: Provide funding to the Department of Public Works and Waste Management's Solid Waste Division for the proper landscaping and maintenance of solid waste facilities and surrounding environs.

Item 5: Provide for an alternate site for a new County landfill at Kaumalapau Quarry to permit compatible activity within the quarry.

Energy

WUDP Response: No items directly related to WUDP listed in Community Plan.

Housing

WUDP Response: No items directly related to WUPD listed in Community Plan.

Social Infrastructure

Objectives and Policies:

Item 1: Provide neighborhood parks which serve a variety of needs, including but not limited to active play fields and passive areas which may be used for community gardens.

WUDP Response: Water allocation for community gardens included in allocation table.

Implementing Actions:

Item 4: Maintain the quality and availability of Cavendish Golf Course for golf course use in perpetuity for Lana`i residents.

WUDP Response: Water allocation for Cavendish Golf Course included in allocation table.

Health and Public Safety

Objectives and Policies:

Item 3: Ensure the long term integrity of medical and emergency medical facilities and services with appropriate allocation of capital improvements funding and staff positions, adequate provision of supporting programs and facilities, and ready access to state-of-the-art medical technologies.

WUDP Response: Agenda item for LWAC to discuss whether allocation for medical, safety and emergency facilities should be added to allocation table.

Item 7: Improve water rescue service and fire protection by providing necessary equipment, training and staffing.

WUDP Response: Fire prevention needs discussed during preparation of watershed chapter, support of strengthened prevention and response incorporated into watershed chapter - mainly for watershed, but access to facilities should also help with other fire rescue needs.

Implementing Actions:

Item 3: Prepare a capital improvements plan to address the immediate and long term facilities requirements for medical and public health services.

Item 5: Study the feasibility of a medical service facility site at Manele.

Item 6: Identify and support a helipad site for medical transport purposes in accordance with the Maui County Disaster Plan for Lana`i.

WUDP Response: Add agenda item for LWAC to discuss whether allocation for medical, safety and emergency facilities should be added to table. Work with fire department and civil defense to acquire grant for helicopter for Lana'i - for prevention of fire spread in the extremely vulnerable key watershed as well as for medical emergencies.

Education

Implementing Actions:

Item 1: Designate an appropriate site consisting of a minimum of five acres for the use of Maui Community College in consultation with the Board of Regents and the University of Hawaii.

WUDP Response: Site is built..

Government

Objectives and Policies

Item 1: Streamline regulatory approval processes through means such as consolidated public hearings and concurrent processing of approvals.

Item 2: Develop land use, building and subdivision codes and standards which are appropriate for Lana`i.

WUDP Response: Recommend use of native and non-invasive non-native species for planting and landscaping codes, and low flow fixtures as per ordinance for building standards. Consider requiring water conservation tradeoff for development rights for new projects, some phases of existing projects.

Item 3: Utilize the County's budgeting process as a means to carry out the policies and priorities of the community plan.

Item 4: Utilize the County's real property tax assessment function as both a means to carry out the policies and priorities of the Community Plan and a mechanism for monitoring and updating the Community Plan.

Item 5: Acknowledge and support the role and responsibility of the Lana`i Planning Commission in monitoring and enforcing the implemnentation of the Lana`i Community Plan.

Item 6: Encourage and expand chore and transportation services for the elderly.

Item 7: Maintain and support non-profit preschool and childcare facilities and services.

Item 8: Provide Public information in multi-lingual formats.

WUDP Response: DWS staff has translated various water conservation materials into Tagalog, and will do the same for watershed protection materials.

Item 9: Encourage State and County Officials to conduct regularly scheduled public informational meetings on Lana`i, with appropriate follow-up to address questions and concerns of residents.

WUDP Response: The establishement of LWAC created a venue for water regular discussion and exchange of information.

Item 10: Encourage improved communications among government agencies and between the public and government agencies in order to improve public service reliability and efficiency.

