APPENDIX O

Groundwater
Resource and
Water System
Assessment

Groundwater Resource and Water System Assessment for the Proposed Puunene Industrial Subdivision in Kahului, Maui

Prepared for:

CMBY 2011 Investment, LLC
P. O. Box 220
Kihei, Maui, Hawaii 96753

Prepared by:

Tom Nance Water Resource Engineering
680 Ala Moana Boulevard - Suite 406
Honolulu, Hawaii 96813

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Introduction

CMBY 2011 Investment, LLC proposes to develop the Puunene Heavy Industrial Subdivision on TMK 3-8-08:19, an 86-acre parcel in Kahului, Maui. Figure 1, shows the project's location. The subdivision would consist of 28 lots on approximately 66 acres, nine (9) acres of drainage retention, and about 11 acres of roads (refer to Figure 2). Water supply from the County Department of Water Supply (DWS) is not available for the project. The intent is to develop onsite groundwater, using this water directly for non-potable requirements and providing reverse osmosis (RO) treatment to supply potable uses.

This report provides estimates of the project's potable and non-potable supply requirements, identifies the water system infrastructure necessary to meet these requirements, and analyzes the project's probable impacts on groundwater resources.

Projected Potable and Non-Potable Supply Requirements

DWS' design standard for industrial use of 6000 gallons per day per acre (GPD/acre) is adopted herein. In addition, it is assumed that the drainage retention area will be landscaped and irrigated at an average of 2500 GPD/acre and that 20 percent of the gross roadway ROW would also be irrigated at 2500 GPD/acre. The latter is equivalent to 500 GPD per gross acre of roadway ROW. The Honolulu Board of Water Supply's (BWS') dual water system guidelines recommend a 30/70, potable/non-potable split for industrial land uses, a reasonable criterion adopted herein. Based on the foregoing, the project's average potable and non-potable water use would be as tallied below.

Projected Average Demand for the Puunene Heavy Industrial Subdivision

Land Use	Area (Acres)	Total		Potable		Non-Potable	
		Use Rate (GPD/Unit)	Amount (GPD)	Use Rate (GPD/Unit)	Amount (GPD)	Use Rate (GPD/Unit)	Amount (GPD)
Industrial Lots	66	6000	396,000	1800	118,800	4200	277,200
Drainage Retention	9	2500	22,500	0	0	2500	22,500
Roadway	11	500	5,500	0	0	500	5,500
Totals	86	--	424,000	--	118,800	--	305,200

Other water system design sizing criteria used herein draw primarily (but not exclusively) from the standards of Maui DWS and Honolulu BWS:

- For both the potable and non-potable systems, maximum day demand is defined as 1.5 times the average use amounts given above. Peak flowrate is defined as 3.0 times the average amounts.

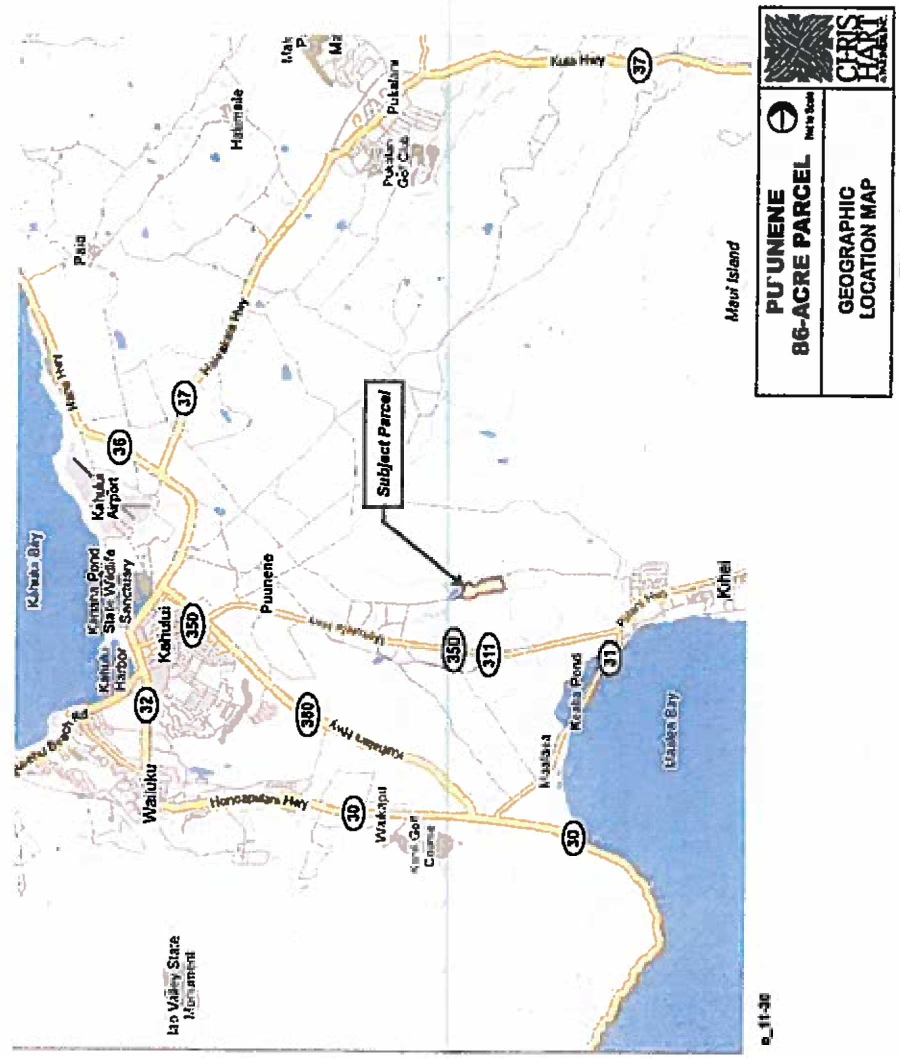
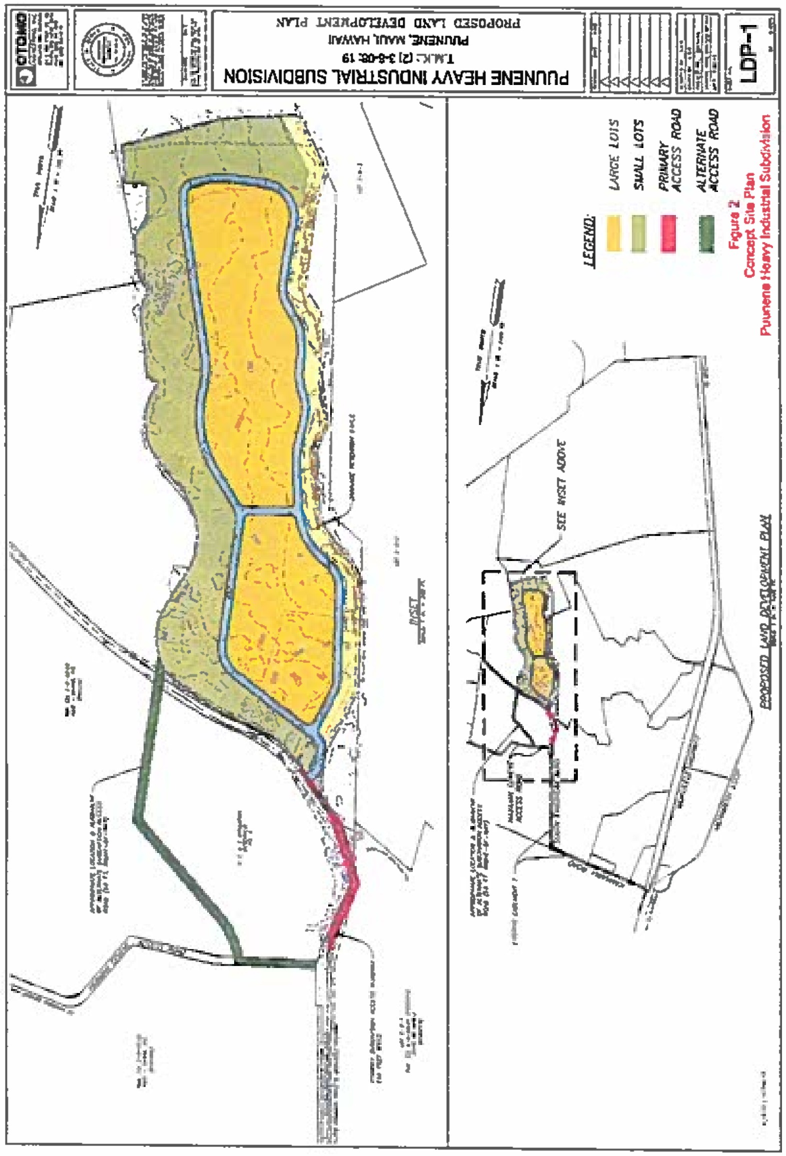