WUDP Response: LWAC membership and invite list includes ex-officio representation by various agencies: Planning Dept, Public Works, and County Council as well as State DLNR-CWRM and DLNR-DOFAW. Voting membership by Lana`i Planning Commission member. DWS staffs the LWAC, as it is advisory to their Board.

Item 11: Encourage and support the use of telecommunications technology to link Lana`i residents with State and County Government functions and activities through an interactive communication mode.

WUDP Response: In deterimining its watershed priorities, LWAC held a SkyBridge meetiing with participation of forestry experts from several islands.

Item 12: Provide for adequate cemetery facilities to meet the current and future needs of Lana`i's residents.

Item 13: Establish a permanent Lana`i Water Advisory Board.

WUDP Response: The Lana`i Water Advisory Committee was formally approved by the Board and established indefinitely by resolution dated March 16th, 1999. This resolution is included as an appendix to the WUDP.

<u>Implementing Actions:</u>

Item 1: Develop a satellite government center for Lana`i with scheduled days for different State and County agencies.

Item 4: Support the centralization of government services in the Lana`i City town core. Establishment of centralized government services at the Administration Building shall be considered.

Item 5: Support the provision of land at Keomoku for distribution by the Department of Hawaiian Home Lands.

WUDP Response: Allocation table includes provision for Hawaiian Home Lands

Planning Standards

Landscaping Native plant species which are found on Lana`i shall be utilized for public and quasi-public facilities (ordinance 2738, pg 60).

WUDP Response: Identification of Public and Quasi Public Facilities, and establishment of native landscaping at said faclilities is an element of the watershed protection plan long term implementation matrix.

Project Districts

<u>Project District 1 - Manele</u>

Project District includes hotel, residential, golf course, commercial, open space, park, and public marina uses. Commercial uses are limited to the hotel, golf clubhouse and Manele small-boat harbor.

Total Area of Project District in Community Plan is 868 acres, including a minimum of 130 acres open space at the Pu`upehe Peninsula. The Community Plan update altered 25 acres from SF to MF and 6.6 acres from SF to Hotel.

WUDP Response:Allocation for Manele PD is included in WUDP. Table of allowable acreages and water-related conditions as these have changed over the years is also incorporated into the WUDP.

<u>Project District 2 - Koele</u>

Project District includes hotel, residential, golf course, open space and other uses. The Community Plan changed 57 acres at 4-9-002:001(por) from PD to Ag; 12 acres of existing woods from PD to OS at TMK 4-9-1:24; 98 acres of existing (Cavendish) Golf Course from PD to PK(GC) (park-golf course); and 238 acres at 4-9-2:001 (por) from Rural to OS (East of Keomoku Rd) and AG (West of Keomoku Road).

WUDP Response: Allocation for Koele PD is included in WUDP. Table of allowable acreages and water-related conditions as these have changed over the years is also incorporated into the WUDP.

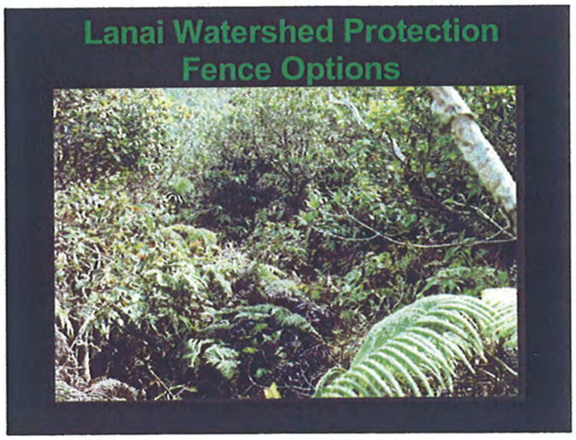
Implementation Responsibilities

WUDP Response: Despite multiple water-related objectives and actions within the text of the plan, the Lana`i Community Plan matrix of Implementation Responsibilities assigns no tasks to the Department of Water Supply. However, it does refer repeatedly to insuring consistency with the WUDP.