Figure 1



- The much larger non-potable system will provide fire protection. Its reservoir sizing will be the larger of the average day demand or DWS' fire flowrate sizing criterion.
- Reservoir storage for the potable system will be the maximum day amount.
- Source capacities of both systems will provide the maximum day supply in a 24-hour pumping day with the largest individual source out of service. DWS' standard is a 16-hour pumping day. However, for the wells within the project site which will draw water from a relatively thin basal lens, a 24-hour pumping day is a more appropriate criterion.
- To account for uncertainty in the 30/70 assumed split between potable and non-potable uses, flowrates used for sizing of all potable system components – source of supply, reservoir storage, and pipelines – will be increased by a factor of 20 percent.
- Based on the salinity of onsite Well 4927-01 (discussed subsequently), it is assumed that the RO treatment will convert 60 percent of the brackish well water for potable use. The 40 percent remainder, referred to as concentrate, will be too saline for non-potable use.
- Potable and non-potable pipeline sizing criteria are identical to DWS' standards for peak and fire flowrate conditions.

Sizes of the Water System Infrastructure

Onsite Wells. The non-potable system's maximum day design use is 457,800 GPD (305,200 GPD x 1.5). The potable system's maximum day use, including the 1.2 sizing factor, is 213,840 GPD (118,800 GPD x 1.5 x 1.2). At the 60 percent rate of RO product recovery, the potable supply capacity will need to be 356,400 GPD. Together with the non-potable supply requirement, a "safe" well pumping capacity of 814,200 GPD or 565 GPM for a 24-hour pumping day will be required. Three 300 GPM wells, one providing standby capacity, would be installed.

RO Treatment. The maximum day potable supply requirement (with the 1.2 factor) of 213,840 GPD is equivalent to a capacity of about 150 GPM. Three 75 GPM RO treatment trains are proposed, one providing standby capacity.

Potable Reservoir Storage. The maximum day amount (with the 1.2 factor) is 213,840 GPD. A 0.25 million gallon (MG) storage reservoir is proposed.

Non-Potable Storage Reservoir. The average demand sizing criterion would require reservoir storage of 0.30 MG. The fire flowrate sizing criterion is based on:

- DWS' 2500 GPM fire flowrate for two hours;

- Coincident maximum day non-potable demand of 318 GPM for the two-hour period;

- Coincident feedwater draw for two RO treatment trains of 250 GPM (150 GPM ÷ 0.6) for the two-hour period;

- Input of two of the three 300 GPM supply pumps for the two-hour period; and

- The reservoir 3/4 full at the start of the fire.

The foregoing translates to a storage requirement of 394,880 gallons, the governing storage criterion. Non-potable reservoir storage of 0.40 MG is proposed.

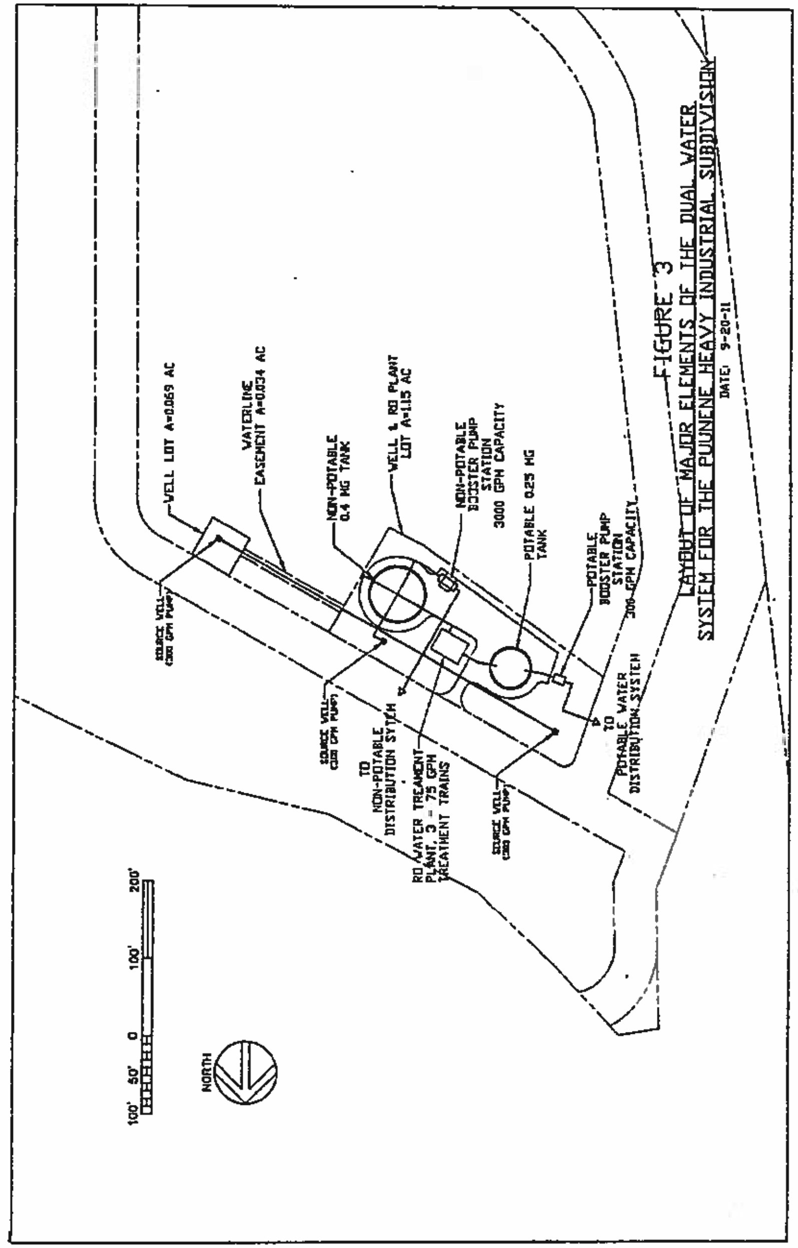
Pumped Distribution. The potable and non-potable storage reservoirs would be onsite and would not provide sufficient gravity pressure for customer use or fire protection. Two automated, multiple pump stations would be provided with start/stop control to maintain system pressure. The potable pump station would be sized to meet peak the flowrate requirement (with the 1.2 factor) of 248 GPM. A capacity of 300 GPM is proposed. A 3000 GPM non-potable pump station would provide the 2500 GPM fire flowrate with the 318 GPM coincident maximum day demand. Backup generator power for the non-potable pump station would be provided to ensure fire protection during a MECO power outage.

System Layout. Figure 3 is a preliminary layout of the water system's major elements described above. These would be located near the north end of the project site. Department of Health (DOH) regulations require a minimum of 1500 feet spacing between the supply and RO concentrate disposal wells. DOH will also require wastewater disposal systems to be 1000 feet or more from the supply wells. For lots within this 1000-foot setback, onsite enhanced septic systems with disposal in a common leach field beyond the 1000-foot setback will be required.

Impact on Water Resources

As there are no natural drainageways across the site and the ground is very permeable, stormwater runoff onto the site from upgradient or from the site to downgradient areas is not known to occur. The subdivision's development concept is to retain and dispose of surface runoff in the 9-acre portion of the site designated for that purpose. Disposal will occur by evaporation and seepage from this area. As such, the project will not impact surface water resources. Its impact will be limited to the underlying groundwater. These impacts, each of which is quantified in sections following, will consist of the following:

- Withdrawal of groundwater for non-potable use and as feedwater to RO treatment to produce the required potable supply;



- Disposal of the RO concentrate in onsite disposal wells;
- Disposal of treated domestic wastewater in leachfields;
- Percolation of excess landscape irrigation and industrial wash water; and
- Change in the quality of onsite rainfall percolating to groundwater.