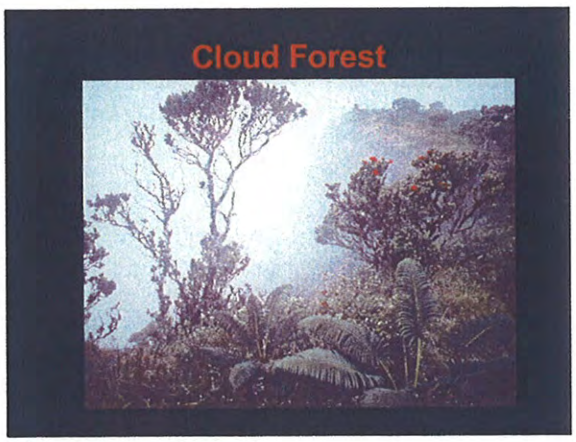
LWAC has addressed various water and issues, from establishing watershed protection in concert with the Biodiversity Group, to questions as to the use of potable water on the upper elevation golf courses, to the scope and staging of Project Districts, to an ongoing venue for addressing water issues, to system monitoring and maintenance, to review of develpment projects and impacts on Lana‘i resources, to operational guidelines developed by a consultant for Castle & Cooke resorts, and reviewed by both the advisory committee and the CWRM.

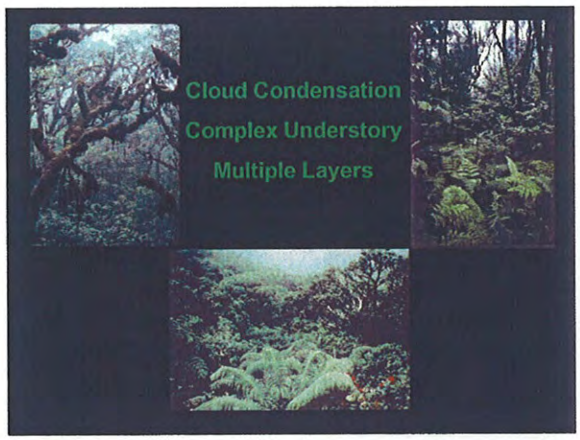
APPENDIX K

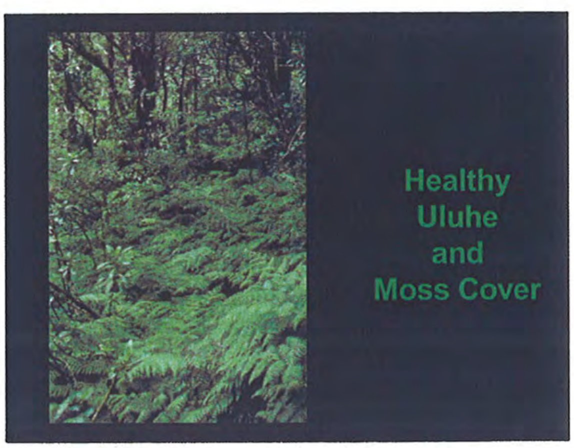
Presentation Made at Public Fence Meeting 04/11/2000

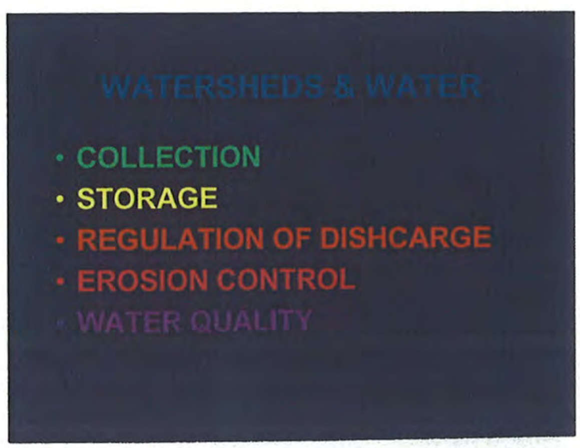

Lanai Watershed Protection
Fence Options


• Introduction
• Watersheds & Water
• Advisory Committee Priorities
• Lanai Species
• Protective Measures
• Peer Review Committee Advice
• Deer & Deer Damage
• Deer Control Options
• Fencing Options
• Close


Cloud Forest

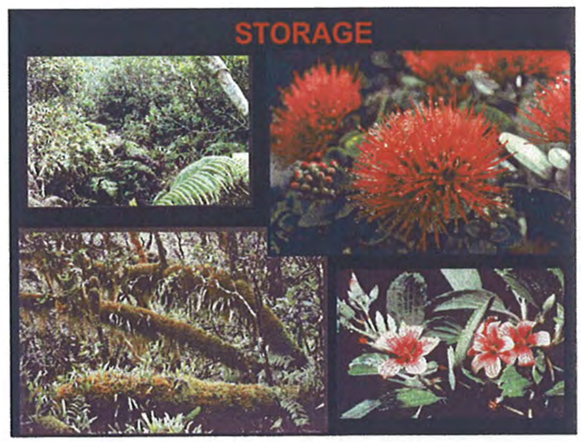

Cloud Condensation
Complex Understory
Multiple Layers


Healthy
Uluhe
and
Moss Cover


WATERSHEDS & WATER
• COLLECTION
• STORAGE
• REGULATION OF DISHCARGE
• EROSION CONTROL
• WATER QUALITY


COLLECTION

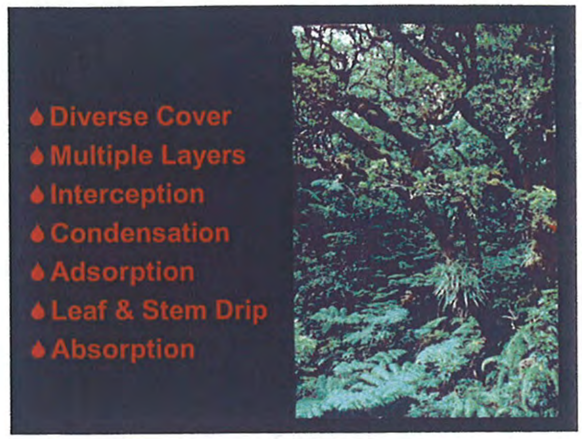

COLLECTION

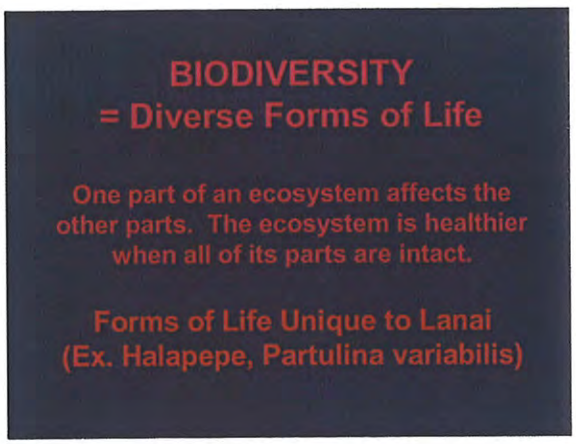

STORAGE


Regulation of
Discharge


Erosion
Control
canopy &
understory
break impact of
rain
root systems
hold soil

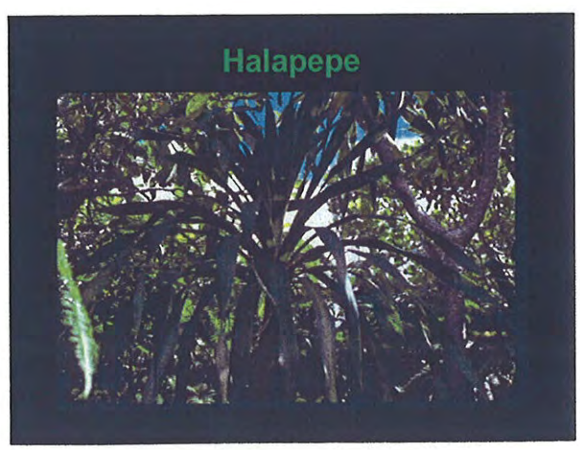

Water Quality
• Adsorption
• Absorption
• Filtration
• Uptake

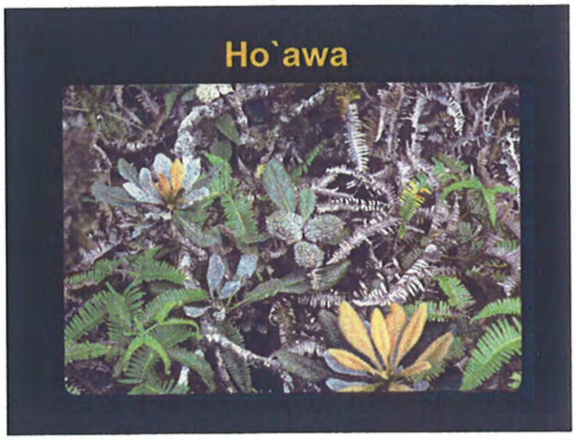

Diverse Cover
Multiple Layers
Interception
Condensation
Adsorption
Leaf & Stem Drip
Absorption


BIODIVERSITY
= Diverse Forms of Life
One part of an ecosystem affects the other parts. The ecosystem is healthier when all of its parts are intact.