Groundwater Occurrence. Knowledge of groundwater occurrence in the Kahului area comes primarily from wells, some of which are listed in Table 1. A number of these have been used by HC&S for sugarcane irrigation for more than 70 years. Groundwater in the Kahului isthmus occurs as a relatively thin basal lens (water levels typically on the order of three to four feet above sea level) floating on saline groundwater at depth and in hydraulic contact with seawater along the Malaea and Kahului Bay shorelines. The following factors significantly influence the quality and quantity of water this groundwater body can provide:

- Although rainfall-recharge directly on the 27-square mile Kahului isthmus is only on the order of five (5) MGD, pumpage by the HC&S plantation was on the order of 45 MGD for decades and still is about 25 MGD.
- Rainfall-recharge may actually be the smallest of the aquifer's sources of recharge. Others include: underflow from Haleakala; underflow from the West Maui Mountain; leakage of water imported in the East Maui Irrigation system; leakage from the Waihee Ditch system of West Maui; and irrigation return from HC&S fields and other agricultural areas.
- Both shorelines, Maalaea and Kahului, have alluvial deposits which function as a caprock, retarding seawater intrusion.

As a result of the aquifer's various sources of recharge, the Kahului Aquifer has potable quality water in some locations and only slightly brackish water over most of the rest of its area. Its sustainable yield, as designated by the State Commission on Water Resource Management (CWRM), is 1.0 MGD. This is based exclusively on rainfall recharge and does not account for the other sources of recharge listed above. Its actual sustainable yield is far greater, even if HC&S were to cease all activities, including the importation of ditch water. The underflow from outside of the aquifer, particularly from Haleakala, would sustain an order of magnitude greater yield than the CWRM's 1.0 MGD sustainable yield amount.

Table 1. Data on Wells in the General Vicinity of the Puunene Heavy Industrial Subdivision Site*

Well: State Number	Well: Owner / Name	Year Drilled	Casing Diameter (Inches)	Ground Elevation (Feet MSL)	Total Depth (Feet)	Elevation at Bottom (Feet MSL)	Lengths of Casing: Solid (Feet)	Lengths of Casing: Perforated (Feet)	Static Water Level (Feet MSL)	Chlorides (MG/L)	Hydraulic Performance Drawdown @ Flowrate (Feet @ GPM)	Installed Pump Capacity (GPM)
4727-01	HC&S Kihei Shaft (Shaft 14)	1900	Shaft	26	23	3			3.5	450-650		3,340
4825-01	HC&S Kihei Shaft 15	1900	Shaft	329					3.6	280-490		12,600
4927-01	Elmer's Farm	?	8	120	148	-28	118	30		250	0.4 @ 240	None
4928-01	Puunene Airport	1942	8	70	70	0						Sealed
4928-02	Puunene Airport	1942	72	60	63	-3						Sealed
5027-01	S & F	2009	12	130	158	-22	131	20	2.85	275	0.1 @ 305	
5028-01	Test Hole HC&S	1926	?	100	140	-40			5.5	80-125		
5028-02	HC&S TH	1935	1	120	400	-280	142	358	2.4			
5127-01	Puunene	?	?	105	165	-60			5.0			
5128-01	HC&S TH	1926	6	145	185	-40			5.0	270		
5128-02	HC&S Shaft 16	1926	Shaft	126	129	-3			6.7	250 to 620	4.7 @ 9444	23,200
5129-04	A&B Waiale 1	2007	14	183	208	-25	177	31	3.4	40	0.4 @ 500	450
5129-05	A&B Waiale 2	2009	14	184	217	-33	181	30	3.3	35	1.1 @ 500	450
5226-02	Puunene Pump 6 Shaft 18	1934	Shaft	162	170	+8 (?)			4.4	330 to 480		16,100
5227-04	Puunene Pump 8 Shaft 17	1939	Shaft	60								8,440
5227-05	Puunene Pump 19 Shaft 35	1952	Shaft	?								7,380

* Information as available from the files of the State Commission on Water Resource Management.

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Groundwater Flowrate Beneath the Project Site. With sources of recharge to the aquifer coming from various directions and significant pumpage occurring at the active HC&S well batteries, the direction and rate of groundwater flow are not known precisely. Approximations used for this assessment are as follows:

- The direction of flow is from northeast to southwest beneath the project site and, perpendicular to this direction, the width of the project is 0.63 miles;
- The groundwater level is 3.6 feet above sea level;
- The groundwater gradient is on the order of 0.6 feet per mile, equivalent to 0.00112 ft/ft; and
- The permeability coefficient is 10,000 feet per day.