Forms of Life Unique to Lanai
(Ex. Halapepe, Partulina variabilis)


Ama`u & Uluhe


Cyrtandra


Halapepe

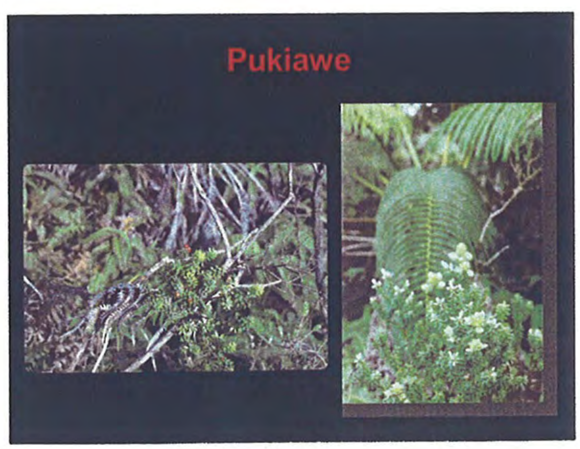

Ho`awa


Hue Hue


Isachne distichiophylla


Kawa`u


`Ohi`a


Pukiawe

Uki

Uki uki

Partulina Variabilis

`Apapane

WORKING GROUP PRIORITIES

- Protect Watershed
- Protect Native Ecosystems
- Consistent with Community Values

Protective Measures

- Control deer, sheep and rodents
- Control invasive plant species
- Prevent introduction of invasive plant and animal species (including insects)
- Provide fire protection
- Selective re-planting
- Collection, storage and maintenance of plant genetic material
- Protection from human disturbance
- Monitoring
- Public Education

Peer Review Committee #1 Issue: Reduce Deer Population

WHY WORRY ABOUT DEER DAMAGE IN THE WATERSHED

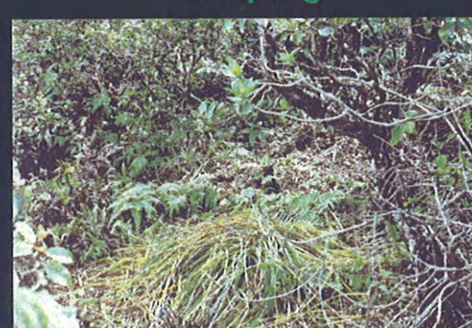
? ? ? ? ? ? ?

Deer & Deer Damage

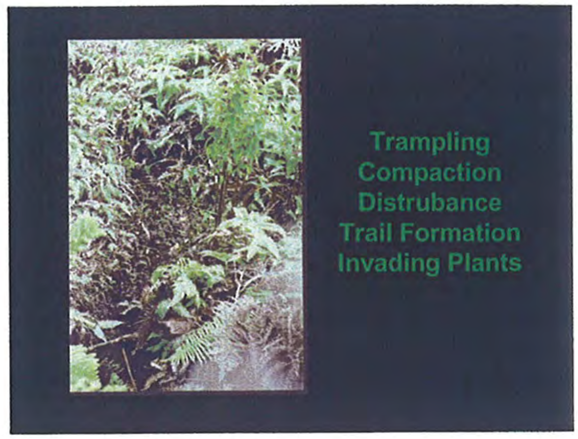
Trampling

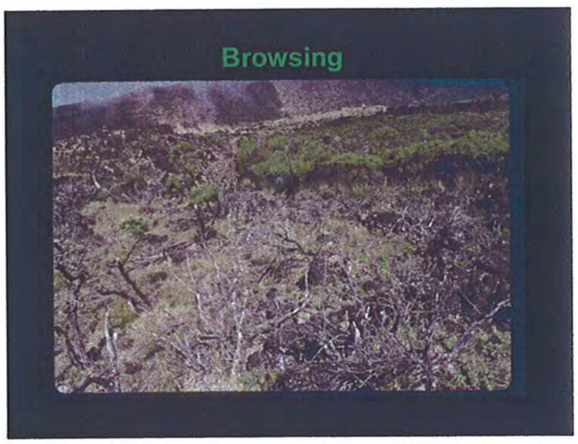
Trampling

Trampling



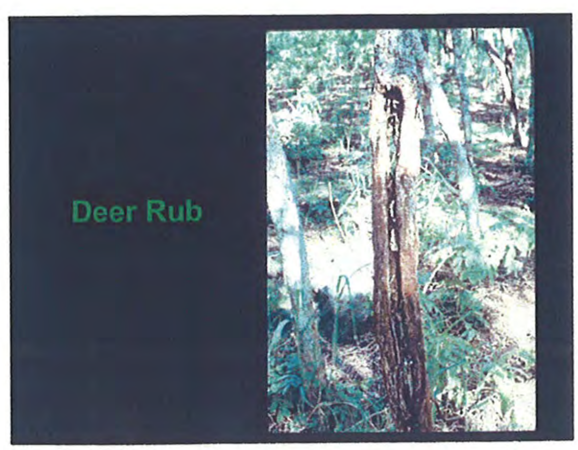

Trampling


Trampling
Compaction
Distrubance
Trail Formation
Invading Plants


Browsing


Browsing


Browsing

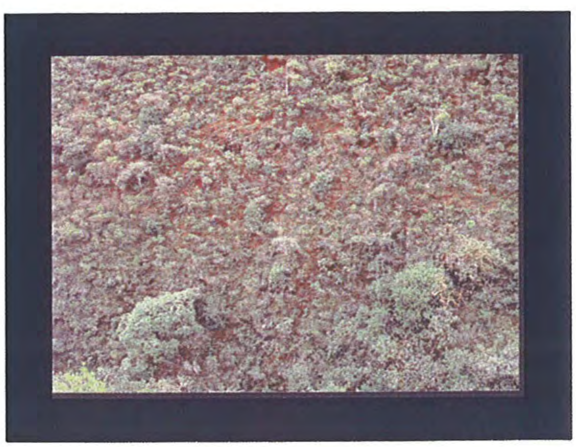

Deer Rub

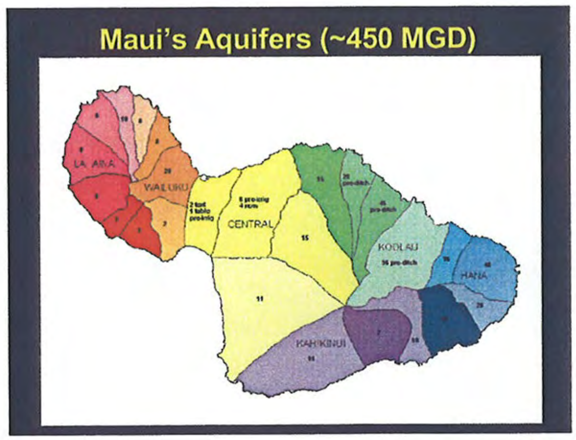




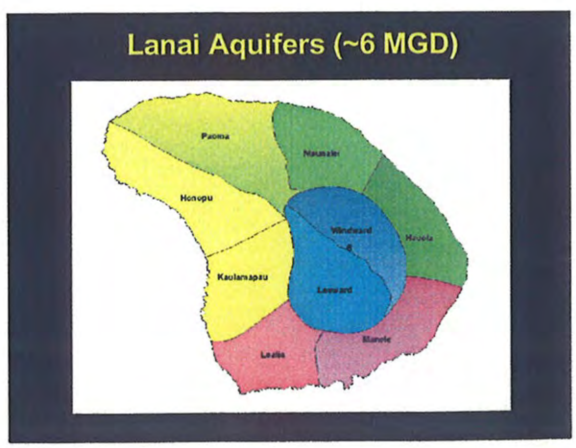






Maui's Aquifers (~450 MGD)
CENTRAL
KOOLAU
HANA


Molokai Aquifers (~84 MGD)


Lanai Aquifers (~6 MGD)
Paoma
Honopu
Kaulanapau
Windward
Leeward
Hauola
Manele

Control of Deer and Sheep

- hunting or other removal
- catch and transport
- fencing and other obstruction
- repellants, sterilizers
- habitat alteration
- introduced predators

Why Select Fencing?

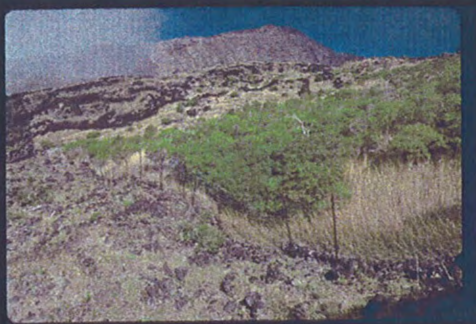
- **Capture & Transport** very expensive, may not be places to send the deer, deer may die in transport
- **Sterilization or reproductive intervention** - administered either by darting or orally with bait. Vaccines still under development. Must be approved by FDA because deer is seen as "food animal", darting vaccine needs to be repeated annually, difficulty getting all deer reliably..OR, if animals are captured and surgically altered..difficulty getting all deer, very expensive, may not help situation in time to save watershed.

Why Select Fencing? (continued)

- **Repellants** - garlic oil, putrid egg solids, predator odor oils, sulphated cod liver oil have been tried. Putrid egg solids had some success in reducing browsing. But no information on how this impacts plants, insects, birds, pollination cycles, etc. Also will not address population problem.
- **Habitat Alteration** - planting desirable forage plants outside watershed, providing water outside watershed, surrounding watershed with thorny plants, etc. Such measures alone will not control population, may risk introduction of species, provision of water could lead to population increase.

Why Select Fencing? (continued)

- **Physical Barriers** - fence, canal, cattle guard, etc. can help keep deer out of desired exclosure or in desired area - not foolproof, but good in concert with other control measures.
- **Hunting** - animals may be able to be eradicated with one huge hunt, or numbers managed with on-going hunting. However steep grades, access problems and other issues mean that if this measure is used it would be more successful concert with other measures, and with some ongoing management .
- **Release of Predators** - introduction of new species poses multiple risks to already threatened watershed.