For these approximations, the groundwater flowrate beneath the project's 0.63-mile width is 4.0 million gallons per day (MGD). Estimated changes to groundwater flowrate presented herein will be as increases or decreases of this 4.0 MGD flowrate.

Groundwater Quality. A short-term pump test and water quality sampling of onsite Well 4927-01 was done in July 2010. Laboratory-detected regulated drinking water constituents are presented in Table 2. The relatively high level of nitrate-nitrogen, a result of ongoing agricultural activities, is notable. However, none of the detected constituents exceed levels allowed by EPA and DOH for drinking water use. During the well's short-term pump test, the salinity of the pumped water was stable and only slightly brackish: salinity was 0.80 parts per thousand (PPT); specific conductance was 1600 µS/cm; and chlorides were 250 MG/L.

Table 3 is a compilation of salinity and nutrient levels from wells in the Kahului Aquifer. Salinities were consistently low, except nearshore at the north end of Malaea Bay where the caprock is absent. High nutrient levels, particularly as nitrate-nitrogen, are present throughout the aquifer. For the project's potential impacts to groundwater presented subsequently, the present quality of the underlying groundwater is taken to be: salinity of 0.80 PPT; nitrogen concentration of 330 micro-molar (µM); and phosphorus concentration of 3.4 µM.

Project's Estimated Changes to the Groundwater Flowrate. The project's onsite wells will draw from the underlying groundwater, but some of this water will be returned in the form of RO concentrate, wastewater from septic systems, excess landscape irrigation, and percolating wash water from the non-potable system. These quantities, expressed as year-round averages at full build-out, are estimated as follows:

MWH LABORATORIES
A Division of MWH Americas, Inc.

750 Royal Oak Dr., Suite 100
Monrovia, California, 91016-3629
Tel: 626 386 1100
Fax: 626 386 1101
1 800 566 LABS (1 800 566 5227)

Laboratory
Hills Report: 338488

Tom Nance Water Resource Engineering
Tom Nance
680 Ala Moana Blvd. Suite 406
Honolulu, HI 96813

Samples Received on:
07/15/2010

Analyzed	Analyte	Sample ID	Result	Federal MCL	Units	MRL
	201007150633	Elmer Farm Well				
07/21/2010 22:06	Alkalinity in CaCO3 units		290		mg/L	2
07/20/2010 17:15	Arsenic Total ICAP/MS		1.7	10	ug/L	1
07/29/2010 20:58	Atrazine		0.12	3	ug/L	0.05
07/20/2010 17:15	Barium Total ICAP/MS		3.9	2000	ug/L	2
07/22/2010 12:45	Beta, Gross		3.1		pCi/L	3
07/21/2010 7:23	Calcium Total ICAP		23		mg/L	1
07/22/2010 03:40	Chromium Total ICAP/MS		5.3	100	ug/L	5
07/20/2010 17:15	Copper Total ICAP/MS		2.8	1300	ug/L	2
	Field pH		7.6		Units	0.1
	Field Specific Conductance		1587		umho/cm	
07/23/2010 12:37	Fluoride		0.68	4	mg/L	0.05
07/20/2010 17:15	Lead Total ICAP/MS		1.5	15	ug/L	0.5
07/15/2010 19:54	Nitrate as Nitrogen by IC		4.5	10	mg/L	0.5
07/15/2010 19:54	Nitrate as NO3 (calc)		20	45	mg/L	2.2
07/16/2010 18:43	PH (H3=past HT not compliant)		8.1		Units	0.1
07/17/2010 13:41	Specific Conductance, 25 C		1600		umho/cm	2
07/16/2010 08:59	Turbidity		1.2	5	NTU	0.05

Table 2

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SUMMARY OF POSITIVE DATA ONLY