FENCELINE OPTIONS

Option 1
13.9Miles
$330,000/410 K
Enclosed Area:
32,055 Acres
HI Volcanoes Nat'l Prk

Assumes:
- $25,000/mile for materials & construction
- 7' woven wire fence
- fence follows roads

Option 1

- **ADVANTAGES**
  - Protects large area
  - Maintenance & monitoring easier near road
  - Per mile costs lower
  - Protects secondary recharge area (windward below cloud forest) as well as upper reaches
  - Requires tie-off in the ocean
- **DISADVANTAGES**
  - Prone to vandalism
  - More fence to maintain
  - Needs more coordination to mitigate hunter impacts

Option 2
14.7 Miles
$370,000/450 K
Enclosed Area:
26,555 Acres
HI Volcanoes Nat'l Prk

Assumes:
- $25,000/mile for materials & construction
- 7' woven fence
- 1 mile off roads

Option 2

- **ADVANTAGES**
  - Protects large area
  - Maintenance & monitoring easier near road
  - Per mile costs lower
  - Protects secondary recharge area (windward below cloud forest) as well as upper reaches
  - Second fence could be added in future to create different control level exclosures
  - Requires Tie-off in the ocean
- **DISADVANTAGES**
  - Prone to vandalism
  - More fence to maintain
  - Needs more coordination to mitigate hunter impacts

Option 3
"Old Pipeline"
23 Miles
>$1.1 Million
Enclosed Area:
22,806.508 Acres

Option 3

- ADVANTAGES
  - Protects large area
  - Doesn't require ocean tie-off
  - Maintenance & monitoring easier near road
  - Per mile costs lower on upper side only
  - Protects secondary recharge area (windward below cloud forest) as well as upper reaches
- DISADVANTAGES
  - Most expensive option
  - Prone to vandalism
  - More fence to maintain - old pipeline route is not road - not efficient use of fence
  - Needs more coordination to mitigate hunter impacts

Option 4
12.1 Miles
$680,000
Enclosed Area:
3,588.127 Acres

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Option 4

- ADVANTAGES
  - Protects most critical recharge area
  - One of the less expensive options
  - Leaves lower reaches for hunter control
  - May be somewhat less prone to vandalism
  - Less impact on hunting community
  - Addresses both deer and sheep
- DISADVANTAGES
  - More difficult terrain for maintenance & monitoring
  - May be more expensive to repair

Option 5
11.5 Miles
Enclosed Area:
1,834.69 Acres

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[illegible]	[illegible]
[illegible]	[illegible]
TOTAL COST	[illegible]

Option 5

- ADVANTAGES
  - Protects part of most critical recharge area
  - Leaves lower reaches for hunter control
  - May be somewhat less prone to vandalism
  - Less impact on hunting community
  - Addresses both deer and sheep
- DISADVANTAGES
  - Leaves out portion of most critical recharge area
  - More difficult terrain for maintenance & monitoring
  - May be more expensive to repair

Option 6 Eradication & Option 7 No Action

Option 6 Eradication

- ADVANTAGES
  - Most protective of watershed
  - End of deer problem
  - No fencing expense
  - No maintenance Expense
- DISADVANTAGES
  - Hunters likely to object
  - Massive undertaking
  - Loss of hunting-related economic input to community
  - Doesn't address sheep

Option 7 No Action

- ADVANTAGES
  - No effort until problems arise
  - No vandalism
- DISADVANTAGES
  - Watershed would be lost
  - Expense to re-create recharge greater than expense to preserve
  - loss of biodiversity

Fenceline Evaluation

	Cost	Miles	Acreage Protected	Recharge Impact *	Hunting Impact *
Option 1	$410,000	13.9	32,055		
19	4 (330K)	4	5	5	1
Option 2	$450,000	14.7	26,555		
15	3 (370 K)	2	4	4	2
Option 3	$1,100,000	23	22,807		
11	1	1	3	3	3
Option 4	$680,000	12.1	3,588		
14	2	4	2	2	4
Option 5	$400,000	11.5	1,835		
17	5	5	1	1	5

* Items from 1-5 where higher score is better