Table 3

Nutrient and Salinity Levels in Kahului Groundwater

Well		Date Sampled	Forms of Nitrogen				Forms of Phosphorus			Silica (µM)	Salinity (PPT)
State No.	Name		NO_3 (µM)	NH_4 (µM)	DON (µM)	TN (µM)	PO_4 (µM)	DOP (µM)	TP (µM)		
4727-01	HC&S Pump 1	8-24-10	569				2.77			823	1.24
4728-08	Kealia A5	8-24-10	85.6	0.20	0.36	86.2	2.20	0.32	2.52	864	1.19
4728-09	Kealia C	8-24-10	81.5	0.60	6.88	99.0	3.28	0.12	3.40	881	1.28
4825-01	HC&S Pump 3	8-24-10	236				3.34			970	0.67
4829-02	MECO-1	10-29-10	271	0.64	25.4	297	2.80	0.36	3.16	596	8.50
4829-03	MECO-2	10-29-10	278	1.32	10.6	290	2.92	0.04	2.96	601	8.39
4830-01	Maalaea Triangle	6-09-11	191	0.20			8.50			859	0.94
4927-01	Elmer's Farm	8-24-10	333				3.73			987	1.10
4930-01	Pohakea 1	2-11-11	152	3.60			5.50			1250	0.43
5128-02	HC&S Pump 7	8-24-10	511				1.91			813	0.64
5227-05	HC&S Pump 19	8-24-10	388				2.00			1001	1.25

- Pumpage by Wells. Average potable use would be 0.119 MGD. With a 60 percent recovery through the RO treatment, draft for the feedwater supply would be 0.198 MGD. The non-potable use would average 0.305 MGD, bringing the total groundwater pumpage to 0.503 MGD.

- Return as RO Concentrate. The RO concentrate, containing dissolved constituents removed from the potable product water, would be returned to groundwater in disposal wells located 1500 feet downgradient of the supply wells. The quantity of concentrate would be 0.079 MGD.

- Return to Groundwater as Treated Domestic Wastewater. Of the estimated 0.119 MGD for within-building potable use, it is assumed that 90 percent or 0.107 MGD would become wastewater that would be treated in septic tanks and disposed of in leach fields.

- Return to Groundwater as Excess Landscape Irrigation. Landscape irrigation by the non-potable system is estimated as:

  - 20% of the 66 acres of industrial lots at 4000 GPD/acre;
  - 20% of the 11 acres of roadway at 2500 GPD/acre; and
  - 100% of the 9 acres of drainage retention at 2500 GPD/acre.

  For these approximations, the estimated total for landscape irrigation would be 0.081 MGD. Of this amount, it is assumed that 15 percent or 0.012 MGD percolates below the root zone and returns to groundwater. The balance would be lost to plant evapotranspiration or direct evaporation.

- Return to Groundwater by Other Non-Potable Uses. The remaining 0.224 MGD of non-potable water use would be external to buildings. Some of it would be lost to evaporation or otherwise consumed and the remainder would return to groundwater via percolation from individual, on-site drainage systems or in the retention area. As an order of magnitude approximation, it is assumed that one-third or 0.075 MGD returns to groundwater.

- Onsite Rainfall-Recharge to Groundwater. Rainfall of about 15 inches per year over the 86-acre project site amounts to a year-round average of 0.096 MGD. As a first order approximation, about 40 percent of this or 0.038 MGD percolates to groundwater with the remainder being lost to direct evaporation or plant evapo-transpiration. It is assumed that this quantity will remain essentially the same after the project is developed.

With the uses and returns to groundwater as estimated above, the net use of groundwater would be 0.23 MGD. This would be 5.8 percent reduction of the estimated 4.0 MGD flow of groundwater directly beneath the site.

Project's Estimated Changes to Groundwater Salinity and Nutrient Levels. Based on data from onsite Well 4927-01 and others nearby, it is assumed that the underlying groundwater has a salinity of 0.8 PPT, a nitrogen content of 330 micro-molar (µM), and a phosphorus content of 3.4 µM. This would also be the quality of water extracted by the supply wells. Salinity and nutrient levels of the project's various water uses and wastewaters are estimated as follows:

- RO Product for Potable Use. It is assumed that the RO supply for potable use will have a salinity of 0.15 PPT and similar reduction of nitrogen and phosphorus. As such, nitrogen and phosphorus concentrations of the product water would be 55 and 0.45 µM, respectively.
- RO Concentrate Returned to Groundwater. Salts and nutrients removed by the RO process would be in the concentrate. Its salinity would therefore be 2.0 PPT. Nitrogen and phosphorus concentrations would be 750 and 6.1 µM, respectively. The concentrate would be discharged into disposal wells designed to deliver the water into strata of similar or greater salinity. This would be in the transition zone below the basal lens.
- Domestic Wastewater. Treatment of domestic wastewater would be in septic systems with disposal in leach fields. The treated effluent would have increases in salinity and nutrient levels. Using typical concentrations for secondarily treated effluent, is it assumed that the salinity would be doubled (to 0.30 PPT) and that nitrogen and phosphorus concentrations discharged in the leach fields would be 1750 and 200 µM, respectively.
- Excess Landscape Irrigation. Excess water applied to landscaping and percolating to groundwater will carry with it dissolved fertilizer. To approximate this, the following assumptions are made: (1) nitrogen in fertilizer would be applied to an average of four pounds/year/1000 ft^2 and phosphorus would be applied at 0.5 pounds/year/1000 ft^2; and (2) 10 percent of the applied nitrogen and two percent of the applied phosphorus would be carried below the root zone. For these assumptions and the estimated 0.013 MGD of excess landscape water, its nitrogen and phosphorus concentrations would be 780 and 8.9 µM, respectively. It is also assumed that due to evaporative losses, the salinity of the percolating water would have doubled.
- Other Non-Potable Water Uses. Uses of this supply will be varied, meaning that there is no single basis to predict changes to the quality of the portion percolating to groundwater. In view of this, it is simply assumed that for the portion percolating to groundwater, its salinity and nutrient levels will have doubled.
- Rainfall-Recharge. Data of the quality of rainfall-recharge are essentially non-existent. Data for rainfall-runoff quality are scarce, but in almost every case, the salinity is very low and nutrient levels are far less than the receiving groundwater. In other words, the rainfall recharge actually

dilutes the receiving groundwater. For the estimates herein, it is simply assumed that the post-development rainfall-recharge is increased by 20 and 2 µM for nitrogen and phosphorus in comparison to pre-development conditions.

Except for the RO concentrate which will be delivered directly to groundwater, all of the other returns to groundwater described above will travel vertically through the sandy soil layer, alluvium, and unweathered lavas to the groundwater below. These various strata will function as a trickling filter to naturally remove nitrogen and phosphorus. Expectable removal rates are greater than 80 percent for nitrogen and more than 95 percent of phosphorus. In the summary of estimated changes listed in Table 4, more conservative natural removal rates of 50 percent of nitrogen and 90 percent of phosphorus are used. The net impacts to the 4.0 MGD of groundwater flowing directly beneath the project site are listed below. All of the changes are modest and, on an aquifer-wide perspective, insignificant. At present, the only current use of groundwater downgradient of the project site are three wells in the Kealia National Wildlife Refuge. These are pumped seasonally when surface water is insufficient to maintain the ponds and wetlands areas. The projected changes due to the development of the Puunene Heavy Industrial Subdivision should be of no consequence to this ongoing use.

- a 5.7 percent decrease in flowrate;
- a 3.8 percent increase in salinity;
- a 1.3 percent increase in nitrogen; and
- a 7.1 percent increase in phosphorus.

Table 4

Summary of Estimated Changes to Groundwater as a
Result of the Proposed Puunene Heavy Industrial Subdivision

I t e m	Flowrate (MGD)	Salinity (PPT)	Nitrogen (lbs / day)	Phosphorus (lbs / day)
Existing Conditions				
• Groundwater Entering Mauka End of Site	4.0	0.80	153.9	3.51
• Addition of Onsite Rainfall-Recharge	0.038	0.12	Neg.	Neg.
Groundwater Leaving the Makai End of Site	4.038	0.79	153.9	3.51
Changes as a Result of the Project's Development				
• Withdrawal by Onsite Wells	-0.503	0.80	-19.35	-0.442
• Rainfall-Recharge	No Change	–	0.11	0.005
• Disposal of Domestic Wastewater	0.107	0.30	10.92	0.552
• Excess Landscape Irrigation	0.012	1.60	0.54	0.003
• Disposal of RO Concentrate	0.079	2.02	6.91	0.120
• Other Non-Potable Water Use	0.075	1.60	2.85	0.013
Total for All Changes	-0.230	0.31	1.98	0.251
Post-Development Groundwater Leaving the Makai End of the Site				
• Quantities	3.808	0.82	155.9	3.761
• Percent Change	5.7% Decrease	3.8% Increase	1.3% Increase	7.1% Increse

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